THIRD EDITION

# CRITICAL THINKING

JAMIE CARLIN WATSON | ROBERT ARP | SKYLER KING

## An Introduction to Reasoning Well

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# critical thinking

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# Acknowledgments

We dedicate this edition to the people who use critical thinking in their everyday work. Those we work closely with include healthcare professionals, clinical ethicists, military leaders, legal analysts, risk managers, and philosophers.

* * * * *

Thanks to Bloomsbury for pursuing a third edition of this book. We have evolved with it, and we believe the changes and new additions make it the best version yet.

And special thanks to Colleen Coulter at Bloomsbury for her patience, guidance, and cheerful assistance through the revision process. Gratitude to Jamie's former student Don Bracewell for assistance with the exercises in certain chapters.

# Preface to the 3rd edition

*You shouldn't drink too much.*

*The Earth is round like an egg.*

*Dinosaurs once roamed the Earth.*

*Milk is good for your bones.*

*It is wrong to get an abortion.*

*God exists.*

*Vanilla ice cream is the best.*

*Zoloft cures depression.*

Are any of these claims true? How could you tell? Could you ever be certain about any of them? Is there some method, some set of tools, to help you decide whether to believe any or all of these claims? Thankfully, the answer to the last question is yes, and this book is a beginner's toolkit for making such decisions—a starter guide to determining whether these claims, or any others, deserve your assent. As with any basic toolkit, this one doesn't include every tool you might use as a careful reasoner, but it has the most fundamental and widely used rules of good reasoning—everything you need to start experiencing the power of critical thinking.

This book is designed to be read, not simply taught from. We attempt to explain each concept simply and thoroughly with engaging examples so you can improve your reasoning even if you aren't taking a class. We also provide many opportunities to practice applying a concept before moving on, including additional real-life examples with specific, chapter-related questions. Our goal is to help you use the tools of good reasoning effectively in whatever context or career you find yourself. In other words, we aim to help you think critically about your world.

This book is also intended to be a primary text for courses in critical thinking, introductory logic, and rhetoric. We explain the basic concepts covered in these courses using a variety of examples from a variety of academic disciplines. We use real-life examples to translate abstract concepts into concrete situations, highlighting the importance of clarity and precision even in our everyday lives. In addition, the order of the chapters is flexible to accommodate a range of teaching styles.

Thanks to the insights and questions of our students and the many people who have used this book, we think the third edition is a significant improvement on the first two, including more tools, more exercises, expanded explanations, and more opportunities to practice thinking critically about real arguments.

## New to the 3rd Edition

In this third edition, we have

- kept the expanded discussions of evidence, propositional logic, probability, and scientific reasoning that we introduced in the second edition, so that we continue to serve the diverse interests of our readers;
- removed the chapter on graduate school entrance exams (feedback on the second edition revealed that this chapter was not providing the benefit we hoped it would);
- added two chapters, one on fake news (Chapter 11) and one on conspiracy theories (Chapter 12) to help you engage more effectively with some of the most pressing issues of contemporary life;
- changed the "Putting It All Together" chapter so that it is a list of easily accessible online articles with discussion questions, some of which are new. With the addition of the new chapters, we decided not to spend the page space;
- changed language and examples to be more inclusive; here are some examples:
    - We removed "he or she" language for indeterminate pronouns. As *Merriam-Webster* points out, the singular "they" has been widely used in English since the 1300s. It's only certain kinds of grammar snobs that have raised a question about it. For more, see the *Merriam-Webster* article, "Singular 'They'": https://www.merriam-webster.com/words-at-play/singular-nonbinary-they

- We changed some examples to reflect a better understanding of sex and gender.

  Consider an example from Chapter 3. We used the categorical claim: "All mothers are female."

  We originally presumed this claim was obviously true, so as to avoid discussion of whether the resulting arguments are sound. But we now acknowledge that the claim is not categorically correct. Now that we have a richer sense of the distinctions between sex and gender, we changed this to:

  "All mothers have uteruses."

  This claim is categorically true regardless of whether you identify as a man or a woman. If a trans woman has a uterine transplant and subsequently has a baby, the trans woman is a mother regardless of the physiological organs with which she was born. Similarly, "All mothers have uteruses" does not imply that fathers cannot have uteruses. If a trans man has a uterus and subsequently has a baby, that man both has a uterus and is a father.

  As a second example, we no longer use "female" as a noun. This was bad grammar, as "female" is an adjective, and it glasses differences in sex and gender. We refer instead to "women" unless talking about animals or students, who could be underage. Even in those cases, we now use "female" as an adjective: "female student," "female fox."

## Using This Book

The content is divided into four main parts. **Part One** is foundational. It explains the basic concepts you will need throughout the other parts, namely, claims, evidence, and arguments. The three remaining parts can be studied in any order, but we have organized them so that they proceed from more abstract, technical reasoning techniques to more concrete, practical reasoning strategies.

In **Part Two**, we explain deductive rules of reasoning, including categorical logic, symbolic logic, truth tables, and the rules of propositional logic. A grasp of these abstract concepts will increase clarity, precision, and organization in your thought and writing.

In **Part Three**, we cover inductive logic, including generalization, analogy, causation, scientific reasoning, and inference to the best explanation.

In addition, we explain over a dozen errors in reasoning to help you to avoid them in your own arguments and to identify them in the arguments of others. For the second edition, we have expanded our discussion of fallacies to include experimental findings about heuristics and biases.

And finally, in **Part Four**, we offer two brand new chapters, one called Thinking Critically about Fake News and one called Thinking Critically about Conspiracy Theories. Given the many new ways that information is being produced and distributed, we thought it important to provide some basic tools for navigating the massive amounts of bad communication we are faced with every day.

We hope you find this updated edition clear and easy to use, but mostly, we hope it contagiously conveys our excitement for this material and how empowering we find it in our own lives.

Here’s to reasoning well!

*Jamie Watson*
*Robert Arp*
*Skyler King*

# part one

# The basics of good reasoning

**In Chapters 1 and 2, we explain the basic concepts involved in good reasoning. The two most basic concepts are *claims*, which are declarative statements, and *arguments*, which are composed of claims and intended to constitute support for the truth of a particular conclusion. With just two major concepts, you would think it would be easy to learn how to reason well. The trouble is, reasoning uses language, which is notoriously messy, and it doesn't take place in a vacuum. There is usually a lot going on around an argument and behind the scenes. For example:**

- **There are many different types of claims and evidence, and if you don't understand the differences, arguments can be misleading.**
- **Many arguments are embedded in broader contexts, which means there's a lot more going on than just the argument (including, in many cases, oversimplification, bias, and intent to mislead). This means you have to sift through a lot of information than is not the argument in order to understand exactly what the argument is.**
- **Arguments are often couched in vague or ambiguous language that obstructs the meaning of the claims involved.**

**We can begin to evaluate how good an argument is and start forming our own good arguments once we clearly understand claims and their relationships to one another. The first two chapters are aimed at helping you get past these obstacles and on to the heart of reasoning well.**

# The basic tools of reasoning

1

We introduce various types of claims, evidence, and arguments. We distinguish *simple* and *complex* claims, identify the different parts of complex claims, explain the strengths and weaknesses of different types of evidence, and explain the different parts of arguments.

## Claims

**Critical thinking** is the conscious, deliberate process of evaluating arguments in order to make reasonable decisions about what to believe about ourselves and the world as we perceive it. We want to know how to assess the evidence offered to support various claims and to offer strong evidence for claims we are interested in. And we are interested in a lot of claims:

- God exists.
- We should raise the minimum wage.
- The Red Sox will win the pennant.
- This drug will make me lose weight.
- This airplane will get me home safely.
- That noise is my carburetor.

Are any of these claims true? Should we accept them or reject them or shrug our shoulders in skepticism? Critical thinking is the process of evaluating the strength of the reasons given for believing claims like these.

As critical thinkers, we want to reduce the number of false claims we believe and increase our fund of true beliefs. Regardless of what field you study or what career you choose, the tools covered in this book are the central means of testing claims, helping us to believe those likely to be true, to discard those likely to be false, and to suspend judgment about the rest. These tools have been handed down and refined through the centuries, starting with ancient Greek thinkers such as Parmenides (b. 510 BCE) and Aristotle (384–322 BCE), making significant advancements through the insights of logicians like Gottlob Frege (1848–1925) and Alonzo Church (1903–1995), and continuing to be refined today with the work of scholars like Susan Haack (1945–) and Alexander Pruss (1973–).

This rich and extensive history of scholarly work has provided us with an immensely powerful set of tools that has transformed a society of blundering tool-makers into the high-precision, computer-driven world around us. Every major technological advancement from ballistics to cell phones, to suspension bridges, to interstellar probes is governed by the fundamental principles of logic. And this book is an introduction to those principle, a starter kit of those tools used to make our lives and our world even better.

No one opens this starter kit completely uninitiated, with a mind that has never reasoned through a problem or tried to convince others that something is true. We have all argued, given reasons for a belief, defended an idea, or searched for evidence. But we often do it poorly or incompletely (even those of us who write books like this). Reasoning well is difficult. Further, no one is free from prejudice or bias. We all have beliefs and desires, and we all want to *keep* the beliefs about ourselves and our the world that we already have, the ones that already seem true to us: Some of us believe abortion is wrong; some believe arsenic is poisonous; others believe a group of men walked on the moon in 1969; more than half the people on the planet believe that a god of some kind exists; and some people believe the statement that "more than half of the people on the planet believe that a god of some kind exists." But should we keep these beliefs? Could we be wrong about them? And if so, how could we know? Answering these questions is one of the primary purposes of critical thinking. But what are we even talking about when we talk about "beliefs" and "arguments" and "the world"?

**Beliefs** are mental attitudes toward claims (also known as propositions). A **mental attitude** is a feeling *about* the world, and helps to inform our reaction to it. For instance, you might have the mental attitude of *fear*, where you dread an undesirable event. Or you might have the mental attitude of *hope*, where you long for a desired event. There are many types of mental attitude, including wishing, doubting, praising, blaming, and so on. Belief is the mental attitude of *assent to the truth of a claim*; when we believe a claim, our attitude is *yes, that's the way the world is*. Of course, we can have the attitude of belief toward a claim regardless of whether that claim is true. When we were young, many of us had the mental attitude of assent toward the claim: "Santa Claus brought these gifts." Isaac Newton had the mental attitude of assent toward the claim, "Space and time are distinct entities." In both cases, we are fairly certain these claims are false (sorry kids). This shows that we can believe false claims.

A **claim** (or **proposition**) is a statement about reality, a declaration that the world is a certain way, whether it really is that way or not. The way the world *is* or *was* or *could be* or *could have been* or *is not* is called a **state of affairs**. In declaring the way the world is, a claim expresses a state of affairs. For instance, Rob could have been taller than he is. That is one way the world *could have been*. Julius Caesar was emperor of Rome. That is one way the world *was*. And snow is white. That is one way the world *is*.

Claims are either true or false because reality can only be one way: there is either a tree in your backyard, or there isn't; you are wearing a shirt, or you aren't; the United States has a president, or it doesn't; two plus two equals four, or it doesn't. So, whether a claim is true or false depends on whether the state of affairs it expresses is really the way the world is. Using a classic example, we can say "The cat is on the mat" is true if and only if the cat really is on the mat, that is, if and only if the world contains a state of affairs in which there is a cat, there is a mat, and that cat is on that mat.

Of course, saying precisely how the world *is* is not always simple. What if the tree is half in your back yard and half in your neighbor's? What if the cat is only *partly* on the mat? In these cases, we have to be careful to define our terms. If by "on the mat" you mean "fully on the mat," then a cat partly on the mat makes the claim "The cat is on the mat" false. If, instead, you mean "some part of the cat is on the mat," then a cat partly or fully on the mat makes "The cat is on the mat" true. We'll say more about making claims precise in Chapter 2.

In this chapter, we will use brackets (< >) to distinguish claims from states of affairs. For example, the state of affairs, snow is white, is expressed by the claim, <Snow is white>. We will drop this notation in later chapters after you are comfortable with the distinction between claims and states of affairs.

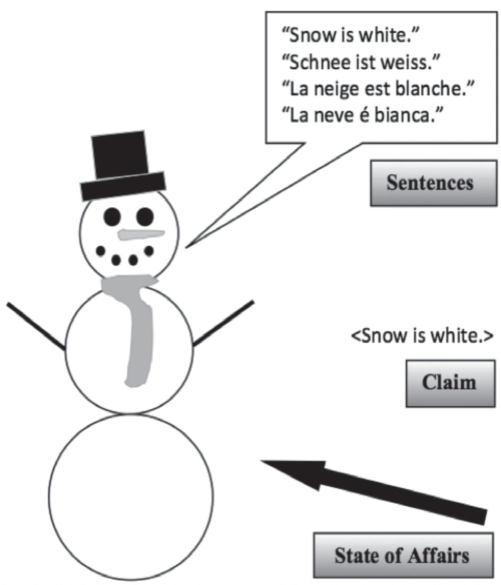
It is important to note that claims are not restricted to a particular human language. Particular human languages (English, French, German, etc.) developed naturally, over many centuries and are called **natural languages**. Natural languages are contrasted with **artificial** or **formal languages**, which are languages that humans create for particular purposes, such as computer languages (PASCAL, C++) and symbolic logic (we'll introduce one symbolic language, called “propositional logic” in Chapter 4). Since we cannot communicate without a human language, claims are expressed in natural languages. In this book, we are using English, but the fact that we’re using English instead of French is irrelevant to the claim that we are evaluating. When we want to point out that we are expressing a claim in a natural language, we’ll use quotes (“… ”) to distinguish it from a claim or a state of affairs. For example, the *claim* <Snow is white> is expressed by the *English sentence*, “Snow is white.”

Another important point is that, while sentences express claims in a natural language, sentences are not claims. This is because a single claim can be expressed by many different sentences. For example, “All stuff like this is white” or “It is white” can both mean <Snow is white> if “all this stuff” and “it” both refer to snow.

Similarly, “Snow is the color of blank copy paper” can also mean <Snow is white> if “the color of blank copy paper” refers to white. Similarly, the English sentence, “Snow is white,” is not the French sentence, “La neige est blanche,” yet both sentences mean <Snow is white>. So, <Snow is white> can be expressed in English (“Snow is white”), German (“Schnee ist weiss”), Italian (“La neve é bianca”), or any other natural language.

To see more clearly the relationship between claims, states of affairs, and sentences, consider Figure 1.1.

**Figure 1.1** Claims, States of Affairs, and Sentences



The *state of affairs* is the color of the snow out of which the snowman is made. The *claim* that expresses this state of affairs is <Snow is white>. And the *sentences* that express this claim can occur in any natural language (as long as those languages have words for "snow" and "white," or as long as those words can be coined in that language).

Why do these distinctions matter? Remember, as critical thinkers, we are interested in *claims*. Claims allow us to communicate about the world—to ourselves, when we are trying to understand the world, and to others; we think and speak and write in terms of claims. If you saw a snowman, you can't give us your *experience* of seeing a snowman. But you can tell us about it, and to do so, you have to use claims. Now, when you tell us about it, you will choose words from your natural language, but those words may be more or less effective at telling us what you want to say about a snowman.

For instance, if you said to a friend, "I saw one of those things we were talking about," you might be expressing the claim <I saw a snowman> and you might be right (that might be a *true* claim). But if your friend doesn't remember what you two were talking about, she can't evaluate your claim—she might not remember that conversation. The phrase, "one of those things we were talking about," is an ambiguous phrase in English (see Chapter 2 for more on ambiguity); it could refer to anything you have ever talked about, including snowmen, rifles, mothers, or dogs. To know what you are asking your friend to believe, and in order for her to evaluate whether to believe you (you might have meant "alien life form" instead of "snowman"), she needs to clearly understand what claim you are attempting to express.

Given what we've said so far, we can define a claim as follows:

**A claim:**
**(1) is a declarative statement, assertion, proposition, or judgment,**
**(2) that expresses something about the world (a state of affairs), and, because of (1) and (2)**
**(3) is either true or false.**

Let's look more closely at these three criteria for a claim.

## (1) A claim is a declarative statement, assertion, proposition, or judgment.

— It is not a *question*, as in: "What time is it?" or "How do I tie a bowtie?"

— It is not a *suggestion* or *command*, as in: "Hey, let's go to the beach today," or "Shut the door!"

— It is not an *emotive iteration*, as in: "OW, that hurts!" or "Yay, Tigers!"

Instead, a claim declares that something is the case, for example, that <The world is only ten thousand years old> or that <Jupiter is the largest planet>.

## (2) A claim expresses something about the world (states of affairs).

Claims are assertions, declarations, or judgments about the world, whether we are referring to the world outside of our minds (the existence of trees and rock), the world inside our heads (what cinnamon smells like, whether you feel jealous), or the ways the world might have been (it might have rained today if the pressure had been lower, she could have gone with him). And claims make precise all the various ways our natural languages allow us to talk about the world. For example, Sally might say: "It is raining right now." And this means the same thing as: "It is the case that it is raining right now" and "Rain is falling from the sky." John might say: "I feel jealous," and this means the same as: "It's true that I am jealous" or "I am not okay with her dating him." Consider these assertions, declarations, or judgments where something is communicated that is or is not the case:

- Leo Tolstoy wrote *War and Peace*.
- It is the case that Edgar Allen Poe wrote *The Murders in the Rue Morgue*.
- The United States is not the country with the largest population in the world.
- It is the case that I believe you are acting immorally.

## (3) Because of (1) and (2), a claim is either true or false.

Since the world can only be one way, claims are either true or false. Some very intelligent people deny that the world can only be one way. They argue that the world is *metaphysically vague*, so that some claims, such as <Mars is dry> and <Patrick Stewart is bald>, are not, strictly speaking true or false, but only *more or less* true or false; the world is fuzzy on things like dryness and baldness. We think, in contrast, that these claims are *linguistically* vague—the words *dry* and *bald* are not as precise as we sometimes need them to be. You don't have to agree with us about this. But regardless of whether you accept metaphysical vagueness, it is not true that a planet is both *dry and not dry* at the same time in the same way, or that a man is both *bald and not bald* at the same time in the same way. All you need to understand for the sake of using this book well is that a claim either:

- accurately expresses some state of affairs, that is, the way the world is (in which case, it is true), or
- inaccurately expresses some state of affairs (in which case, it is false)

Most of us think that a claim is true if and only if it accurately expresses some state of affairs, that is, it *corresponds* to some feature of reality. If a claim does not correspond to some feature of reality, it is false. This is a commonsense meaning of the word "true" that is called the **correspondence theory of truth**. There are other theories of truth (pragmatic, coherence, identity, deflationary, etc.), but this commonsense definition captures what we typically mean when we say a claim is true, and in practice, it is not greatly affected by the technical implications of those other theories. Therefore, *correspondence with reality* is what we will mean by *truth* in this book.

Like actions, claims have *values*. Actions can have a variety of values; they can be good or bad, useful or useless, legal or illegal, and acceptable or unacceptable, and many other values in addition to these. Claims can have a variety of values, too, but we are concerned only with **truth value**, that is, whether the claim is true or false. So, when we talk about a claim's truth value, we are talking its status as true or false.

Claims (a–d) below are considered true claims. We say they are "considered" true because to say we *know* they are true or that we are *certain* they are true is to make a strong assumption about our access to the way things really are. Remember, people thought for centuries that the earth is at the center of the cosmos and that space and time are different entities. Now, we think we know better, but our evidence could be mistaken. We are pretty sure the following claims are true, that is, what they communicate accurately corresponds to some state of affairs in the world, and they have a truth value, *true*:

a. The population in the United States presently is over 200 million.
b. Charles Darwin wrote *The Origin of Species*.
c. Most children are born with two feet.
d. Some snakes are black.

Claims (e–h) are considered false claims, that is, what they communicate does not accurately correspond to some state of affairs out there in the world, and they have a truth value, *false*:

e. Greece has the largest population in the world.

f. William Shakespeare lived in New York City.

g. All whole numbers are fractions.

h. No snakes are venomous.

Notice, when someone writes or says that something *is* the case, he is saying that the claim expressing some state of affairs is true (the claim corresponds to some state of affairs). Similarly, when someone writes or says something *is not* the case, he is saying that the claim expressing some state of affairs is false (the claim does not correspond to some state of affairs). Here are some examples of ways to express that a claim is true or false:

## Expressing claims in a variety of English sentences:

**Claim: <It is raining outside right now.> expressed as true**

Sentences:

- "In fact, it is raining outside right now."
- "It is the case that it is raining outside right now."
- "It is true that it is raining outside right now."

**Claim: <This shirt is mine.> expressed as false**

Sentences:

- "This shirt is not mine."
- "It is true that this shirt is not mine."
- "It is not the case that this shirt is mine."

**Claim: <All whales are mammals.> expressed as true**

Sentences:

- "I say that all whales are mammals."
- "It is the case that all whales are mammals."
- "The claim, 'all whales are mammals,' is true."

**Claim: <Most snakes are venomous.> expressed as false**

Sentences:

- "The claim, 'Most snakes are venomous,' is false."
- "It is not the case that most snakes are venomous."
- "It is false that most snakes are venomous."

## Different Types of Claims

All the claims we have discussed so far are **descriptive claims**, that is, they express the way the world *is* or *was* or *could be* or *could have been*, as in a report or explanation. For example, the following are all descriptive claims:

- <Most of you are paying attention in class right now.>
- <At least one of us is sleeping in class.>
- <We all could be at the beach.>
- <There are ten people in this class.>

But claims can also be **prescriptive** or **normative**, that is, they can express that the world *ought to be* or *should be* some way. For example, the following are all prescriptive claims expressed by English sentences:

- <You should be paying attention in class right now.>
- <No one should be sleeping in class.>
- <We shouldn't be at the beach.>
- <There should not be more than fifty people in this class.>

Prescriptive claims are common in law (<You should stop at stop signs>), society (<You should stand when you shake someone's hand>), religion (<You should wear a hijab in public>), and ethics (<You should not hurt people without just cause>). These categories of *ought* claims are often referred to, respectively, as legal norms, social norms, religious norms, and ethical norms.

Prescriptive claims need not refer to non-actual states of affairs. It could be that the world is, in some ways, exactly how it should be. For instance, it could be true that <You should be paying attention> and also true that <You are paying attention>.

Where the *ought* comes from in prescriptive claims is controversial. In legal norms, what makes them true (and therefore, gives force to the *ought*) seems to come from a combination of the desire not to be punished and a willingness on the part of the legal system to punish people for not following the prescription. So, as a society, we have "created" legal norms by agreeing to use force (and agreeing to have force used upon us) to uphold them. (It's worth noting that some people believe law is "natural" and that humans discover legal norms derive from nature, but we will set that aside for now.) But where do *moral* norms come from? What makes morally prescriptive claims true?

These questions are beyond the scope of our discussion here, but they highlight an important dimension of critical thinking: Different types of claims are subject to different truth conditions. Natural claims are made true or false by nature; legal claims are made true or false by lawmakers, judges, and juries; your beliefs about how you feel (hot, cold, sad, angry) are made true or false by your body; and so on. These differences in types of claims and the question of what makes them true show the importance of learning to think critically in specialized fields like law and ethics.

### Getting familiar with … different types of claims

**For each of the following English sentences (indicated by quotation marks), identify whether it expresses a *descriptive claim, prescriptive claim, question, command, emotive iteration*, or some combination.**

1. "Is that Sally?"
2. "That is a Doberman Pincer."
3. "Please close the window."
4. "There are flies accumulating on grandpa's head."
5. "Yikes!"
6. "Is that car a Porsche?"
7. "Holy semantics, Batman!" (Robin, from the 1960s Batman television show)
8. "There's a tear in my beer 'cause I'm cryin' for you dear." (Song lyric from Hank Williams, Sr.)
9. "Should we try Burger King for once?"
10. "Smoking is bad for your health."
11. "You shouldn't smoke."
12. "That's totally, like, bogus, man!"
13. "It is not the case that she does not like chocolate."
14. "If you build it, they will come."
15. "How much more of this do I have to endure?"
16. "Stop!"
17. "You should not kick the seat in front of you."
18. "I wish the clock worked."
19. "Is that a real Rolex?"
20. "Stop asking me whether I should wait for you."

## Operators

Claims of every type can be simple or complex. A simple claim communicates one idea, usually having just one subject and predicate, as in the following examples:

- Metallica rocks.
- Jenny is in the garden.

- The new edition of *Encyclopedia Britannica* is out.
- Two plus two equals five. (*Remember, claims can be true or false, so, even though this sentence is not true, it is still a claim.*)

A complex claim is one or more claims to which an *operator* has been applied. A logical operator is a tool that allows us to express more complicated states of affairs. You are probably familiar with *mathematical* operators like +, –, ×, /, and =. Mathematical operators are *functions*: they allow us to derive new numerical values from given numerical values. For example, if we are given the numerical values 3 and 5, and we apply the mathematical function +, we can derive the new numerical value, 8. Logical operators are also functions—they allow us to derive new truth values from given truth values. In this book, we will discuss five logical operators (see Figure 1.2). In some logic books, different symbols are used for operators, so in Figure 1.2 we have put the symbol that we will use for the operator and put an alternative in parentheses. For example, the symbol for "and" will be the ampersand, "&" in this book. But other books might use the dot symbol, "•."

The most basic operation is simply to deny the truth of a claim, to say *it is not the case*. The **not** operator allows us to negate a claim. For example, the claim <It is raining> is negated by denying it: <It is not the case that it is raining>, or, more smoothly in English, "It is not raining." A negated claim is called a **negation**. Here are five more examples; the operator appears in bold and the negated claim is underlined:

- Jenny is **not** lying. (Notice that the single claim <Jenny is lying> is split by the operator. For the sake of clarity and simplicity, the structure of natural languages often requires us to place operators in places where a formal language like logic would not.)
- It is **not** raining.

**Figure 1.2** Logical Operators

| Operator | Symbol | Example |
|---|---|---|
| and | & (also • ) | It is a cat **and** it is a mammal. |
| or<br>(sometimes requires "either") | v | It is **either** a cat **or** a skunk. |
| not | ~ (also ¬ ) | It is **not** raining. |
| if…, then… | ⊃ (also →) | **If** it is a cat, **then** it is a mammal. |
| if and only if | ≡ (also ↔) | He is a bachelor **if and only if** he is single. |

- **It is not the case that** George W. Bush rigged the 2000 presidential election.
- Hercules was **not** a real person.

Another simple operation is to say that two claims are both true, that is, to say claim A is true **and** claim B is true. The **and** operator allows us to *conjoin* claims in this way, and the result of applying the *and* operator is called a **conjunction**. Each claim conjoined in a conjunction is called a **conjunct**. Here are a few more examples; the operator appears in bold and the conjuncts are underlined:

a. John is in grade school **and** he is ten years old.
b. Leo the lion is a constellation **and (**he is**)** an astrological symbol.
c. Jack is a hunter, fisherman, and marksman. (This complex claim is a conjunction of three simple claims: Jack is a hunter **and** Jack is a fisherman **and** Jack is a marksman. English allows us to simplify by dropping *and*s. The operator is *implied* in English, but when we translate this sentence into logic we make it explicit.)
d. Sara is not only a competent marksman, (**and**) she is also an expert computer tech **and** (she is an expert) linguist.

Notice that English allows us to include phrases unrelated to claims for ease of expression. In (e), *not only* and *also* are extraneous to the claims <She is a competent marksman> and <She is an expert>. Notice, also, that, in some cases, implied content is part of the claims (e.g., the underlined content in parentheses in (c) and (d)). See Chapter 2 for more on extraneous material.

Two claims can also be *disjoined*, which is to say that either one claim is true **or** another is. Claims that are operated on by the **or** operator are called **disjunctions**. Each claim in a disjunction is called a **disjunct**.

Disjunctions are unique in that there are two possible ways to read them. We might read a disjunction *exclusively*, which means either claim A is true or claim B is true, *and both cannot be true*. This reading of the *or* operator is called an exclusive reading, or the "**exclusive *or***." Alternatively, we might read a disjunction inclusively, which means either claim A is true or claim B is true, *and both might be true*. This reading of the *or* operator is called an inclusive reading, or the "**inclusive *or***."

The exclusive or would be useful when dealing with mutually exclusive disjuncts, such as <It is raining>, <It is not raining>. For any given definition of "rain," it is exclusively true that <It is raining or it is not raining>. But exclusive truths are rare in common usage. In many cases, both disjuncts could be true. For instance, consider the claims <The battery is dead>, <The alternator is broken>. If a car won't start, we might, after some investigation, determine that <The battery is dead or the alternator is broken>. The truth of either claim would be sufficient for explaining why the car won't start. But it could be that both are true: The battery is dead and, at the same time, the alternator is broken. That may be improbable or unlikely, but it is not impossible, which means we cannot use the exclusive *or*.

Because in many cases, the disjuncts of a disjunction might both be true, and because it is difficult to tell sometimes when two claims are mutually exclusive, logicians have adopted the practice of treating all disjunctions inclusively. We will follow that practice in this book: All *or* operators should be read inclusively; both disjuncts might be true. Here are some examples of disjunctions (notice that "either" is extraneous; it is simply used to make the English sentences read more easily):

a. Either Jacqui will do the job **or** Henri will be called in as backup to do the job.
b. Either the budget will be settled **or** the meeting will last past 7:00 p.m.
c. That thing over there is either a wolf **or** (that thing over there is) a really large dog.
d. The sales figures indicate a recession **or** (the sales figures indicate) a problem with our accounting **or** (the sales figures indicate) serious embezzlement.

Some claims are *conditional* upon others. This means that we can rationally expect some claims to be true *if* certain other claims are true (but not *only if* they are true; they may be true for other reasons, too). **Conditional** (also called **hypothetical**) **claims** employ the ***"if … , then …"*** operator. This is because the truth of the claim following the "then" is logically (though not causally) conditional on the claim following the "if." They are sometimes called *hypothetical claims* because they do not express the way the world is, but how it could be. For instance, the conditional <If it is raining, then the sidewalk is wet> does not express either that it is raining or that the sidewalk is wet, but that (conditionally) *if* it is raining, *then* the sidewalk is wet. This conditional claim can be true even if it isn't raining.

Conditional claims have two parts: an **antecedent**, which is the claim following the "if" (recall that "ante" means "comes before," as in poker) and a **consequent**, which is the claim following the "then" (think: con-sequence, which literally means "with, in a specific order"). English allows a variety of ways to express conditional claims, many of which do not use the "if… then…" formula explicitly. For instance, "The moon will look bright tonight if the sky is clear" expresses the conditional <If the sky is clear, the moon will look bright tonight>. The antecedent comes after the *if*; even though it does not come first in the sentence, it is still logically prior to the consequent. English makes things more difficulty with the phrase "only if," which acts like the "then" in a conditional. So, if we said, "The moon will look bright tonight only if the sky is clear," we would be expressing the conditional, <If the moon will look bright tonight, then the sky is clear>. The antecedent comes before "only if" in English sentences.

Here are a few examples:

a. **If** Smith is elected, **then** our taxes will be raised.
b. The tide rises **if** the moon comes closer to the Earth. (Notice that the consequent comes before the antecedent in this English expression of the claim, <If the moon comes closer to the Earth, then the tide rises>)
c. All the pins will fall **only if** you roll the ball just right. (Because of the *only if*, the claim retains its logical order, <If all the pins will fall, then you roll the ball just right>.)
d. **If** the candy is not in the pantry, (**then**) someone took it. (Notice that the *then* is implied.)

The most complicated operator is the **bi-conditional**, which is expressed as "if and only if." Claims operated on by "if and only if" are called *bi-conditionals* because two conditionals (hence, the "bi") are being conjoined (the "and" operator). Imagine a conditional that is true even if you swap the antecedent for the consequent. For instance, we think the following conditional is true:

- **If** Pat has brown hair, **then** she is brunette.

Now, notice that this conditional is also true if we swap the antecedent with the conditional:

- **If** she is brunette, **then** Pat has brown hair.

So far, we have applied operators to simple claims. But the rules of logic allow us to apply operators to any claims, regardless of whether they are simple or complex. So, if we *conjoin* these two conditionals (we say they are both true), we get this very cumbersome complex claim:

- If Pat has brown hair, then she is brunette **and** if she is brunette, then Pat has brown hair.

If we operate on two complex claims, we get another complex claim. The result of *conjoining* two claims, regardless of whether they are simple or complex, is a conjunction. The result of disjoining two complex claims is a disjunction, and so on. So, our complex claim about Pat is a conjunction (it conjoins two conditional claims).

The bi-conditional is helpful because, in cases where the conditional runs in both directions, as in our conditionals about Pat, we can simplify the set of conjunctions into a more manageable complex claim:

- Pat has brown hair **if and only if** she is brunette.

Here are some more examples of the bi-conditional:

- A person is a bachelor **if and only if** a person is an unmarried man.
- Utensils go in this drawer **if and only if** they are sharp.
- A person is alive **if and only if** doctors can detect brain activity.
- A person is legally permitted to drink alcohol in the United States **if and only if** they are twenty-one years old.

# Major Operators

Finally, when operators are applied to complex claims, one of the operators becomes dominant; it takes over the truth-functional role of the claim, and the dominant operator is called the **major operator**. For example, if we apply a negation to the complex claim (A & B), the negation is the major operator: ~(A & B). Whatever truth value (A & B) has, the negation changes it; the negation operates on the conjunction, not the simple claims. Similarly, if we conjoin two conditionals (A ⊃ B) and (B ⊃ C), the result is a conjunction: ((A ⊃ B) & (B ⊃ C)). The conjunction operates on the two conditionals, and therefore, determines the truth value of this complex claim. We will say more about major operators in Chapter 4. For now, just be aware that, when a complex claim includes more than one operator, the major operator determines whether the claim is a negation, conjunction, disjunction, conditional, or bi-conditional.

These are the five basic logical operations you will use in thinking critically about the world. In Chapters 4, 5, and 6, we explain how these operators affect the truth values of claims and how they are used in arguments. For now, here are some practice activities to help you get familiar with these concepts.

## Getting familiar with … operators

**A. Identify the following English sentences as expressing *simple* or *complex* claims. If a claim is complex, say whether it is a *conjunction, disjunction, negation, conditional*, or *bi-conditional*.**

1. “If the clock is broken in this room tomorrow, I’ll scream.”
2. “That is not the same movie we were just talking about.”

3. "Eating the right kinds of foods builds muscles and doing so helps your immune system."
4. "You have to do it or else you'll get in trouble."
5. "You should join the club."
6. "You'll make the team, if you pass the tests."
7. "You have to take the final exam if and only if your grade is less than an *A* going into the final exam."
8. "It would be necessary to invent one, if there were no god."
9. "Either the universe is only thousands of years old or the geologists are right."
10. "In 1969, on space flight Apollo 11, the first humans walked on the moon."
11. "You are a lawyer if you are a barrister."
12. "That liquid is water if and only if it is $H_2O$."
13. "He's either a doctor or he's just wearing a white coat."
14. "The market price of gold has risen substantially over the past two decades."
15. "That is not what Special Theory of Relativity implies."

**B. These last five complex claims are trickier because they involve more than one operator. See if you can figure out whether the major operator is a *conjunction, disjunction, negation, conditional*, or *bi-conditional*.**

1. "If the case goes to trial, then the lawyer gets his day in court and we get to tell the whole story."
2. "If it rains tomorrow, then we can either go to the mall or hang out here."
3. "He will arrive and she will arrive shortly thereafter if and only if the dog stays and the cat goes."
4. "There is no food left and we do not have any money."
5. "There are three candidates and one of them is qualified if and only if her previous employer verifies her work history."

## Quantifiers

In addition to operators, claims can also have *quantifiers*. A quantifier indicates vaguely how many of something is referred to in a claim. When we say "vaguely" here we mean that the quantifier tells us the quantity of something but not a specific quantity, and there are three basic quantifiers: *all*, *some*, and *none*. For example, if you want to express a claim about every single bird, let's say, that it has feathers, you would use the *all* quantifier:

<All birds have feathers.>

If you want to say that *at least one* bird has feathers or that *a few* of them do, that *many* of them do, or that *most* of them do, you would use the *some* quantifier:

<Some birds have feathers.>

Some is not very precise; it simply means at least one, but it can refer to many or most, as well. It is even consistent with *all*. If *all* birds have feathers, then at least *some* do.

And if you want to say that birds are featherless creatures, you would use the *none* quantifier, which is just written "no":

<No birds have feathers.>

The quantity of something in a claim is also called the *scope* of that claim, or, in other words, how much of reality is included in the claim. The relationship between quantifiers and scope can be seen in an analogy with a literal viewing scope (Figure 1.3). The "scope" of the viewing scope refers to what you can see when looking through it. The quantifier in a claim tells you what you can see when looking through the scope.

The difficulty with recognizing and interpreting quantifiers is that natural languages, like English, allow us to express quantities in ways other than *all*, *some*, and *no*, and they also let us *imply* quantities to simplify our expressions. For example, instead of saying, "Some dogs are beagles," you might say, "One species of dog is the beagle." With respect to quantities, this means <Some dogs are beagles>. Further, instead of saying, "All ducks float," you might just say, "Ducks float," implying that all do.

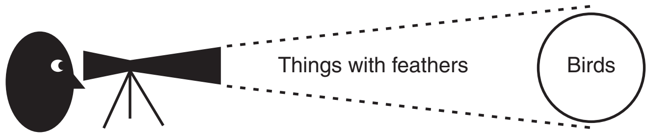
We will discuss quantifiers in more detail in Chapter 3, where we will show how quantifiers affect the truth values of claims and how quantifiers are used in arguments. For now, here are some exercises to help you get familiar with the concepts.

## Getting familiar with … quantifiers

**For each of the following English sentences, identify whether the claim is about *all* of something, *some* of something, or *none* of something.**

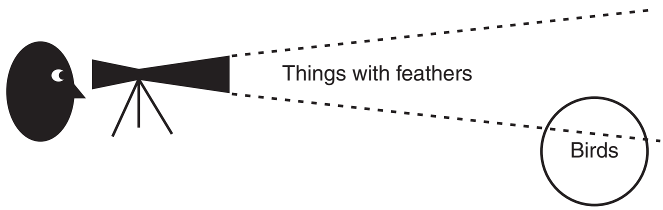
1. "Three ducks walked across the farm today."
2. "Airplanes have two wings."
3. "Politicians do not tell the truth."
4. "There is no food left in the pantry."
5. "Some lawyers are nice people."
6. "No time is a good time for goodbye."

**Figure 1.3** The Scope of a Claim



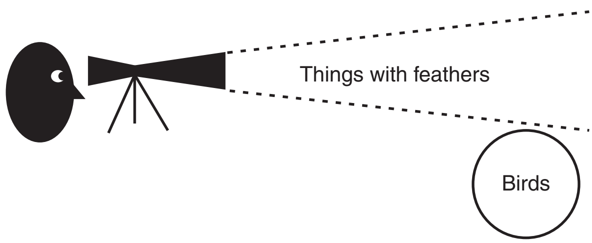

**Claim: <All birds have feathers.>**

In this diagram, all birds fall within the scope of things that have feathers. If reality is this way, the claim <All birds have feathers> is true.




**Claim: <Some birds have feathers.>**

Here, some birds fall within the scope of things that have feathers.




**Claim: <No birds have feathers.>**

Here, no birds fall within the scope of things with feathers.

7. "All those people are dressed funny."
8. "All subatomic particles are comprised of mass and spin."
9. "At least one member of the Board of Directors is honest."
10. "A few of those chairs are broken."
11. "Those tables are painted black."
12. "More than half of all politicians are men."
13. "There isn't any coffee left in the pot."
14. "Everyone in that sorority is wealthy."
15. "Lightning never strikes twice in the same place."

16. "Doc Martins are shoes."
17. "I've read half of all my books." [Hint: "Some things that are my books"]
18. "These mugs are made of ceramic."
19. "Sandstone is porous."
20. "There just isn't any way to tell whether Schrödinger's cat is dead." [Hint: "No things…"]

## Evidence

To determine whether a claim is true or false, or *likely* to be true or false, critical thinkers need **evidence**. Evidence is a reason or set of reasons to believe that a claim is true or false. Evidence may or may not be conclusive (some piece evidence may suggest something is true without being a strong enough reason to believe it). Nevertheless, evidence plays a critical role in arguments—it constitutes the support for the truth of a claim. A claim may be true or false in absence of support; but critical thinkers only have a reason to believe a claim if there is sufficiently strong evidence that it is true.

Evidence can take the form of *a claim* or *set of claims*, or it can take the form of *a psychological state*. When it takes the form of a claim or set of claims, those claims make another claim seem true. For example, taken together, the claims <All men are mortal> and <Socrates was a man> are evidence for the further claim <Socrates was mortal.> When it takes the form of a psychological state, some experience or set of experiences make a claim seem true. For instance, the psychological state of *seeing a ball as red* is a reason to believe the claim <The ball is red> is true.

Evidence can also be a combination of claims and psychological states, as when you see an animal is in a field, and you believe the claim <Animals that look like that are cows>, and then you conclude that <There is a cow in that field>.

Whether it is a claim or psychological state, evidence works by making a claim *seem true*, regardless of whether it is. Seeing that a wall looks red is evidence that it is red. It could really be red, in which case, your seeing it as red is evidence for its being *true*. But the wall could be also white with a red light shining on it (as you might find in your fancier coffee establishments). In that case, the wall seems red to you, and its seeming red is *evidence* that it *is* red, but, in fact, it is not red. You have evidence for a *false* claim.

The fact that you could have evidence for a false claim means there is a gap between the way the world *seems* to us—our *evidence* for states of affairs—and the way the world really is. The existence of this gap has led many philosophers to become skeptics. But the existence of such a gap is not sufficient, on its own, to justify skepticism. For now, it should just make us extremely cautious about which beliefs we accept. To have very strong beliefs about reality, we need to have very strong evidence—that is, very good reasons to believe a claim. And we may never be *100 percent certain* that a claim is true. But being cautious with our beliefs, taking evidence seriously, and understanding the limitations on our evidence is all part of what it means to think critically.

Evidence is important for (1) forming beliefs about claims, (2) evaluating beliefs about claims, and (3) persuading others to adopt claims you believe. It is difficult to form beliefs without evidence. For instance, could you make yourself believe that there is a large, pink elephant in your room right now? Without evidence, it seems extremely difficult. Similarly, it is often difficult to believe contrary to your evidence. For instance, could you force yourself to believe that the dollar in your pocket is really worth $100? Examples like these led philosopher W. K. Clifford (1845–1879) to make the strong claim that, "It is wrong always and everywhere for anyone to believe anything on insufficient evidence" (1877). This claim is probably too strong. (Is there good evidence for it? Many people think there isn't.) But it emphasizes just how hard it is to form good beliefs without evidence.

Evidence is also important for *evaluating* claims. Let's say that Rob, one of the authors of this book, asserts that "this chapter was typed on a computer." This claim is supported *for him* by his senses; he *sees* that he is typing it on a computer. It is also supported by memory; he *remembers* typing it on a computer. This claim can be supported *for you* by a still different source of evidence, perhaps *testimony from Rob* (whom you may or may not know to be a reliable witness) or your *background beliefs* that, for the most part, books are now written on a computer. The point is that the strength of your belief that he wrote this chapter on a computer depends on the strength of your evidence for this claim.

Finally, evidence is important for convincing others that what you believe is true. If Skyler, one of the other authors, tells you, "Rob Arp is President of the United States," a critical thinker has reasons to believe this is false. For instance, you may be able to gather direct evidence that it is false (you could follow him around noting that he does nothing presidential, plus there don't seem to be any Secret Service people around). Or you may be able to gather indirect evidence that it is false (the inference from your beliefs that you have not seen him on TV, plus the testimony of appropriate authorities on the subject—someone else is president!). So, if Skyler wants to convince you that Rob is president, he needs to offer new and sufficient evidence for removing or substantially weakening your (currently very strong) evidence that Rob is not president.

Evidence can be strong or weak depending on how well it supports a claim. The fact that one person in history died is weak evidence that *all* people are mortal. But the fact that most people in history died (except perhaps Elijah and Enoch, if you believe the Bible), is strong evidence that all people are mortal.

In the next section and Chapter 2, we will see how evidence can support claims strongly or weakly in arguments. But individual instances of evidence have strength conditions, too. For instance, a mathematical theorem is typically stronger evidence than testimony. And seeing something directly is often stronger evidence than remembering it. To see why, it is helpful to understand different sources of evidence.

An intuitive way to understand evidence is to divide it into two types of sources: **direct evidence** and **indirect evidence**. Direct evidence is information that you, as a critical thinker, have immediate access to, for instance, seeing that something is red or round or recognizing that a particular claim follows from a mathematical theorem. This doesn't mean you have direct access to *reality*; your mind and eyes and ears and taste buds are all instruments, like microscopes and computers, which can be calibrated differently. So, your picture of reality may be distorted, but, when a source of evidence is direct, whatever picture or belief you're getting is immediately available to you. Indirect evidence, on the other hand, is mediating information, or information that tells you second-hand something about what you're really interested in. For instance, if someone testifies that they saw someone hit your car, what you want to know is whether someone hit your car. But you didn't see whether someone hit your car; you don't have direct access to the fact of the matter. Instead, you have a mediating bit of information, the testimony that someone hit your car. Indirect evidence, like testimony, is information that aims to connect information you would normally get from direct evidence with your belief.

These categories can be helpful when evaluating the strengths and weaknesses of different pieces of evidence. This is one reason that legal courts prefer *eyewitness* testimony rather than *hearsay* testimony.

## Types of *direct evidence*:

**Sensory evidence** (vision, hearing, touch, taste, smell)

**Logical entailment** (e.g., the rules of inference we will discuss in

Chapter 6)

**Mathematical entailment** (claims that follow from the rules of arithmetic,

geometry, etc.)

**Intuitions** (moral or rational)

**Introspection** (personal access to your beliefs and feelings)

**Definitions** (A definition can provide evidence that some claim is true in virtue of the meaning of the words in the claim. For example, if you understand what the word "bachelor" means, then if someone says that Jack is a bachelor, this is evidence that Jack is unmarried.)

### Types of *indirect evidence*:

**The results of scientific experiments** (mediated by instruments and experiments, see Chapter 9)

**Testimony** (mediated by someone else's sensory evidence or experiments)

**Memory** (mediated by time)

**Scientific theories** (mediated by experiments and widespread acceptance by scientists)

**Specific types of inductive inferences** (mediated by incomplete information; see Chapters 7 and 8)

Indirect evidence is generally (though certainly not always) weaker than direct evidence because there are more opportunities for the evidential content to be corrupted. We could be mistaken about what we see directly because our eyes or visual processing systems could fail in some way. If we add glasses, there is one more instrument that could fail. If we add a microscope, there is yet one more. If we connect a computer to the microscope there is still another. This is not to say that we should not trust this combination of sources, but simply that we must remember to take all the possibilities for error into our evaluation of what to believe.

Indirect evidence is not always weaker than direct because we could, for instance, discover that computers are more reliable mathematicians than humans—they make fewer errors in calculations. In this case, even though I don't understand the calculations directly, the computer's testimony that a certain calculation produces a certain result would be more trustworthy than even the judgment of the mathematician who programmed the computer. Of course, the human mind is an ineliminable part of the process—someone has to program the computer *and* check its reliability. But given evidence of our own mistakes, we have a reason to trust computers more than people about mathematics. Often, the further our evidence is from the states of affairs that determine claims' truth values, the more fragile our evidence becomes.

Consider the experimental data necessary to test a new medicine. We can't have any direct evidence of a medicine doing its thing in someone's body. So, we can only use indirect evidence. In order to have *all* relevant data, we would have to administer the medicine to *all* those affected by whatever problem the medicine is designed to solve. But before we make it available to everyone, we need to know it's safe and that works on everyone the same way. To test a medicine, we take a small sample of the population and give them the drug. Given differences in genetics and lifestyles, the medicine probably won't work the same for everyone. Let's say it solves the problem in 80 percent of cases. Does the drug work? And for what type of body? This is certainly very different evidence than a mathematical proof. We will discuss experimental evidence in greater detail in Chapter 9. The point here is simply to point out the importance of understanding the strengths and weaknesses of different types of evidence, and that different sources of evidence must be evaluated in different ways.

## Emotions as Evidence?

You may be wondering why we did not include emotions in our discussion of evidence. "Go with your gut" and "Listen to your heart" are common refrains in contemporary culture. And surely, you might think, the fact that we feel disgusted by something is evidence that it is disgusting. Or you might think that because we feel sympathy or a desire to help someone that is evidence that some situation is sympathetic or that that person deserves our help. You are in good company if you agree. The philosophers David Hume and William James gave prominent places to emotion in our rational lives.

While emotions play an important role in bringing important things to our attention (like predators and con artists), and for encouraging us to reconsider some beliefs (for instance, that texting your ex when drunk is a good idea), we have strong reasons to believe our emotions are unreliable *as reasons for thinking claims are true*. We often feel sympathy regardless of whether someone deserves it (jurors are often made to feel sorry for guilty defendants in order to convince them to acquit). We often feel a desire to help someone when we shouldn't (when a child is begging not to get an injection of penicillin to cure a bacterial infection). We feel jealous when we have no right to be. We are often hypersensitive, hypercritical, and our feelings about a situation are often disproportionate to the event that caused them. The Enlightenment thinker Michel de Montaigne writes, "Our senses are not only corrupted, but very often utterly stupefied by the passions of the soul; how many things do we see that we do not take notice of, if the mind be occupied with other thoughts?" (from *Apology for Raymond Sebond*).

To be fair, emotions are not always or completely *ir*rational; sometimes they are simply *a*rational (i.e., they are neutral with respect to rationality). David Hume argues that, without emotions, we wouldn't get off the couch and *do* anything—we simply wouldn't care. The interest we take in anything is a function of emotion. This means that emotions are integral to critical thinking; we must have an interest in responsible and true beliefs to motivate us to exert the energy required to think clearly about them. But a motive to do or believe something is not an indication of that thing's goodness or truth. We may be motivated to give money to the homeless, oblivious to whether this actually helps the homeless or whether it perpetuates the problem. This means emotions are essentially arational. Whether a belief or act is true or good depends on the way the world is, and our beliefs about the way the world depend on our evidence. Even Hume argues that our emotions should be guided by reason. Without a guide, emotions, much like our senses, can deceive us. Thus, we can check our emotions by testing them against our senses and reason, and we can test our senses by testing them against reason. How do we test our reason? That's a bit tricky. And some basic points of reasoning we have to accept because we can't imagine any alternative (e.g., the deductive rules of inference in Chapter 4). But also see Chapter 10 for a discussion of how reasoning can go wrong and how we might learn when it does.

For now, note some similarities and differences between sensory evidence and emotions. Both sensation and emotion are passive experiences—they happen to us, and we cannot decide to see, hear, touch, smell, taste, or *feel* other than we actually do. Further, both sensations and emotions occur independently of any judgments we might make about them. You can judge that your jealousy is misplaced or irrational, but you can't force yourself to stop feeling jealous. You can believe that a sensory experience is deceptive, even if you can't stop seeing a deceptive image (optical illusions like 3-D images are examples of this—you *believe* a surface is flat, but you don't *see it as* flat).

Sensations and emotions are distinct, though, when it comes to their subject matters. Sensory experience seems to pull our attention outside of ourselves to focus on what the world is like. If you see a red wall, you have evidence that the wall is red. Emotions, on the other hand, tend to be responses to sensory experiences, and they are more about us than about the world. If you see your ex- with someone else, you may begin to feel jealous. But your jealousy is not directly a judgment about the world outside your mind; it is a response to a situation that you interpret as painful. Jealousy reveals something about you, not the world. Maybe your ex is simply having lunch with a co-worker or friend. Maybe they're helping a stranger and not in a romantic relationship with that person. Emotion can motivate a judgment about your inner experience, but it is not necessarily about the world outside that experience.

These distinctions are especially important when reasoning about moral questions. We may come to feel sorrow at the way certain animals are forced to live, for instance, caged in zoos without the freedom of their natural environments. This sorrow might suggest that it is *wrong* to keep animals in zoos. But upon reflection, we can recognize that some zoos are incredibly humane, giving previously injured animals safety from predators, medical treatment, and an ample food supply. Our sorrow, we come to realize, is more about our interpretation of the situation than the situation outside our minds.

Although emotions and sensory experience have a lot in common and both can be mistaken, sensory experience seems to have a better track record of presenting reliable information than emotions. For this reason, we leave emotions off of our list of basic sources of evidence.

## Getting familiar with … evidence

**A. To the best of your ability, provide two pieces of evidence for each of the following claims, regardless of whether you think they are true (some of them aren't). Search the internet if you need to. If you cannot find any particular evidence, try to make it up. Identify whether the evidence you find is direct or indirect (and for whom).**

1. <The Sun's distance from the Earth is about 92,960,000 miles.>
2. <Rust on metal is caused by a substance that is trapped in the metal and released with moisture.>
3. <Your calculator is right that 2 + 2 = 4.>
4. <There is E. coli in your intestines.>
5. <Men have never walked on the moon.>
6. <Jack the Ripper likely was a surgeon.>
7. <The words on this page are black.>
8. <There is not an elephant sitting next to you.>
9. <The atomic mass of a hydrogen-1 atom is smaller than the atomic mass of a carbon-12 atom.>
10. <The information in the previous question came from Wikipedia.>
11. <The world has a large amount of suffering.>
12. <Your calculator is a reliable source of evidence about basic arithmetic calculations.>
13. <Your calculation is not a reliable source of evidence about the authorship of ancient texts.>

14. <Wikipedia is a more reliable source of evidence about history than your history textbook.>
15. <You are older than all your siblings.>

**A bit more difficult:**

16. <An all-knowing, all-powerful, all-good god exists.>
17. <O. J. Simpson killed two people.>
18. <Bread will nourish you the next time you eat it.>
19. <Humans and chimpanzees evolved from a common ancestor.>
20. <There are no words on this page.>

**B. Identify each of the following as either a sense experience or an emotional experience (or as a combination or as a different sort of experience altogether).**

1. seeing red
2. feeling sad
3. feeling something sharp
4. feeling hot
5. touching something soft
6. smelling something burnt
7. tasting something sweet
8. feeling bitterness
9. hearing something hurtful
10. hearing a loud clanging

**A bit more difficult: (explain your responses)**

11. smelling something that reminds you of being a child
12. remembering feeling sad
13. feeling the location of your hand without moving it
14. recognizing that you don't believe in Santa Claus
15. understanding that three plus five is eight
16. feeling the temperature drop
17. feeling that it is about to rain
18. tasting your favorite food
19. thinking about your (long deceased) childhood pet
20. imagining a character in a novel

## Arguments

In an argument, one or more claims are used to support the truth of another claim. *Support* could mean several different things. It might mean *logical* *entailment*, *makes probable*, *is evidence for*, or *provides a good reason for*. Since this is a critical thinking book, we are interested in evaluating the truth value of our beliefs, so we will talk about support in terms of *evidence*, and allow that some evidence is logical, some is probabilistic, and some includes reasons that are weaker than these.

As we have seen, claims can be either true or false, and evidence suggests that some claims are true and others are false. So, there is a general normative presumption that whether we should believe a claim depends on how good our evidence for that claim is. Arguments help us organize claims so we can see clearly how well our evidence supports a claim.

Any time we make a claim and then attempt to support that claim with another claim or claims, we are, for better or worse, arguing. The ability to construct arguments distinguishes critical thinkers from creatures who depend solely on stimulus-response mechanisms for their rational capacities—creatures like invertebrates, infants, and computers. To influence invertebrates' and infants' behaviors, we have to engage in some form of conditioning, whether positive or negative, operant or classical. We cannot reason with them. The same goes for computers; computers must be programmed, and they only do what they are programmed to do. But with rational creatures, we can influence both behaviors and beliefs by appealing to reasons; we can *argue* with them. We can do this well, using the principles of good reasoning in the appropriate contexts with strong evidence, or we can do it poorly, with rhetorical and logical fallacies. Whether critical thinkers argue well or poorly, they are, nevertheless, arguing. So, our definition of argument is as follows.

**An argument is:**

1. **one or more claims, called a *premise* (or *premises*),**
2. **intended to support the truth**
3. **of a claim, called the *conclusion*.**

A **conclusion** is a claim in need of support by evidence. **Premises**, along with the overall structure of the argument, are the claims that support the conclusion. There is at least one premise and only one conclusion in a complete argument, and arguments often have more than one premise.

Pay special note to part (2) of this definition. A set of claims is an argument if someone *intends* it to be an argument. Sometimes people express themselves in ways that are not arguments, for instance:

> "We all went to the store today. We bought candy. We went home right afterward. We went to sleep. Brit slept the longest. Farjad got sick."

This is not an argument, but a narrative (a story) composed of claims. It has a logical structure in the sense that narratives have a coherent order—each event naturally or intuitively follows the previous event. But it does not have a logical structure in the argumentative sense—there is no indication that any one of these claims supports (or is intended to support) the truth of any other.

Sometimes people attempt or intend to support a conclusion but do it poorly. For instance:

> "The sky is blue. And the grass is green. Therefore, the fool is on the hill at midnight."

The word "therefore" (as we will see in later in this chapter) tells us that the author intends the claim to be supported by the previous claims—it is not simply supposed to follow them chronologically, it is supposed to follow *from* them *logically*.

Since the person making these claims *expects* you to believe something (specifically, <The fool is on the hill at midnight>) on the basis of other claims (<The sky is blue> and <The grass is green>), this is an argument. Of course, this is obviously a bad argument, even if you can't yet explain *why* it is bad. We will get to that. The point here is simply that *bad arguments are still arguments*. We can identify them, evaluate them, and show why they are bad using the tools you are learning in this book.

One of the main reasons to treat bad arguments as arguments is called **the principle of charity**, which states that one should always begin an argument by giving a person the benefit of the doubt. This is because what sometimes seem like poorly supported or silly-sounding claims turn out to be true! Think of the "silly" idea that the earth revolves around the sun (as opposed to the opposite) or that germs spread disease (as opposed to miasma). Both beliefs were largely dismissed until the evidence was too strong to ignore. In addition—hold on, now—*you* might be wrong even about things you believe very strongly. (We know. It's hard. Take deep breaths.) We've all been wrong before. And it might turn out that someone's argument for a claim that you don't believe is *much better than* any arguments you can come up with for your contrary belief. So, take people's claims seriously—at least until you evaluate them.

The principle of charity also says that one should try to give "the most charitable reading to" someone's argument (thus the *charity* part of the principle) by making implicit claims explicit, clarifying unclear terms, and adding any premises that would strengthen the argument. Since we are finite creatures and do not know everything, it is not always obvious when an argument is bad. In addition, just because a person disagrees with you does not mean her argument is bad. Once you've made the argument as strong as it can possibly be, then you can evaluate precisely how strong it is.

The idea here is that you are only rational in believing a claim if you have been responsible enough to consider the evidence against that claim. This is a bit too strong; we rarely consider the evidence *against* going to the grocery store when deciding whether we should (unless it's rush hour or it's snowing) or the evidence against taking a flight to a conference when deciding how to get there (unless it's a holiday, or it's just a few hours' drive). Yet, in both cases, our beliefs are probably rational, or, at least they are probably not *ir*rational. Nevertheless, having good reasons is an important feature of rationality, and the *possibility* that you are wrong is a reason for adopting the principle of charity.

Another reason to adopt the principle of charity is that it will help you refute your opponents' claims when they aren't well supported. If you are not aware of your opponents' reasons or have not considered them carefully, you will be unable to respond clearly and forcefully when faced with them. For this reason, we like to call the principle of charity *The Godfather Principle*. In the film *The Godfather: Part II* (1974) the protagonist, Michael Corleone tells one of his caporegimes (captains), Frank Pentangeli:

> My father taught me many things … . He taught me: Keep your friends close, and your enemies closer.

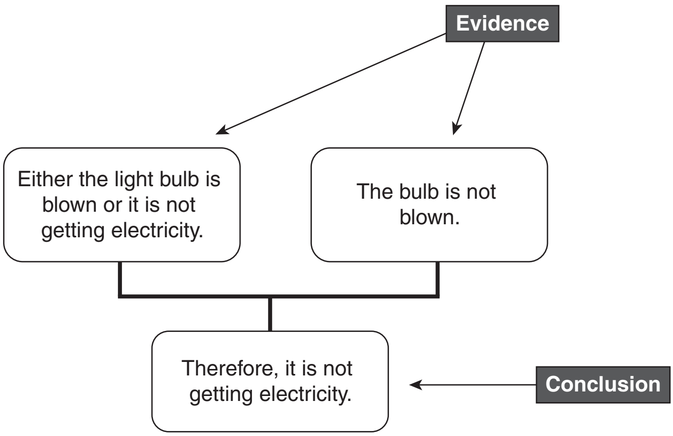
The idea is that, if you do not know what your opponents are thinking, you will not be able to respond adequately.

Part (2) of our definition of an argument also says that premises support the *truth* of a conclusion. Not all reasons to believe a claim have to do with truth, so some definitions of argument may leave this out. For instance, some reasons might be **practical reasons** or **normative reasons**: It might be *better for you*, or *more useful to you*, or *more helpful for others to believe* something that is false. It is perfectly reasonable to call practical reasons "arguments." In this book, however, we are interested primarily in helping you evaluate what the world is really like—we are interested in thinking critically about what is true. And even practical reasons are subject to truth questions: Is it *true* that one belief is more useful to you than another? Similarly, normative reasons—claims about what should (morally or legally or socially) be done, or what I ought to do—are true or false of the world. So, for our purposes, an argument involves premises that are intended to support the *truth* of a conclusion.

With those qualifications in place, consider an example of an argument. Imagine you walk into your bedroom and find that the light bulb in one of your lamps will not come on when you turn the switch. In this scenario, let's say that there are *only two possible explanations* for why the light bulb will not come on:

> Either the light bulb is blown or it is not getting electricity. (Premise 1)

**Figure 1.4** The Light Bulb Problem




With this in mind, you investigate to see whether the bulb is blown, for instance, you try it in several different lamps. You might have instead chosen to test the socket, say, with another bulb or a meter. But let's stick with the bulb. Suppose you try it in another lamp, and it works perfectly. Now, by the evidence of your senses and what it means for a light bulb to work properly, you are justified in believing:

> The bulb is not blown. (Premise 2)

Given premises 1 and 2, you may now infer the claim:

> The light bulb is not getting electricity. (Conclusion)

This argument is illustrated in Figure 1.4.

Your first piece of evidence (premise 1) is a combination of logical and sensory evidence: Given your sensory experience with how bulbs work, there are only two states of affairs that could explain why the bulb doesn't light when you turn the knob. Your second piece of evidence (premise 2) is sensory: You tested the bulb and saw that it is not blown. From this evidence, you can conclude that the bulb was not getting electricity (you'll see precisely why you can draw this conclusion in Chapters 4 and 5).

Now, what if the bulb did not work in any other lamp? What conclusion could you draw? Do you have a reason to believe the socket has electricity?

> Either the light bulb is blown or it is not getting electricity.
>
> The bulb is blown.
>
> Therefore, the light bulb is getting electricity?

Not on this evidence alone—it could also be that the breaker for that outlet is tripped or that the socket is bad. To find out whether the socket has electricity, you would need to know whether other, properly functioning bulbs work in that socket.

So, from the fact that the bulb is not blown, you *can* conclude that it was originally not getting electricity. But from the evidence that the bulb is blown, you *cannot* conclude with any confidence that the socket has electricity.

Here are two more examples of arguments. Note how the premises are intended to provide support for their conclusions:

Premise 1: Ticks wait to attach onto an unsuspecting back or leg.

Premise 2: Anything that does that is insidious.

Conclusion: Therefore, ticks are insidious.

Premise 1: Harry is taller than Sarah.

Premise 2: John is taller than Harry.

Premise 3: If John is taller than Harry, then John is taller than Sarah.

Conclusion: So, John is taller than Sarah.

## Getting familiar with … arguments

**For each of the following sets of sentences, identify whether it is most likely intended as an argument or as something else (a narrative, list, or informational statement). If it is intended as an argument, try to identify the premises and conclusion.**

1. "There is a stain on this rug. The dog was the only one in this room today, and the rug wasn't stained last night. So, the dog must have stained the rug."
2. "Soldiers are the backbone of this country. They stand for the freedom we respect so highly. I support soldiers."
3. "There's a concert on Tuesday. We're going to a party on Wednesday. And I have a work function on Thursday night. I wish I had more time in my week."
4. "There are only two options on the ballot: Republican and Democrat. You're not one of those liberal Democrats. So, you can only vote Republican."
5. "We left early, around 8 PM, and went to Sue's house. Immediately after that, we went to open mic night at the café. By the time we left, got gas, and got home, it was after midnight."
6. "We left early, around 8 PM, and went to Sue's house. Immediately after that, we went to open mic night at the café. By the time we left,

got gas, and got home, it was after midnight. So, there is no way you could have seen us at the restaurant at 9:30."

7. "She's 21, she has an excellent driving record, and she doesn't drink. It is safe to trust her with your car."
8. "We only need three things from the store: arugula, butter, and a bag of potatoes."
9. "After the sermon, Reverend Harris drove home and found his front door open. He was astonished to find that nothing was out of place. He surmised that he simply forgot to close the door when he left."
10. "There is a standard protocol for politicians in this situation. They simply change the subject and act as though they are being unfairly accused. This is not the way responsible leaders act."
11. "There is a long line of railroad workers in my family. On my dad's side, they stretch back to the early 1800s. On my mom's side, they go back to the 1840s."
12. "We can trust that the ancient text is reliable. Several linguists trace its writing patterns to the time it claims to have been written. Historians have identified other texts that corroborate the story. Plus, according to classicists, no one in the ancient world seems to doubt its authenticity."
13. "The story he told was a long one. First, he explained every detail of his childhood home. Then, he described his extensive family lineage. And what seemed to take the longest is when he began describing all his childhood pets."
14. "When she left this morning, I told her take three things: her umbrella, her book bag, and her lunch. She forgot all three."
15. "Detective Rogan carefully sifted all the evidence before finding what he was looking for. The bellhop was the only person with motive, but there was no evidence. But now he knew that the gun in the bellhop's locker fired the bullet that killed the victim. Since there were no other suspects, Rogan concluded that it must have been the bellhop."
16. "It was the bellhop. I know because the victim was shot with the gun found in the bellhop's locker, the bellhop had motive to kill the victim, and there are no other potential suspects."
17. "Don't you remember? I told you I only want three things for Christmas: a computer, a wool sweater, and new music for my Kindle. Jamie remembers; he can tell you."
18. "One way to argue that the Big Bang occurred is to point to the inflation of the universe and to the background microwave radiation."
19. "Yes, you should believe that the Big Bang explains our universe. Edwin Hubble discovered that all galaxies are moving away from one another, which suggests that the universe is inflating. And Arno Penzias and Robert Wilson discovered the cosmic microwave

background that documents much, much earlier stages of the universe's development that explain today's stars and galaxies, which suggests that the energy in the universe used to be much more dense than today."

20. "There are only three ingredients needed for making good Scotch: water, barley, and yeast. These are then aged in oak barrels for several years."

## Identifying Arguments

Before we can evaluate an argument (the subject of the next chapter), we must clearly identify it. Perhaps you recall writing persuasive papers or giving argumentative speeches in high school or college. In those papers and speeches, you had a thesis statement or topic sentence you had to defend or explain. The thesis statement/topic sentence was essentially your argument's conclusion, while your defense/explanation was your argument's premises. Also, your teacher likely had you state your conclusion first, then go on to support your conclusion. This is how you will often find arguments structured in books, magazines, or newspapers. But they are not always packaged this way. Sometimes, an author will leave you hanging until the end, for effect. Sometimes, an author is careless, and you can't quite figure out what the conclusion is supposed to be. Since arguments are packaged in many different ways, we need some tools for picking out conclusions and premises.

The simplest first step in identifying an argument is to pick out the conclusion. The basic goal of an argument is to *convince or persuade* others of the truth of some claim. So, if someone made the above argument about the light bulb and lamp, presumably they would want others to be convinced or persuaded that the bulb is not getting electricity (for instance, the maintenance superintendent of their building). The same goes for "Ticks certainly are insidious." The speaker making those claims wants others to be convinced of their truth.

So, step one, ask yourself: "Is the author/speaker trying to convince me that some claim is true?" If the answer is yes, you've found an argument. The next step is to ask, "What claim, *exactly*, is this person trying to persuade me to accept?" Remember, the claim you're being asked to accept is the conclusion.

Conclusions can often be identified by **indicating words or phrases**. Consider this argument:

> Daily cocaine use causes brain damage. Brain damage is bad for you.
> **Therefore**, daily cocaine use is bad for you.

In this example, the word "therefore" indicates that the claim following it is the conclusion of an argument. The claim <Daily cocaine use is bad for you> is the conclusion. Not all arguments will have indicating words. For example, if we remove the "therefore" from the cocaine argument and change the order of the claims, as long as the speaker/writer intends it to be an argument, it remains an argument and <Daily cocaine use is bad for you> remains the conclusion:

> Daily cocaine use is bad for you. Daily cocaine use causes brain damage.
> Brain damage is bad for you.

But in this case, it is less clear that the author intends this as an argument. Thankfully, there are often conclusion indicating words or phrases. Here are some common examples:

**Common Conclusion-Indicating Words and Phrases:**
Hence; Thus; Therefore; So; So that; This shows us that; We may conclude/deduce/infer that; Entails; Implies; Consequently; It follows that; It must be the case that

Once you have identified that a set of claims is an argument and you have clearly identified the conclusion, step three is to ask, "What claims are being offered in support of the conclusion?" The claim or claims supporting the truth of the conclusion are the premises. As with conclusions, premises are sometimes accompanied by indicating words or phrases. For instance:

> Because the water trail leads to the sink, the sink is leaking.

In this argument, the word "because" indicates that the claim immediately following it is a premise. English grammar gives us a clue about the conclusion. The sentence would be incomplete (a fragment) without more information; it is a dependent (or "subordinate") clause in need of an independent clause to complete the thought:

> Because the water leads to the sink.

Though <The water trail leads to the sink> is a simple claim and, by itself, an independent clause, the addition of "because" changes the grammar and lets you know it is evidence for something, which, in this case, is that <The sink is leaking>. What claim are we supposed to accept? That the sink is leaking. What supports this claim? The water trail leads to the sink. Here are some additional premise indicating words and phrases:

**Common Premise-Indicating Words and Phrases:**
Because; Since; For; For the reason that; As; Due to the fact that; Given that; In that; It may be concluded from

Conclusions and premises can be found anywhere among a set of claims presented to a person; the conclusion could come first, it could be couched in the middle of a set of premises, or it could be the last thing someone says. Consider these examples:

## Examples of premise- and conclusion-indicating phrases:

1. Bill says, "That nuclear power plant is not good for our city." He wants you to be convinced of the truth of this claim, and so do you. So, you ask him to support this claim. He argues as follows:

"That nuclear power plant is not good for the city …" (conclusion) because "it emits large amounts of radiation" (premise) and "that's not good for the city" (premise).

Now you have a piece of reasoning you both can work with.

2. Sally says, "Johnny is not the killer." She wants you to be convinced of the truth of this claim, and so do you. So, you ask her to support this claim with other claims: you ask for her argument. She goes on:

"If Johnny were the killer, then there would have been powder residue on his hands right after" (premise). "The police checked his hands, and there was no residue" (premise). So, "Johnny is not the killer" (conclusion).

Again, now you have a piece of reasoning that both of you can evaluate.

## Getting familiar with … identifying arguments

**For each of the following arguments, identify the conclusion and premises, underlining any indicating words and phrases you find.**

1. "The project has been unsuccessful, and there is no hope that it will be successful. And the money we are spending on it could be used better somewhere else. If these things are true, you should cut the program. Therefore, you should cut the program."
2. "If there is some evidence of misconduct, you should investigate it. And since you now have some evidence, you should investigate."

3. "In light of the fact that the first three experiments showed no positive results, and since the fourth experiment showed only slightly positive results, we must conclude that the drug is not effective for treating that illness. This is because experiments with drugs that do not yield overwhelmingly positive results suggest that those drugs are not effective."
4. "Foreign policy is our number one concern. The incumbent has shown us time and again that he does not fully understand foreign policy. Mr. Brant, on the other hand, has extensive experience in foreign policy offices all over the world. Only someone who understands foreign policy is a rational choice. And since Mr. Brant is the only other candidate, Brant is the only rational choice."
5. "There are three reasons you should not vote for candidate Williams. She is caustic and mean. She is lazy and irresponsible. And she has no experience managing people. You should not vote for people with these qualities."
6. "I know you think the Supreme Court's recent decision is sexist against women. But consider that none of the justices cited gender as a reason for his or her decision. Plus, many women support the ruling, which means they do not find it sexist. If there is no evidence for sexism, you should not believe the decision is sexist."
7. "There are many people who were concerned that Descartes had become a Protestant sympathizer. In addition, he threatened the standard educational practices in the Jesuit universities. Anyone who raises such concerns could be a target for assassination. Therefore, it isn't unreasonable to believe he was poisoned."
8. "I know you think your free-throw shooting runs hot and cold, but your so-called streaks do not exceed the expectations of pure chance. If chance is the culprit, all your pre-game rituals are just wastes of energy. If they are wastes of energy, you shouldn't do them. Hence, you shouldn't do them."
9. "[Women's] inferiority [to men] is so obvious that no one can contest it for a moment. … All psychologists who have studied the intelligence of women, as well as poets and novelists, recognize today that they represent the most inferior forms of human evolution and that they are closer to children and savages than to an adult, civilized man. They excel in fickleness, inconstancy, absence of thought and logic, and incapacity to reason" (from social psychologist Gustave Le Bon, 1879).
10. "After proper correction of the data, women have slightly larger brains than men. Those with larger brains have better prospects for education and success. Therefore, women are intellectually superior to men" (adapted from an argument by Maria Montessori, 1913).

## Exercises

**A. Identify whether the following claims are simple or complex. If it is complex, identify which operator is being used. If more than one operator is used, identify the major operator.**

1. <That is not a toaster.>
2. <That woman is good and just.>
3. <She's either with us or against us.>
4. <The state of national security in this country is deplorable.>
5. <Oil prices dropped today by seven dollars and foreign markets rose.>
6. <If Reina wants to go to the movies and he's broke, then he will have to borrow money from me or Pedro.>
7. <Either we keep health care private or the government will become socialist.>
8. <It will not work.>
9. <He's a keeper.>
10. <The person in black is dancing with me.>
11. <The report from the Center for Disease Control will be released on Tuesday of next week.>
12. <If there are seven winners, and all of them are men, then we have to do a recount.>
13. <There are seven dwarves and one lady living in one house, or else I am seriously misreading this situation.>
14. <Either there isn't any room left in the inn or that guy is being a real jerk.>
15. <The dog will go outside every hour if and only if it is not thunder storming and I give him a treat.>
16. <Politicians are greedy and deceitful, and we either have to give up democracy or accept corruption.>
17. <The cat is on the mat if and only if there is a cat, and there is a mat, and the cat is on the mat.>
18. <If the polls are correct, then tomorrow night, we will have a new mayor, and she will be from Poughkeepsie.>
19. <Either the standards of good journalism are lower than ever, and the media panders to ratings, or the amount of newsworthy material is surprisingly low.>
20. <There will be four cars and three trucks on the lot in the morning if and only if the paperwork is signed and the payment successfully transferred into the account.>

**B. In each of the following arguments, identify whether the evidence offered is direct or indirect and explain your answer.**

1. Of course she knows how to cook. Remember, she took all those cooking classes.

2. The test results indicate you have a bacterial infection.
3. Look there (pointing). The hot-air balloon looks like a big eye.
4. Any number greater than two is also greater than one. That's part of what it means to be greater than two.
5. This candle is lemon-scented. Just smell it.
6. The weather forecaster said it is going to rain today. Therefore, I'm taking my rain jacket.
7. Did you see that report on CNN last night? The commentator said that violence is escalating in the Middle East. Man, it must be tough over there.
8. If Bill is taller than Sue and Sue is taller than Dave, then of course Bill is taller than Dave.
9. Every other time you have taken Tylenol it has reduced your pain. So, if you're in pain, you should take Tylenol.
10. I remember that when I was a kid, gasoline was much less expensive.

**C. Locate the conclusion and premises in each of the following arguments by asking the questions:**

- **What claim, exactly, am I being encouraged to believe? (What is the conclusion?)**
- **What claims are supposed to be doing the encouraging? (What are the premises?)**

**Some will have indicating words or phrases, and some will not.**

1. "There's no stamp on that envelope. The Post Office won't deliver it. The Post Office delivers only if there's a stamp."
2. "He obviously did not do it, because, if he had, then the door would be open; and it's not."
3. "That's illegal, and you should not do something if it's illegal. So, you shouldn't do it."
4. "Since he has to go, and since, if he has to go, then you have to go, I guess, therefore, that you have to go."
5. "That my daughter scuffed up the gym floor with black-soled shoes is false for the following reasons: she has never been to that gym and she does not own black-soled shoes."
6. "Sally's name is on the inside of the bag, and the bag smells of the same perfume Sally wears. These wouldn't be true if Sally wasn't there. This shows us that Sally was there."
7. "John likely trains. Most professional athletes have to train. John is definitely a pro athlete."
8. "In several studies, drinking green tea has been shown to improve your health. My health will likely improve because I drink green tea."
9. "Christians are monotheists. Catholics are monotheists. Catholics are Christians."

10. "You're either a sheep or a critical thinker, and you're no sheep; so, you're a critical thinker."
11. "God exists provided there is no evil. God does not exist. There is evil everywhere."
12. "Because an expert says this drug will ease my pain, and because other people tell me it relieved their pain, I believe this drug will ease my pain."
13. "We can conclude that the butler did it, since either the butler or the driver did it. And, we know the driver didn't do it."
14. "Your shoes are muddy. Your hair is wet. If you were not out in the garden in the rain, your shoes wouldn't be muddy, and your hair wouldn't be wet. Hence, you were out in the garden in the rain.
15. "If I think, then I exist. I think. Therefore, I exist." (adapted from René Descartes)

**A bit more difficult:**

16. "Either Plato or Democritus believed in the theory of forms. Plato believed in the theory of forms only if he was not an atomist. Democritus was an atomist only if he did not believe in the theory forms. Democritus was an atomist. Hence, Plato was an atomist."
17. "I don't stud enough. That's because, if I smoke or drink too much, then I don't sleep well. And if I don't sleep well, then I feel rotten. And, of course, if I feel rotten, I don't exercise, and I don't study enough. And I do smoke too much."
18. "The Bible is not literally true. If the Bible is literally true, then Earth was created in six days. If Earth was created in six days, then carbon dating techniques are useless, and scientists are frauds. Scientists are not frauds."
19. "If God changes, then he changes for the worse or the better. If he changes for the better, then he isn't perfect. If he's perfect, then he doesn't change for the worse. Therefore, if God is perfect, then he doesn't change."
20. "What *is not* cannot be spoken of because there is nothing to speak of. What *is* cannot come to be or cease to be, since in either case, it would be what is not. What *is not* is nothing and cannot be something. Therefore, what *is* exists eternally, unchanging." (adapted from Parmenides)

**D. Using the material from this chapter, answer the following questions about evidence.**

1. Explain what evidence is without using examples.
2. Explain two types of direct evidence, and explain the difference between direct and indirect evidence.

3. Explain two types of indirect evidence, and give an example of when indirect evidence is stronger than direct evidence.
4. Explain what features sense experience and emotional experience have in common.
5. How do emotions differ from sense experiences?
6. Why do philosophers generally think that emotion is an *unreliable* source of evidence?
7. Explain one reason for thinking that emotions should not be completely excluded from critical thinking.
8. Which of the following is an example of direct evidence that a ball is red?
   a. Seeing that the ball is red.
   b. Reading that the ball is read.
   c. Hearing someone say the ball is red.
   d. Remembering the ball is red.
9. Which of the following is an example of indirect evidence that your cat just meowed?
   a. Hearing a recording of your cat meowing.
   b. Remembering your cat meowing.
   c. Hearing your cat meowing.
   d. (a) and (b)
10. Which of the following is an example of an emotional experience?
   a. Feeling hot.
   b. Feeling the hair on your leg.
   c. Feeling sad.
   d. Feeling the tension in your neck.

**E. Given the problems with appealing to emotions as evidence, explain how you might respond to each of the following phrases if someone introduced them in an argument. Identify which claim or sentiment might constitute an emotion or appeal to emotions; explain whether this sort of emotion constitutes a legitimate source of support for the claim or appeal.**

1. "What do you mean you don't favor the education tax? How could you be so callous as not to care that our children get a good education?"
2. "The Eagle is a symbol of strength and courage. As an emblem of the United States, it represents our strength and courage as a nation."
3. "You'd better start reducing your carbon emissions. You don't want the world to end in economic catastrophe do you?"
4. "You shouldn't be so dogmatically against torture of terrorist suspects. There is widespread disagreement about its effectiveness."
5. "You should reconsider your opposition to forced sterilization of the

mentally handicapped. The Nazis thought it was a natural implication of Darwinian evolution, and the United States practiced it for many years in the 20th century."

## Real-Life Examples

# 1. A Grisly Crime Scene

Chief Gresham arrived quickly on the scene of the murders. Officers had already roped off the area but hadn't disturbed any of the evidence. Gresham wandered through the carnage, attempting to determine what happened. On one side of the room lay three bodies near one another, two men and one woman, all fully clothed. Laid across the two men was a steel flagpole with a black obelisk on top. The hands of the two men were bound and each had a single gunshot in the back of his head. The woman's hands were unbound and the wound was in her temple. Across the room was another body, a man, with a large stab wound in his stomach and a gun in his left hand. No knife could be seen. The only other items in the room were a couch, a desk chair, a gallon of bleach, a can of white paint, and an empty bookshelf. Chief Gresham quickly concluded that no one outside the room was responsible; the crimes were committed by one or more of the deceased.

Gresham has been called to court to testify about his conclusion and he needs your help writing his report.

1. **Using only the evidence available to you, construct an account of the events leading to the deaths in the room.** Identify the relevant evidence and what type of evidence it is. Note: An account is not an argument; it is simply a series of meaningfully connected claims that explain an event or set of events. An explanation can be used in an argument, as we will see.
2. **Using appropriate premise or conclusion indicating words and phrases, construct an argument for Gresham that has the following complex claim as its conclusion:**
   <The woman killed the two bound men and the man with the gun, and the man with the gun killed the woman.>
3. **Construct an argument for Gresham that has the following, alternative conclusion:**

<The man with the gun killed the two bound men and the woman, but the woman killed the man with the gun.>

## 2. The Emotional Topic of Abortion

**Jen and Abby are arguing about the particularly sensitive issue of abortion. Jen doesn't think abortions are morally permissible, while Abby thinks they are permissible in many cases. Unfortunately, both make mistakes when defending their views. Consider the following fragment of the conversation between Jen and Abby, and *regardless of whether you agree with any of their arguments*, evaluate their positions *according to whether they appropriately appeal to experience and emotion*.**

**Jen:** In general, people rightly think it is wrong to kill humans who haven't done anything wrong. A fetus is simply an unborn human, so there is a burden of proof that isn't met when you say that abortion is permissible.

**Abby:** I don't need a burden of proof; all I need is my life. My life would be infinitely more complicated and difficult if I were forced by law to complete the pregnancy.

**Jen:** It sounds like you're saying that your own inconvenience overrides a fetus's right to life. Does this hold in every instance? If it is less convenient for me to work twenty years for a house, can I just kill someone who already owns one?

**Abby:** Of course not. I don't mean that inconvenience justifies murder. I just don't feel that abortion is murder. I mean, for the first four weeks, an embryo is just a clump of cells; it doesn't *look* anything like a human being.

**Jen:** Let's take that for granted for a moment. What do you say about abortion *after* four weeks, when it *does* look like a human being, and actually invokes many parental feelings (in both men and women) who see pictures of eight and ten-week-old fetuses? These feelings tell us that the fetus is a valuable human being.

**Abby:** I say those people are just letting their emotions get the better of them. Just because something looks like it is morally valuable, or makes you feel all fuzzy inside, doesn't mean it is. I think a woman has the right to do whatever she wants with her body, including getting an abortion.

**Jen:** But doesn't the law disagree with you now that Roe v. Wade has been overturned by the Supreme Court? Is there still a "right" to abortion?

**Abby:** We cannot confuse law and ethics. That's a red herring fallacy. Laws are supposed to protect rights, but sometimes they don't. If you remember, Jim Crowe laws that required the separation of people of different skin colors in public were bad laws. They violated rights. I think the Supreme Court was wrong in the case of Roe v. Wade, and it doesn't change the moral argument.

**Jen:** Okay. Even if that is true, you just said that a being doesn't have a moral right to life before four weeks *because it doesn't look* like a human being with a right to life. And anyway, a woman doesn't have the right to do just anything she wants with her body, like block someone's driveway indefinitely or take off all her clothes in a public place or sell her organs.

**Abby:** But you think fetuses are "people" with "rights." How do you know?

**Jen:** When I see those pictures of aborted fetuses, I can just feel that it's true.

# Evaluating arguments

# 2

In this chapter: We expand on our discussion of how to identify arguments. We explain how to reconstruct an argument from contexts that have extraneous material, buzz words and phrases, and incomplete information. We explain how to rephrase vague and ambiguous language to clarify the claims used in arguments. At the end, we distinguish inductive from deductive arguments.

Once you've located an argument, it is time to reconstruct it. Arguments are typically found embedded in paragraphs with other, irrelevant information. They are found in complex orations made by politicians on TV, and in disjointed conversations around the table at a bar. In order to clearly evaluate an argument, it must be extracted from this rhetorical clutter and verbiage. *Reconstructing an argument* involves stripping away everything that is not absolutely necessary to the argument and then arranging the claims so that the premises are clearly distinguishable from conclusion.

## Extraneous Material

**Extraneous material** is anything in a passage that does not do rational work in an argument, that is, words or phrases that do not play a role in a premise or the conclusion. Extraneous material makes natural languages rhythmic and rich and explains why *Moby Dick* is a classic and most dime store romances aren't. Consider this beautiful passage from the book of Proverbs:

> My son, if you receive my words and treasure up my commandments with you, making your ear attentive to wisdom and inclining your heart to understanding; yes, if you call out for insight and raise your voice for understanding, if you seek it like silver and search for it as for hidden treasures, then you will understand the fear of the LORD and find the knowledge of God. (Proverbs 2:1–5, English Standard Version)

Logically, this passage expresses an uncomplicated conditional claim:

> If you act wisely and diligently seek knowledge, then you will know God.

Everything else is extraneous. But the extraneous material makes a simple idea very poetic. The author's point is not to argue, but to evoke a certain sort of emotional attitude. If we wanted to argue about the conditional, we would first need to strip away the extraneous material.

Sometimes, instead of making a passage beautiful, extraneous material gets in the way; it *occludes* meaning rather than revealing it. Governmental language can be some of the worst. Writing guru William Zinsser tells the story of a US government document from 1942 explaining preparations to be made for blackouts during air raid drills.[1] In 1942, the United States had recently entered World War II, and there was a worry about enemy air raids. To protect people from raids at night, President Franklin Roosevelt called for "blacking out" all windows in factories so light would not shine through, turning them into easy targets. But someone else wrote the order, and they were less than clear about it:

> Such preparations shall be made as will completely obscure all Federal buildings and non-Federal buildings occupied by the Federal government during an air raid for any period of time from visibility by reason of internal or external illumination.

This sentence is ungainly and difficult to understand. With commendable insight, President Roosevelt responded, "Tell them that in buildings where they have to keep the work going to put something across the windows." Roosevelt removed the extraneous material to make the order clearer. We might put it even more simply as a conditional:

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[1]William Zinsser, *On Writing Well*, 25th Anniversary Edition (New York: HarperCollins, 2001), p. 8.

> If you are working through the night, then cover the windows to prevent light from shining through.

Here are some common categories of extraneous material you will want to remove when reconstructing an argument:

## Types of Extraneous Material

**(1) Set up or background phrases:**

Once again …; It pains me to have to relate to you …; To begin …; Let me just say a few words about …; X was born on February …; Let me give it to you straight …; It has recently come to my attention …; Stop me if you've heard this …; As you are well aware …; etc.

**(2) Expressions of personal feeling or commentary:**

It happens over and over …; Some of the worst X …; … X rears its ugly head …; It's pretty obvious …; It should be clear that …; No one could doubt…; I can't believe …; You know, it's really frustrating when …; It's really sad that …; Descartes was a great philosopher who …; I would like to propose that …; Unfortunately, …; Happily, …; etc.

**(3) Transition phrases:**

In addition …; … which leads me to my next point …; On one hand … , on the other hand …; … insofar as …; … naturally …; … of course …; Didn't you know, …; You know, …; That raises the question …; … which leads us to ask …; …which raises another point …; etc.

In addition to making meaning poetic and cumbersome, extraneous material can be used to make audiences feel like there is meaning when there is none. Leaders of organizations have a nasty talent for stringing together extraneous material without saying much of anything at all. You can construct whole presentations out of extraneous material without conveying any information at all. Imagine being welcomed into an organization with the following speech:

> I would like to begin our time together by welcoming our newcomers. We are sincerely looking forward to getting to know you all and to sharing with one another our knowledge and abilities so we can move ahead and be the best we can be. In addition, I look forward to hearing all your great new ideas and learning about the experiences you are bringing to the table. Of course, we have a long history of quality and achievement, and we're looking once again to the future; we're dreaming big so that our tradition of excellence

> will further extend our reputation into this community and into our world. Together, we can do anything.

In addition to the categories above, public speakers also introduce words or phrases that *seem* meaningful, even technical and academic, but that have no meaning at all. This is a type of extraneous material called “buzz words.” Buzz words sound interesting and informative, and in some contexts they may be meaningful, but they are often used in ways that prevent them from meaning anything clearly. Words and phrases like “synergy,” “freedom,” “crisis,” “rights,” “paradigm,” “holistic,” “robust,” “leverage,” “productivity,” and “think outside the box” have no clearly defined meaning outside of very particular contexts. In their book, *A Brief History of Liberty*, David Schmidtz and Jason Brennan identify at least *ten* different meanings of the word “freedom” that politicians use to gain support from audiences.[2] So, when buzz words are not explicitly defined in a particular context, they have only the pretense of meaning. Combining extraneous material and buzz words, you can make up exciting nonsense:

> Today, I invite you to embrace your potential for excellence! This year holds robust new opportunities, and by leveraging our efforts and thinking outside the box, we can achieve a synergy that propels us toward unprecedented success. We are starting a new initiative that will shift the paradigms of our industry in exciting and innovative ways. It is a holistic restructuring of our operational mindset. The face of culture is changing, and we’re changing with it, moving forward to meet our customers just where they need us the most.

Some call this “politispeak” or “politalk” or “businesspeak.” Good reasoners call it *nonsense*. There is no information in this passage. But it is tempting to think there is. You can imagine someone saying: “Hey, we should invest in this company.” And if you ask why, the response might include the passage’s jargon: “Because they are shifting the paradigms of the industry! They are meeting their customers where they need them!” What do these sentences mean? Who knows? We haven’t been told. When this happens, we have to demand that speakers define their terms.

If you cannot ask a speaker precisely what they mean (for instance, when this speech is given at a sales convention or on the internet), then you have a decision to make. You can ignore the claim and hope for the best, or you can stipulate definitions for the buzz words to try to make sense of the claim. If you choose the latter, it is important to acknowledge that you may be

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[2]David Schmidtz and Jason Brennan, *A Brief History of Liberty* (Malden, MA: Wiley-Blackwell, 2010), 6–14.

mistaken about your stipulated definition. To see how this might work, here's an example.

Imagine that you open a book on college success and you read the following:

> An important part of developing a career plan is understanding the difference between a job and a career …. In this context, a career is a high-performance job that requires postsecondary schooling and has the potential for advancement and a high economic salary, among other things.[3]

The author is trying to distinguish "career" from "job," and she explicitly qualifies the latter as "minimum wage job." This seems strange: many people who get paid by the hour make more than minimum wage. What about people who get paid on commission? Would these types of jobs be as attractive as a "career"? If not, does the author really mean to contrast "hourly job" with "salaried job"? Who knows? But let's stipulate for the sake of argument. We'll say that her distinction between a *career* and a *minimum wage job* really comes down to the difference between a *job with a salary* and a *job that pays by the hour* (also recognizing that jobs that pay on commission are a different category entirely).

Now, take note of several vague terms and phrases that occlude the meaning of this definition:

- high-performance
- postsecondary schooling
- potential for advancement
- high economic salary
- among other things

Here are some questions you might ask about these terms:

- What is a "high-performance" job? Is it one where you move a lot? Is it a musical career? You look in the index of the book and find nothing. You notice the term is used throughout the book without ever being defined. As it turns out, you could drop the word from the book and lose none of the meaning: it is truly extraneous.
- What is "postsecondary schooling"? Secondary education is high school, but what does postsecondary education have to do with a *high-performance* job? (Of course, we still don't know what *high-performance* means.) Does welding school count? EMT school? Is college alone good enough, or should one also go to graduate school? Why think all postsecondary schooling distinguishes a salaried job from an hourly job?

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[3]Lisa Fraser, *Making Your Mark*, 9th ed. (Toronto, ON: LDF Publishing, 2009), p. 3.

- What sort of advancement makes the difference between a salaried job and an hourly job? Presumably, employees in both receive raises, promotions, and increased benefits. What says *high-performance* about advancement? (The author does say that “a career has unlimited potential” whereas a “minimum wage job” has “limits.” But this is empirically false. All jobs have limits; very few corporate employees rise to the level of CEO, CFO, or COO; and some CEOs started as hourly workers.)
- What counts as a “high” economic salary? Relative to whom? We (Jamie and Rob) have met restaurant employees who make more per year than we do. But we have PhDs, and they don’t have college degrees. But if they did, would they have a high-performance job? (They sure do move a lot.) Does a local musician who plays regular gigs and doesn’t get paid by the hour have a “high-performance” job?
- Finally, the phrase “and other things” is about as uninformative as you can get.

This quick analysis shows that this definition of “career” is useless. It is not helpful for understanding what a career is, and it certainly does not help us distinguish it from a “minimum wage” job.

If we cannot distill any plausible meaning from a sentence or passage, or cannot distill any that the author would plausibly agree with, then we have a reason to think the claim is actually unclear. When these claims are used in arguments, whether as premises or conclusions, the arguments fail to be good arguments. Their conclusions do not deserve your assent because there is no clear relationship between the premises and the conclusion. We will say more about evaluating arguments at the end of this chapter. For now, beware of extraneous material, especially buzz words.

## Getting familiar with … extraneous material

**Rewrite each of the following sentences as claims, removing any extraneous material and identifying any buzz words that need to be defined.**

1. “Methodically, coldly, the salty wind scratched relentlessly against the old, stolid sea wall.”
2. “Our excellent and exciting new products will be on the shelves before you know it.”

3. "A vital aspect of any job is the ability to work well in a group and deal effectively with all personality types."[4]
4. "Our industry is in crisis. Now, more than ever, we need to pull together for the sake of the company."
5. "These are hard times, and we must all make sacrifices for the good of everyone."
6. "We need you to assess whether students are learning in your classes. Grades are not informative; we need qualitative measures that tell us whether your teaching methods are effective."
7. "You need to keep your standard of excellence high."
8. "It is what it is."
9. "I won't run if I don't believe that I have a vision and the leadership capacity to create a better future for our kids and a better future for this nation." Barack Obama[5]
10. "If we actually want to change this country and we want to move America the way it needs to move, we're going to have to do it, all of us, together. Instead of staying home and complaining, we're asking people to help." John Edwards[6]
11. "This year I am asking you to maximize your efficiencies."
12. "I am officially streamlining the efficiency of this corporation."[7]
13. "In order to compete, we innovate. In order to innovate, we redefine. And how do we redefine? With a new definition."[8]
14. "What we need right now is to reemphasize freedom! To embrace our forefathers' commitment to a nation free from tyranny, free from terrorism, free from fear. And it is only by increasing our faith in the police and the military that we can enjoy that freedom."
15. "Get ready for an exciting year! We are bigger and better than ever, with new programs and ideas that will make working here even more exciting and rewarding than ever."
16. "In order to increase the quality of our service, we have simplified the following menu."
17. "The future holds endless possibilities. Embrace your potential."
18. "There is a bridge between hard work and success, and that bridge is the spirit of man." (from a motivational poster)
19. "Today is the tomorrow you've been waiting for."
20. "Our forces are fighting for liberty and for the values that made this nation great. They are fighting for traditional values, like family, community, faith, and hard work. So today we need to honor these troops for continuing to make America great!"

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[4]Lisa Fraser, *Making Your Mark*, 9th ed. (Toronto, CA: LDF Publishing, 2009), p. 7.
[5]Quoted in Jay Dixit, "Decision '08: Reading between the Lines," *Psychology Today*, July 1, 2007, http://www.psychologytoday.com/collections/201106/read-my-lips-politispeak/between-the-lines.
[6]Ibid.
[7]Steve Carrell as Michael Scott in the television show *The Office*, "Initiation," Season 3, Ep. 5, 2006.
[8]From the television show *Better Off Ted*, "Jabberwocky," Season 1, Ep. 12, August 2009.

# Implicit Claims (Enthymemes and Disguised Claims)

Often, when people are constructing arguments, they intentionally omit a premise or conclusion. The premise or conclusion is there, but it is implicit. Consider this simple argument:

> If you are innocent, then we wouldn't have caught you with your hand in the cookie jar.

We immediately see that the arguer intends you to believe, "You are not innocent." But, of course, that claim is not explicit in the argument; it is an implicit conclusion. Making the conclusion explicit, the argument would look something like this:

1. If you are innocent, we wouldn't catch you with your hand in the cookie jar.
2. We did catch you with your hand in the cookie jar.
3. **Therefore, you are not innocent.**

An argument tha+t implies a premise or conclusion is called an **enthymeme**; and arguments that imply premises or conclusions are described as enthymemic. Here are more examples of enthymemic arguments.

### Examples of Enthymemes with Implied Conclusions:

**"If it is raining, then my car seats are getting wet. And it is definitely raining."**

1. If it is raining, then my seats are getting wet.
2. It is raining.
3. Thus, my car seats are getting wet.

**"There are three ways out of here, and the first two didn't work."**

1. There are three ways out of here.
2. Two ways don't work.
3. The third way works.

**"FixIt Company was included in the exposé last night, and all those companies are corrupt."**

1. FixIt Company was included in the exposé last night.
2. All the companies included in the exposé are corrupt.
3. Hence, FixIt Company is corrupt.

### Examples of Enthymemes with Implied Premises:

**"If you can't find a way out, there isn't one. So, I guess we're stuck."**

1. If you can't find a way out, there isn't one.
2. You can't find a way out.
3. Therefore, there isn't a way out (we're stuck).

**"A person makes it into the academy only if they pass the course. She didn't make it in.**

1. A person makes it into the academy only if they pass the course.
2. She did not pass the course.
3. Thus, she didn't make it in.

**"We knew that, if the screen was red, we could get out. So, we got out just fine."**

1. If the screen was red, we could get out.
2. The screen was red.
3. Hence, we could get out (and we did!).

Enthymemic arguments are often used strategically to trip up your reasoning. Sometimes the premise or conclusion is implicit because the arguer doesn't *want* to say it explicitly. If the arguer said it explicitly, it might sound silly, or it might raise obvious questions that they don't want to answer, or you might challenge it. As a critical thinker, your goal is to identify explicitly all of the premises and conclusions in an argument. In doing so, you can evaluate the quality of the argument more effectively.

## Questions Used as Claims

In Chapter 1, we noted that a claim is distinct from a question. But there are times when claims are disguised as questions. We call these **disguised claims**, and the most common example is the *rhetorical question*, for example:

- "What do we have to lose?"
- "If all your friends jumped off a bridge, would you do it, too?"
- "Why am I still standing here?"

Disguised claims may play the role of a premise or a conclusion in an argument. Consider these examples:

1. "Why should we have to pay for the plumbing bill? We rent this place; we don't own it. Plus, the toilet has been causing us problems since we moved in."
2. "You must believe she will win the election. Only a crazy person would believe she won't. Are you a crazy person?"
3. "Don't you want a senator that shares your values? Candidate Johnson shares the values of everyone in this community."
4. "Isn't insurance a good thing? Don't you want insurance? How could you possibly be against the government's providing insurance for everyone?"

In argument (1), the disguised claim is the conclusion. The question, "Why should we have to pay for this plumbing bill?" disguises the claim: "We should not have to pay for the plumbing bill." In argument (2), the disguised claim is a premise. "Are you a crazy person?" disguises the claim: "You are not a crazy person." We can make each of these arguments explicit, as follows:

- **"Why should we have to pay for the plumbing bill? We rent this place; we don't own. Plus, the toilet has been causing us problems since we moved in."**

  1. We rent this place, we don't own it.
  2. <u>The toilet has been causing us problems since we moved in.</u>
  3. We should not have to pay for the plumbing bill.

- **"You must believe she will win the election. Only a crazy would believe she won't. Are you a crazy person?"**

  1. Only a crazy person would believe she won't win the election.
  2. <u>You are not a crazy person.</u>
  3. You must believe she will win the election.

- **"Don't you want a senator that shares your values? Candidate Johnson shares the values of everyone in this community."**

  1. You want a senator who shares your values.
  2. <u>Candidate Johnson shares your values.</u>

3. Therefore, you want Johnson to be senator.

   [Note: This argument is also an enthymeme; the conclusion is left implicit.]

- **"Isn't insurance a good thing? Don't you want good things? How could you possibly be against the government's providing insurance for everyone?"**

1. Insurance is a good thing.
2. You want good things.
3. If anyone offers to provide insurance, you should not be against his or her doing so.

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4. Therefore, you should not be against the government's providing insurance for you.

   [Note: This argument is also enthymemic; the arguer assumes premise three is true but does not state it explicitly.]

## Getting familiar with … implicit claims

**For each of the following arguments, identify the implicit claim and identify whether it is missing or disguised. Some arguments have multiple implicit claims.**

1. "God made dirt and dirt don't hurt."
2. "You can't have a drink. You have to be 21 to drink."
3. "You have to be registered to vote. And you're not registered, are you?"
4. "Abortion kills innocent people. Therefore, abortion is wrong."

   [Don't get distracted here. Forget about whether the claim "Abortion kills innocent people" is true. It may or may not be. Your assignment is to identify the implicit premise or conclusion of the argument.]

5. "Every religion is a story about salvation. So, Buddhism is a story about salvation."
6. "All humans have civil rights. You're a human, aren't you?"
7. "You shouldn't put that child on trial. He is only four years old."
8. "I know that cats have live young because all mammals have live young."
9. "All liberals are elitist atheists. You're not an elitist atheist, are you?
10. "The standard price for this package is three times higher than the other brands'. You don't want to pay three times more, do you? So, you don't want this package."
11. "You have to score at least a 90 to pass this exam, and you only scored an 87."

12. "There is only one requirement for this job, and you have it." [Note that "it" is ambiguous (see the following section "Ambiguity and Vagueness" for details). Make clear what is intended here.]
13. "It's not over until the music stops. And the band plays on."
14. "Today will be a good day. Fridays are always good days."
15. "I'm having a beer because it's five o'clock somewhere."
16. "If the server's down, then we won't have internet for a week. It looks like the server's down, so…."
17. "If Creationism were true, there wouldn't be any vestigial organs. Yet, what about the tailbone and appendix?"
18. "If evolution were true, there would be a complete fossil record of all transitional forms. And I don't of any archaeologist, paleontologist, or geologist who claims the fossil record is complete."
19. "Islam is a violent religion. We know this because most terrorists say explicitly that they are members of Islam."
20. "Removing goods from the commons stimulates increases in the stock of what can be owned and limits losses that occur in tragic commons. … Therein lies a justification for social structures enshrining a right to remove resources from the unregulated commons: when resources become scarce, we need to remove them if we want them to be there for our children. Or for anyone else's."[9]

## Ambiguity and Vagueness

Once you've eliminated extraneous material from an argument, identified any missing premises or conclusions, and translated all disguised claims into explicit claims, you can begin to focus on the words and phrases that are supposed to be doing rational work. But even when no words or phrases are extraneous or disguised, they may not be clear. Natural languages are powerful because they allow for a wide variety of complex and subtle meaning. This allows speakers to use a word or phrase one way in one context and very differently in a different context. If the meaning or context isn't specified, our language can become *ambiguous* or *vague*.

[9]David Schmidtz, "Why Isn't Everyone Destitute?," in David Schmidtz and Robert Goodin, *Social Welfare and Individual Responsibility* (Cambridge, UK: Cambridge University Press, 1998), p. 36.

## Ambiguity: Lexical and Syntactic

A word or phrase is ambiguous if it has more than one clear meaning. For instance, the word "law" has several clear meanings, for example, criminal law, civil law, moral law, natural law. And sometimes it is difficult to figure out which meaning is intended. For example, "We are bound by law not to fly." Does the speaker mean there is a civil injunction against flying, for example, because of a bad storm? Or is there a criminal action against this particular pilot preventing his company from flying? Or does the speaker mean something more poetic, for instance, that natural law prevents humans from flying like most birds? Since *law* is ambiguous in these ways, it is difficult, without more information, to evaluate the truth of this sentence.

There are two types of ambiguity: **lexical ambiguity** and **syntactic ambiguity**. A word is *lexically* ambiguous if it has *more than one clear meaning*, as we have seen with "law." "Bank" is also lexically ambiguous because it could mean a river bank, a savings bank, a blood bank, a sharp turn, or a mass of something, such as a computer bank or bank of clouds. The word "human" might mean a being with a certain sort of DNA or it might mean a being with certain physical traits, as Socrates is supposed to have said, "a featherless biped."[10]

### Some common lexically ambiguous words:

match (make the same; a fire starter; a game)

pen (a writing tool; to enclose)

chip (golf technique; poker money; contribute)

suit (clothing; legal proceeding)

virus (illness; malicious computer program)

hard (difficult; resistant; tough)

draw (to pull out; to represent with a pencil or pen)

head (leader; body part)

mouse (rodent; computer hardware)

bank (storage facility; a steep slope)

To resolve lexical ambiguity, make sure your terms are properly qualified. If you mean "moral law," say *moral law*, and not just *law*. If you mean "river

[10]In his dialogue *Statesman*, Plato writes that Socrates gives this definition of human (266e). Diogenes Laertius tells us that, upon hearing this, Diogenes of Sinope took a plucked chicken into Plato's Academy and said, "Here is Plato's [human]" (VI.40).

bank," use *river bank*, and not just *bank*. Context will often make clear what an arguer means (legislators rarely discuss natural laws), but it is never bad form to be precise when constructing an argument.

A phrase is *syntactically* (or structurally) ambiguous if *the arrangement of words allows for more than one clear interpretation*. For instance, "I canceled my travel plans to play golf," might mean:

> My travel plans included playing golf but I cancelled those plans,

or it might mean:

> I cancelled my travel plans *in order to* play golf.

Notice that specifying the type of travel in this example will not help. For instance, I might have said, "I canceled my vacation to play golf." Since golf is typically a leisure activity, we might associate it with a vacation. But I might still have meant, "I canceled my [family] vacation to play golf [with my friends]." And if you knew I was a competitive golfer, playing golf would not necessarily indicate an activity associated with leisure or vacation.

Consider also, "The community has been helping assault victims." Notice that, in a case of syntactic ambiguity, the ambiguity does not result from just one word, but from the way the words are arranged. We hope the speaker means the community has been helping victims of assault and not helping *to assault* victims. Also, imagine reading a novel with the line, "The child was lost in the hall." Out of context it is not clear what happened. It might be that a child went missing in the hall, or that a child died in the hall, or that a child in the hall could not find her way.

Since sentences can be arranged in a number of ways, there is not a set of common syntactic ambiguities, but here are a few more examples.

## Some Examples of Syntactic Ambiguity:

**Murderer gets fifteen years in luggage case.**

- The murderer involved in the "Luggage Case" is sentences to fifteen years in prison.
- The murderer is sentenced to spend fifteen years in a luggage case.

**Supreme Court tries stabbing suspect.**

- The Supreme Court places stabbing suspect on trial.
- The Supreme Court tries to stab a suspect.

**Committee's head discovers hidden arms.**

- The committee's head finds weapons that were hidden.
- The committee's head finds appendages of which he wasn't aware.

**Sister sues after wrongful death.**

- After her wrongful death, the nun sues.
- After a woman's wrongful death, her sister sues.

To eliminate syntactic ambiguity, you must rely heavily on context. If either or all meanings could be legitimate interpretations, you may have to assume one meaning just for the sake of argument. If one is more plausible, explain why. If both or all interpretations are equally plausible, you may have to construct different arguments for each interpretation.

## Vagueness

A word or phrase that's **vague** has a clear meaning, but not precisely defined truth conditions. A word's truth conditions are those conditions on which we could say for sure that the claim in which the word is used is true or false. For instance, we all know what it means for someone to be "bald," but *at what point* does someone become bald? How many hairs can be left and someone still be considered bald? The same goes for "dry." Sitting at my desk, I would consider myself dry, but that doesn't mean there are no water molecules on my skin. So what does it mean? How many water molecules must I have on my skin before I am no longer dry?

Consider the word, "obscene." In 1964, US Supreme Court Justice Potter Stewart, speaking in his official capacity as Justice, said that he could not define "obscenity," "But I know it when I see it." That a group of highly educated, highly experienced men could not successfully define "obscenity" is quite a testimony to the word's vagueness. (Perhaps if there had been some women justices?) But obscenity *has* a clear meaning; we all know what it means to say something is obscene. But what actually counts as obscene? That's more difficult.

### Some common vague terms include:

| | |
|---|---|
| **tall/short** | (Napoleon would be short today, but not when he was alive.) |
| **close/far** | (If you live in Montana, 80 miles is nearby; if you live in NYC, not so much.) |
| **weak/ strong** | (Schwarzenegger won Mr. Universe, but he's got nothing on a grizzly bear.) |

| | |
|---|---|
| **soft/hard** | (I thought my dog's fur was soft until I got a cat.) |
| **fat/thin** | (The painter Reubens would likely think today's fashion models are emaciated.) |
| **pile or heap** | (How many grains of sand does it take to make a "pile"? The world may never know.) |

Eliminating vagueness is not easy. You will almost always have to find a different, more precise word. If you cannot find an alternative, you can sometimes stipulate what you mean by a word. For instance, you might begin, "By 'pile' I mean five or more grains of sand" or "I will use 'fat' to mean someone who is more than twenty pounds over their ideal body weight. And by 'ideal body weight,' I mean the result of the following calculation …."

Sometimes an alternative is not available, and stipulation will not help. If this is the case, your argument will be inescapably vague. If you find yourself with an inescapably vague argument, you may want to reconsider offering it. It is unlikely that your conclusion will be very strong. If you're stuck with offering an inescapably vague argument, be sure to admit the vagueness and allow that an unanticipated interpretation may strengthen or weaken your argument.

## Getting familiar with … ambiguity and vagueness

**Identify each of the following sentences as lexically ambiguous, syntactically ambiguous, or vague. Rewrite each sentence, resolving the ambiguity or vagueness.**

1. "He was assaulted by the lab mice."
2. "The man in the corner office is too tall."
3. "The doctor gave her a prescription for pain."
4. "We have an outlet shortage."
5. "They were discussing cutting down the tree in her house."
6. "The road is long."
7. "That test was unfair!"
8. "Hey, grab that mouse."
9. "She is a nice person."
10. "You are a good teacher."
11. "He saw her duck."
12. "The interrogator snapped his fingers."
13. "The President is doing a terrible job."

14. "The Senator's most recent policy is ineffective."
15. "John Locke was a great philosopher."
16. "She called him in the shower."
17. "Although, he looked for an hour, he could not find the match."
18. "Walk this way."
19. "My uncle, the priest, married my father."
20. "She heard the man with the microphone."

## Argument Form

After you have identified all the claims of an argument clearly, it is helpful to organize the claims in the argument so that the premises are clearly distinct from the conclusion. The typical way of organizing the claims of an argument is called argument form or **standard argument form.** To put an argument into argument form, number the premises, and list them one on top of the other. Draw a line, called the derivation line, below the last premise, and then list the conclusion below the line. If you look back through this chapter, you will notice we have been using standard argument form already, but here are two more examples:

**1. "The government is out to get us, since we're taxed everywhere we turn and our privacy rights are constantly violated."**

In argument form:

1. We are taxed everywhere we turn.
2. <u>Our privacy rights are constantly violated.</u>
3. Therefore, the government is out to get us.

**2. "Sam lost the golf clubs, and he lost the score card. He'll never make it as a caddy. Oh, and he showed up late to the club house, too."**

In argument form:

1. Sam lost the golf clubs.
2. Sam lost the score card.
3. <u>Sam showed up late to the club house.</u>
4. Therefore, Sam will never make it as a caddy.

These are not very good arguments, but they are arguments, nevertheless. We will discuss what makes an argument good in the remaining sections of this chapter.

# Two Types of Argument: Deductive and Inductive

Once you have organized an argument into argument form, you can identify the type of argument with which you are dealing. It is imperative that you understand an argument's type in order to evaluate it well. This is because different types of arguments are evaluated according to different standards. A bad version of one type of argument may be a good version of another type. The type matters!

## Deductive Arguments: Validity and Soundness

There are two basic types of arguments: *deductive* and *inductive*. In a **deductive argument**, the conclusion follows from the premise(s) with *necessity* so that, if all of the premises are true, then the conclusion cannot be false. This is *not* to say that the conclusion *is* true or that the premises *are* true. We are saying only that a deductive argument is structured such that, *if* all premises are true, *then* the conclusion must be true. In other words, in a deductive argument *it is not possible for the premises to be true and the conclusion false*. Such arguments are called valid. **Validity** is the name for this very specific relationship between the premises and the conclusion. In a valid argument, the premises *entail* the conclusion.

It's important to emphasize our unique sense of *valid*. You will find that the word "valid" has three meanings in contemporary English. One meaning is "legitimate," for instance, when someone says, "You've got a valid point" or "That claim is valid." Another meaning refers to whether a scientific test or measurement captures what it intends to. For example, a test for IQ is valid if the results really reflect the test-taker's IQ. (See Chapter 8 for a discussion of valid scientific instruments.) The third use is the structure of an argument as we have defined it here. When evaluating arguments, only the third use is legitimate.

**Caution: In logic, *claims are never valid or invalid*. Only a deductive *argument* where the conclusion necessarily follows from the premise(s) is valid. Claims are true or false; arguments are valid or invalid. All inductive arguments are invalid.**

Here is a classic example of a deductive (and, therefore, valid) argument:

1. All men are mortal.
2. Socrates is a man.
3. Therefore, Socrates is mortal.

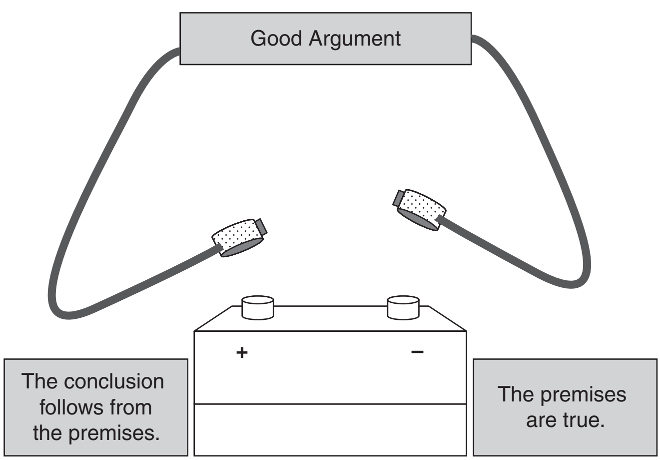
Notice that, if these premises are true, the conclusion must be true. This is not to say that the premises are true; it might turn out that some man is immortal. Nevertheless, the argument is still valid (the premises still entail the conclusion even if premise 1 turns out to be false). Validity refers only to the relationship between the premises and the conclusion; it does not tell you whether the premises or conclusion are true. This means that validity is not all there is to a good deductive argument. In addition to validity, in order to be a good deductive argument, the argument's premises also have to be true. If an argument is *valid* and has *true premises*, it is **sound** (see Figure 2.1 at the end of this section).

Here's an example of a deductive (and, therefore, valid) argument with *false* premises:

1. All ducks are green things.
2. All green things are shiny.
3. Therefore, all ducks are shiny.

If these premises are true, the conclusion cannot be false, so the argument is valid. But the premises are not true, so these premises give us insufficient reason to believe the conclusion. Therefore, the argument is unsound. Validity without soundness can also happen when we have independent reasons for thinking the conclusion is true:

**Figure 2.1** The Battery Analogy



1. All ducks are green things.
2. All green things float.
3. Therefore, all ducks float.

Again, this argument is valid, but the premises are false, so the argument is unsound. That doesn't mean we don't have *any* reason to believe the conclusion is true (presumably, you have *some* evidence that all ducks float), but that reason is *independent* of these premises—it comes from somewhere else.

Of course, validity is much easier to test than soundness. For example, the following argument is valid:

1. Either nothing exists or God exists.
2. Something exists.
3. Therefore, God exists.[11]

If the premises are true, the conclusion cannot be false. Are the premises true? Premise 2 is uncontroversial. But it is very difficult to imagine how we might test premise 1. Here is another example:

1. If the universe is deterministic, no one is morally responsible for her actions.
2. The universe is deterministic.
3. Therefore, no one is morally responsible for her actions.

Again, the conclusion follows necessarily from the premises, but are the premises true? Philosophers and physicists are still wrestling with both claims. In this book, we will focus on evaluating validity in deductive arguments. But don't forget that an argument is good only if it is sound, so it requires both validity and true premises.

## Getting familiar with … validity

**For each of the following incomplete arguments, fill in the missing premise or conclusion to construct a valid deductive argument. (Don't get discouraged. This is tough to do without the tools we will introduce in Chapters 4, 5, and 6. But try to get a feel for what it would mean for premises to guarantee a conclusion.)**

[11]This example comes from George Mavrodes's book *Belief in God: A Study in the Epistemology of Religion* (New York: Random House, 1970), p. 22. If you can find it, we highly recommend this as an excellent example of critical thinking applied to religion.

**1.**

1. All Christians are monotheists.
2. __________________________________
3. Therefore, all Christians believe in one god.

**2.**

1. …
2. All warm-blooded animals are mammals.
3. So, all cats are warm-blooded.

**3.**

1. If people are wicked, they should act wickedly.
2. People are wicked,
3. Hence, …

**4.**

1. Our Sun is a star.
2. __________________________
3. Our Sun is composed of helium.

**5.**

1. You’re either serious or you’re lying.
2. ____________________________
3. Hence, you’re lying.

**6.**

1. All cats are mammals.
2. All mammals are warm-blooded.
3. So, …

**7.**

1. If it rains we stay, and if it snows we go.
2. It either rains or snows.
3. Therefore, …

**8.**

1. …
2. All ducks are green.
3. So, all ducks float.

**9.**

1. …
2. All scientists utilize the scientific method.
3. This shows us that all chemists utilize the scientific method.

**10.**

1. If it is round, then it is red.
2. ______________
3. Therefore, all cars are red.

## Inductive Arguments

The second major type of argument is the inductive argument. In an **inductive argument**, the conclusion follows from the premise or premises with *some degree* of confidence, but the conclusion does not follow necessarily, as it does in the case of deductive reasoning. For example, predictions about the weather based on atmospheric data are inductive. Weather forecasters predict with some degree of confidence, but they are sometimes wrong. Similarly, a doctor's belief that a certain medicine will cure your illness is an inductive inference based on what they know about the medicine and what they know about your symptoms. Bodies differ, and some illnesses have the same symptoms despite requiring very different treatments. So, given your symptoms, a particular medicine is *likely* to help you, but not necessarily.

Inductive reasoning sometimes discussed in terms of probability, and for readers who like math or card games, this can be a very helpful way to understand inductive reasoning. And for the rest of us, thinking about induction in terms of probability can help us understand math a little better.

If we think of the conclusion in a deductive argument following with 100 percent probability from its premises, we can think of the conclusion of an inductive argument as following with any probability less than 100 percent. When kitchen cleaners, for example, say they kill 99.9 percent of bacteria, they are saying, "This cleaner will very, very likely kill all the bacteria in your kitchen, but we can't be 100 percent sure."

Probability is measured on a decimal scale between 0 and 1, where fifty percent probability is P(0.5), 90 percent probability is P(0.9), and 100 percent probability is P(1). If a claim is zero percent probable, it is impossible. If it is 100 percent probable, it is certain. "Certainty," for our purposes, applies only to valid arguments. There are different kinds of probability, and we will discuss some of those in Chapter 7. But for here, just note that we are talking about probability *given the evidence* or *relative to the evidence* (which we will call *epistemic* probability in Ch. 7). A conclusion can follow from premises with greater or lesser degree of epistemic probability. If a conclusion follows from some evidence with *certainty*, then the argument is valid. Remember that validity means that, if the premises are true, the conclusion cannot be false—this doesn't mean the premises *are* true, only that the structure of the argument guarantees the conclusion as long as the premises are true. If the premises make the conclusion probable to some degree less than P(1), the argument is invalid, and usually inductive.

Here are two examples of inductive arguments that use probabilities explicitly:

**A.**

1. There is a 75 percent chance of getting caught in the rain.
2. If I get caught in the rain, I will be wet and miserable.
3. So, I will probably be wet and miserable.

**B.**

1. I will give you five dollars, but only if you flip this coin, and it lands on heads twice in a row,
2. The probability of a coin's landing on heads twice in a row is about 25 percent.
3. If the probability is 25 percent, then it probably won't land on heads twice in a row.
4. Therefore, I will probably not give you five dollars.

Here are two examples of inductive arguments that do not use probabilities explicitly:

**C.**

1. Most vegetarians are also in favor of welfare.
2. Nicolai is a vegetarian.
3. So, Nicolai is probably in favor of welfare.

**D.**

1. Some of the people in my class are working a full-time job.
2. Of those that are working a full-time job, 25 percent are parents.
3. If you work a full-time job and you are a parent, you will probably not do well in this class.

4. Joan is in this class.
5. Therefore, Joan will probably not do well in this class.

These arguments are not particularly strong, but they are inductive nonetheless. A conclusion *follows from* a premise if, independently of any other considerations, the evidence makes the conclusion more likely than P(0). The question then becomes: When is it rational to believe an inductive argument? How strong does the probability have to be? Is strength enough to make an inductive argument good?

Very generally, if the degree is high enough relative to the premises, and if all of the premises are true, then the conclusion likely or probably is true. If the arguer achieves her goal and the conclusion follows from the premises with a *high degree of likelihood*, the argument is **strong**. On the other hand, the conclusion does not follow with a high degree of probability, the argument is weak. If the argument is *strong* and the *premises are true*, the argument is **cogent** (**kō**-jent). An inductive argument is good only if it is cogent (see Figure 2.1).

It is important to understand why the strength of an inductive argument has nothing to do with the truth of the premises. As we said with deductive arguments, we do not mean that the premises *are* true, only that, *if* they are, the conclusion is also likely to be true. However, in an inductive argument, it is still possible that the conclusion is false *even if the premises are true*. This means that *all inductive arguments are invalid*.

But just because an argument is invalid, this doesn't mean it is a bad argument. It simply means we cannot evaluate it as if it were deductive. We need to see whether it is cogent. It may turn out to be a good inductive argument, even if invalid. So, just as validity is not the only feature needed to make a deductive argument good, strength is not the only feature needed to make an inductive argument good. In both types of arguments, the premises must also be true.

Consider an example. Jamie's friend ordered a book from a certain book shop, assuming it would arrive, as most books do, undamaged. Jamie's friend reasoned like this:

1. In the past, when I received a book from this book shop, it was undamaged.
2. My current book order is similar to my past book orders.
3. So, I will probably receive this new book undamaged.

The conclusion is, "I will probably receive this new book undamaged." Provided the premises are true, the conclusion is probably true, but it is not certainly true. It makes sense to conclude that his book would arrive undamaged, given his past experience with the book shop. But the truth concerning his success in getting a book in good shape in the *past* does not guarantee that he will in the *future* receive a book in good shape. It's always possible that the book is damaged in shipping, or that someone at the shop accidentally rips the cover without knowing it prior to shipping, so the conclusion is merely probable or likely true. In order to let others know this conclusion follows only with some degree of probability, and not with certainty, we include phrases like, "it is likely that," "probably," "there's a good chance that." In fact, Jamie's friend did get the book in good shape, but he needn't *necessarily* have received it that way based on his premises.

Similarly, consider the kind of reasoning someone may have utilized just before Joel Schumacher's *Batman and Robin* came out in 1997. Because of the wild financial success of *Batman Forever* in 1995, someone might have concluded that *Batman and Robin* would be just as successful. No one would bet their life on this conclusion, but the filmmakers risked millions on it. Surprisingly—and to the dismay of the investors and many Batman fans—*Batman and Robin* was a failure and heavily criticized by fans and movie buffs alike. This is an example of inductive reasoning where it seemed as if the conclusion was true but turned out to be false.

## Good Arguments: The Battery Analogy

Whether someone intends to offer a deductive or an inductive argument, for that argument to be good, it must meet two conditions:

1. The conclusion follows from the premises—it follows *validly* in the case of deductive arguments, and it follows *strongly* in the case of inductive arguments.
2. All the premises are true.

If either of these conditions or both is missing, then the argument is bad and should be rejected. We can draw an analogy with the battery on a car. A car battery has two terminals. A car will start only if cables are connected to both terminals. If one or both of the cables is disconnected, the car won't start. The same goes for an argument: There are two conditions, and both must be met in order to successfully support a conclusion. Consider the following diagram of the battery analogy:

## Inductive Strength Indicators

How can you tell whether an inductive argument is strong or weak? An argument is generally strong if the probability that the conclusion is true given the premises is greater than 50 percent. The higher the better. But this doesn't mean you should always believe a conclusion that is more than 50 percent likely given the premises. For instance, if there are two possible conclusions, and one is 52 percent likely given a set of premises while another is 65 percent given the same premises, the latter is clearly preferable. Similarly, there are times when the probability that a claim is true is very low, but it is still rational to believe. For instance, the chance that our universe exists because of a Big Bang event is very, very low. All one-time events are highly improbable, plus a Big Bang universe is just one among many ways our universe could have been (imagine rolling a 1,000-sided die and that our universe is a 7). Nevertheless, the evidence we had in the twentieth century made a Big Bang universe more likely than, say, a steady state universe, or a cyclical ekpyrotic universe. So, even though the probability is very low that our universe is a Big Bang universe, it is currently rational to believe that it is. Where will the evidence point in the twenty-first century? We would need to ask physicists.

Sometimes determining strength will be a matter of calculating measurable percentages, for instances, when you have discrete magnitudes, for instance, when rolling dice or tallying scientific or statistical data (though the magnitudes themselves can be tricky, see Chapter 9). But even when you don't have specific numbers, there are some indicator words that will help you decide whether an inductive argument is strong. Consider the following two arguments:

**A.**

1. **Most** members of Congress voted to invade Iraq in 2002.[12]

<u>2. John Kerry is a member of Congress.</u>

3. Therefore, (it is likely that) Kerry voted to invade Iraq in 2002.

**B.**

1. **Many** members of Congress voted to invade Iraq in 2002.

<u>2. John Kerry is a member of Congress.</u>

3. Therefore, (it is likely that) Kerry voted to invade Iraq in 2002.

Since "most" means "more than 50 percent," argument A is strong. Since "many" does not indicate anything with respect to percentage or likelihood, argument B is weak. If 100,000 people vote for a governor, that's many people, but it may only be 40 percent of the voters. Here are two more examples:

**C.**

1. **Almost all** Republicans are conservative.

<u>2. John McCain is a Republican.</u>

3. Therefore, (it is likely that) McCain is conservative.

---

[12]This was a "joint resolution" of the US Congress called "Authorization for Use of Military Force Against Iraq Resolution of 2002."

**D.**

1. **A significant percentage** of Republicans are conservative.

2. John McCain is a Republican.

3. Therefore, (it is likely that) McCain is conservative.

Since "almost all" means "more than 50 percent," argument C is strong. Since "a significant percentage" does not indicate what percentage counts as "significant," argument D is weak. 30 percent is not an insignificant amount, but it is not sufficient in this case for making an argument strong. But context is important. As we noted earlier, 30 percent may be more than enough if alternative claims are less likely to be true.

### Some Examples of Quantifiers

| **Strong Quantifiers:** | **Weak Quantifiers:** |
|---|---|
| Most | Some |
| Almost all | A few |
| It is likely that | It is possible that |
| Most likely | Somewhat likely |
| The majority | A percentage |
| Almost definitely | Could be |
| Highly probable | Many |
| More often than not | A significant percentage |

## Strong *claims*?

Sometimes, people will say "That's a strong claim you're making!" and this might suggest that our use of "strong" also applies to claims. But this use of "strong" is very different. When people (often philosophers) say a claim is *strong*, they mean the claim is very difficult to support. For instance, "All gold found in nature is yellow." Since we have never seen all the natural gold, it is difficult to support the claim that *all* natural gold is yellow. When people say a claim is *weak*, they mean the claim is fairly easy to support; it might even be trivial. For example, "All the documented gold found in nature is yellow." To support this claim, we would only need to gather the records documenting natural gold.

So, for our purposes, the adjective "strong" is reserved for arguments. Claims are true or false; inductive arguments are strong or weak, cogent or uncogent; deductive arguments are valid or invalid, sound or unsound; and arguments are good or bad.

## Getting familiar with … argument strength

**For each of the following inductive arguments, explain whether the conclusion is (a) highly likely, (b) somewhat likely, (c) somewhat unlikely, or (d) highly unlikely.**

**1.**

1. Rover the dog bit me last year when I tried to pet him.
2. Rover has been castrated and has been much calmer in the past three months.

3. Rover will bite me when I try to pet him today.

**2.**

1. Jones had sex with Brown's wife.
2. Brown told Jones he was going to kill Jones.
3. Jones was murdered.

4. Brown is the murderer.

**3.**

1. Watches are complex, and they have watchmakers.
2. The universe is complex like a watch.

3. The universe has a universe-maker.

**4.**

1. The sign on Interstate 95 says the town is 1 mile away.

2. The town is, in fact, 1 mile away.

[Consider: Would the argument be stronger if we added the premise: "Road signs are usually accurate"?]

**5.**

1. Rajesh loves Bobbi
2. Bobbi loves Neha.

3 Rajesh loves Neha.

**6.**

1. My friend knows a person of type X who is rude.
2. My sister knows a person of type X who is rude.
3. So, all people of type X are rude.
   [Note how quickly such arguments motivate racism, sexism, and ageism.]

**7.**

1. Almost all of the beans in this bag are red.
2. Hence, the next one I pull out definitely will not be red.

**8.**

1. The Tigers beat all of the other teams during the season.
2. The Tigers have the best overall stats of any team.
3. The championship game is about to begin, and all of the Tiger teammates are in good health.
4. It is very likely that the Tigers will win the championship game.

**9.**

1. The Tigers beat all of the other teams during the season.
2. The Tigers have the best overall stats of any team.
3. The championship game is about to begin, and all of the Tiger teammates are in good health.
4. The Tigers' quarterback just broke his leg.
5. But the Tigers will still probably win the championship game.

**10.**

1. Paulo is a Democrat.
2. In the past, many Democrats have voted for bill X.
3. So, Paulo will vote for bill X.

## Simple and Complex Arguments

In Chapter 1, we introduced the basics of reasoning, which involved defining claims, operators, quantifiers, evidence, and arguments. In this chapter, we introduced some ways of teasing arguments out of their larger context and distinguished two types of arguments. All of the arguments we've seen so far have been simple arguments. A **simple argument** is an argument with only one conclusion.

However, many arguments have two or more conclusions, and one conclusion will serve as the premise for a further conclusion. We will call arguments with more than one conclusion, **complex arguments**. Consider the following simple argument:

1. Daily pot-smoking causes brain damage.
2. Daily pot-smoking impairs thinking.
3. Anything that causes brain damage and impairs thinking is bad for you.
4. Daily pot-smoking is bad for you.

As critical thinkers, you are not always only going to want evidence for the truth of a conclusion, sometimes you will also want to (a) provide evidence for the truth of the premises, or (b) use that conclusion in another argument. In fact, most discussions and debates involve both (a) and (b). Here is a complex argument that builds on the simple argument above:

1. Daily pot-smoking causes brain damage.
2. Daily pot-smoking impairs thinking.
3. Anything that causes brain damage and impairs thinking is bad for you.
4. **Daily pot-smoking is bad for you.**

4. **Daily pot-smoking is bad for you**.
5. You should not do what is bad for you.
6. You should not smoke pot daily.

Note how the conclusion of the first argument is used as the premise in the second argument. This is an example of (b) and is typical of reasoning that involves many different claims.

Let's say that someone agrees that 6 follows from claims 1–6, but she is skeptical of your first claim. If someone were to ask you to justify premise 1, you might offer the following complex argument:

7. In study A, reported in a reputable journal, daily pot-smoking caused brain damage in 78 percent of subjects.
8. In study B, reported in a reputable journal, daily pot-smoking caused brain damage in 82 percent of subjects.
9. In study C, reported in a reputable journal, daily pot-smoking caused brain damage in 70 percent of subjects.
10. In study D, reported in a reputable book, daily pot-smoking caused brain damage in 87 percent of subjects.
11. In study E, reported in a reputable book, daily pot-smoking caused brain damage in 77 percent of subjects.

1. **Daily pot-smoking causes brain damage**.

1. **Daily pot-smoking causes brain damage.**
2. Daily pot-smoking impairs thinking.
3. Anything that causes brain damage and impairs thinking is bad for you.
4. Daily pot-smoking is bad for you.

In this case, you have given an example of (a); you have provided reasons for believing the premise of another argument. Premise 1 is the conclusion of this argument, and the two together constitute a complex argument.

You may also need an argument for, "Daily pot-smoking impairs thinking" (How many days? How much pot?) and "Anything that causes brain damage and impairs thinking is bad for you" (If the pot is medicinal, what's the alternative?) and "You should not do what is bad for you" (Not anything? What counts as "bad"?) Just remember, *if you are making the claim, the burden is on you to support it*.

Consider another complex argument:

> Hey John, it looks as if we can't go sledding. If it's above freezing, it is too wet to sled and if it is raining, it's above freezing. And, of course, it's raining!

To see the structure of this complex argument clearly, we can break it up into two simple arguments and place each in argument form, like this, noting how the conclusion of the first simple argument acts as the premise in the second simple argument:

1. It is raining.
2. If it is raining, then it is above freezing.
3. **It is above freezing**.
4. If it is above freezing, it is too wet to sled.
5. It is too wet to sled.

One important thing to notice about this complex argument is that there is an *ultimate conclusion*, or final conclusion that the speaker wants to make: "It is too wet to sled," or, in more disappointing terms, "We can't go sledding." In most complex arguments, there will be an ultimate conclusion that all other arguments are leading to. This is the main point of the conversation. It is easy to get distracted with the infinite variety of things that can go wrong with an argument and the attempt to support claims with evidence. But try not to lose track of the ultimate conclusion!

## Wrapping up: Evaluating arguments

With everything in Chapters 1 and 2 in mind, here's a rough strategy for identifying and evaluating arguments:

1. Identify the conclusion.
2. Identify the premises.
3. Remove extraneous material, and resolve any ambiguity and vagueness.
4. Identify whether the argument is intended to be inductive or deductive.

5a. If deductive, ask whether it is valid. (Chapters 3–6 will help with this.)

5b. If inductive, ask whether it is strong. (Chapters 7–10 will help with this.)

6. If the answer to 5a or 5b is yes, ask whether the premises are true.
7. If the answer is yes, you have a good argument.

And finally, consider one more bad argument:

1. Grass is green.
2. <u>The sky is blue.</u>
3. The fool is on the hill at midnight.

What should we make of an argument like this? Clearly, it's nonsense. But, since it is being offered as an argument, we must (for the sake of charity … ahem, The Godfather Principle) treat it like one. Using the strategy above, and stipulating that there is no extraneous material, we can reason as follows:

Is the argument valid? No, the premises do not guarantee the conclusion.

Is it at least strong? No, the premises do not strongly support the conclusion.

In fact, the conclusion follows with a degree of probability much less than 50 percent; it follows with zero probability. Given the premises, the conclusion is 0 percent likely. (Its *relative* probability is 0 percent; this doesn't mean that its objective probability is 0 percent—we may have independent evidence that it is more probable than zero—that is, assuming we can figure out what it means.) Therefore, though the premises are probably true, since the argument is weak, it is a bad inductive argument.

## Exercises

**A. Each of the following claims involves an ambiguity. Write out each possible meaning so that the ambiguity is resolved. Identify which type of ambiguity is being committed.**

1. He could not draw his sword.
2. He couldn't find the match.
3. He lost his suit.
4. She caught a virus.
5. She mastered the art of writing at the university.

6. He asked her about the universe in his kitchen.
7. The bystanders were struck by the angry words.
8. She got sick eating potato chips.
9. The turkey is ready to eat.
10. I once saw an alligator in my pajamas.

**B. Each of the following claims includes a vague term. Rewrite the claim to eliminate the vagueness.**

1. The old man was bald.
2. She was the tallest woman.
3. Reubens mostly painted large women.
4. Her skin was completely dry.
5. The painting was still wet.
6. Cook it until it is done.
7. Just watch until the good part, then turn it off.
8. We are almost there.
9. An organism is valuable the moment it is a person.
10. You will understand after you're grown.

**C. In these arguments, identify whether the underlined claim is a premise or a conclusion.**

**Remember, don't look only for premise and conclusion indicating words, but also ask yourself:**

- **What claim, exactly, am I trying to be convinced of? (conclusion)**
- **What claims are intended to convince me? (premises)**

1. <u>The post office delivers only if there is a stamp</u> and given that the letter lacks a stamp, the post office will not deliver.
2. Most people make it via the road in 11 minutes. <u>He took the road</u>, so he will make it in about that time.
3. Philosophy entails critical thinking. <u>Philosophy entails arguing</u>. Critical thinking entails arguing.
4. Only band members are allowed on the stage. You're not allowed onstage since <u>you are not a band member</u>.
5. I will get either liberty or death. <u>They will not give me liberty</u>. They will give me death.
6. The universe must be billions of years old because <u>there is plenty of evidence in textbooks</u>.
7. <u>Moral responsibility requires free acts</u>. Free acts imply the falsity of determinism. Thus, if we are morally responsible, determinism must be false.
8. He believes only in the visible; <u>the soul is not visible</u>, so you see, he won't believe in it.

9. The polls put Bush ahead right now. <u>He is sure to win later</u>. [The argument is missing a premise. What could it be?]
10. God either is not powerful enough or good enough to prevent evil. God is good. <u>Hence, either evil exists and God is not powerful enough to prevent it or God is powerful enough to prevent it and evil does not exist.</u>
11. <u>Most of the beans in this bag are red</u>. The next one I pull out will be red.
12. You will have good health since you're drinking tea and <u>tea is linked to good health in studies</u>.
13. <u>The dog did not attack</u>. It must be that the man wasn't a stranger. [This argument is missing a premise. What could it be?]
14. Even though it is possible to lose, they are sure to win the game. <u>They are up so many points</u>.
15. <u>The kitty is asleep</u>, as her eyes are closed. [This argument is missing a premise. What could it be?]
16. Either your eyes are in the blue spectrum or in the brown spectrum. <u>Since your eyes are not in the brown spectrum</u>, we can conclude that your eyes are in the blue spectrum.
17. Brown birds forage. <u>Blue birds are a lot like brown birds</u>. It is likely that blue birds forage, too.
18. <u>If it is a spade, then it is a member of a traditional deck of cards</u>. It is not a spade. Therefore, it is not a member of a traditional deck of cards.
19. You're either rich or poor. And you're not rich, so <u>you must be poor</u>.
20. <u>The crowd went wild</u>. If the crowd went wild, our team probably won. Therefore, our team probably won.

**D. Now, go back through the arguments in part C above and:**

**1. place each into argument form, and,**
**2. to the best of your ability, identify whether the argument is deductive or inductive.**

**E. For the following arguments:**

- **Locate the conclusions and premises of the argument.**
- **Place the argument in argument form.**
- **Identify the argument as *simple* or *complex* and *deductive* or *inductive*.**
- **In the process, remove any extraneous material and resolve any vagueness or ambiguity.**

1. If the floor is flooded, then we need to trudge through water. The floor is flooded. Thus, we need to trudge through water.
2. Siberian tigers are an endangered species. We should set up more programs to protect Siberian tigers, since any animal that is endangered should be protected.

3. Van Halen's version of "You Really Got Me" will probably go down in history as more significant than The Kinks' version of the same song. Eddie Van Halen's guitar work is amazing. David Lee Roth has more charisma in his voice than the lead singer from The Kinks. And, Alex's drumming can't be beat (pun intended!).
4. In China, just prior to an earthquake, not only did a bunch of snakes suddenly wake up from hibernation, but dozens of fish were seen leaping from lakes and rivers, so I heard. Maybe animals can predict earthquakes. Also, it is reported that cows and horses have refused to enter barns just before an earthquake. And, pet-owners give accounts of their pets acting strangely just before the onset of an earthquake.
5. Spiders keep pesky insects away. You should stop killing every spider you see. And they mostly pose no threat to us, too.
6. Critical thinking is the key to a successful future. Your college allows you to take a critical thinking course to fulfill a core course requirement. Since you want a successful future, you should take the critical thinking course.
7. Why do I think it is key to a successful future? Lawyers, doctors, and engineers are successful people. And people who master critical thinking skills have a much higher chance of becoming a lawyer, doctor, or engineer.
8. The provost said that complying with the new regulations will allow us to keep enrollment high. If we keep enrollment high, we will be able to meet our budget. If we are able to meet our budget, you get to keep your job.
9. Since you want to keep your job, you should help us comply with the new regulations. The new regulations help keep enrollment high because those regulations mean we are accredited and many students only choose colleges who are accredited.
10. Bill Clinton was actually a bad president, maybe one of the worst we have ever had. He had sex with an intern, for goodness's sake! And any president that does that, in my book, is bad news.
    [Note: "Bad" is vague; clarify when you reconstruct.]

## Real-Life Examples

# I. A Logic Problem

**The following problem can be worked out individually or as a group activity. Try it to test your deductive reasoning abilities.**

Six friends—Andy, Ben, Carol, Dawn, Edith and Frank—are snacking around a round table, and each had either a fruit or a vegetable and each had only one of the following snacks: apples, bananas, cranberries, dates, eggplant (a vegetable), or figs. From the information provided below, try to figure out where each person sat and what snack they had. Try to construct clues using complex claims and deductive arguments:

- The man to the right of the date-eater will only eat vegetables.
- Dawn is directly across from the eggplant-eater.
- Andy loves monkey food and is to the left of Dawn.
- The apple-eater, who is two seats over from Andy, is across from the cranberry-eater.
- Frank is across from the fig-eater and to the right of Edith.
- Carol is allergic to apples.

## II. Enthememic Arguments

**Reconstruct the following enthememic arguments, supplying the missing premise or conclusion.**

- You would not like that coffee shop. The baristas do not understand customer service. The atmosphere is mediocre. The Wi-Fi signal is weak. And there are very few comfortable places to sit.
- "Removing goods from the commons stimulates increases in the stock of what can be owned and limits losses that occur in tragic commons. Appropriation replaces a negative-sum with a positive-sum game. Therein lies the justification for social structures enshrining a right to remove resources from the unregulated commons: when resources become scarce, we need to remove them if we want them to be there for our children. Or anyone else's."

(from David Schmidtz, "Why Isn't Everyone Destitute?" in David Schmidtz and Robert E. Goodin, *Social Welfare and Individual Responsibility: For and Against* (Cambridge University Press, 1998), p. 36.)

# part two

# Deductive reasoning

**In Chapters 3–6, we explain three methods of deductive reasoning: categorical logic (Chapter 3), truth tables (Chapter 5), and basic propositional logic (Chapters 4–6). Categorical logic helps us reason deductively about quantified claims, that is, the *all*, *some*, and *none* claims we discussed in Chapter 1 and to understand the various logical relationships among these quantified, "categorical" (category-based) claims. Truth tables show the logical relationships among the parts of complex claims. They also help demonstrate the concept of validity, provide intuitive tests for validity, and provide a foundation for understanding propositional logic. Basic propositional logic is a more powerful logical system than categorical logic, and it helps us to reason deductively about a wide variety of non-categorical claims. We will explain how to translate natural language into propositional logic and tests for validity in propositional logic.**

# Thinking and reasoning with categories

3

**We explain the concept of a category, the four standard types of categorical claim using the quantifiers we discussed in Chapter 1, and the Venn diagram method for testing categorical arguments for validity. We also explain the traditional square of opposition, which shows the logical relationships between different types of categorical claim and discuss the limitations of categorical logic.**

## Categories

Categorical logic is a form of deductive reasoning that allows us to determine whether claims about categories follow from other claims with certainty. In other words, we are able to identify whether any argument formulated with standard-form categorical claims is valid or not (see Chapter 2 for a refresher on validity).

There are certain inferences we can make with standard-form categorical claims that are immediate. For example, it's true that "No cats are dogs," so we know immediately that "Some cats are dogs" is false. Also, given that "No cats are dogs" is true, we can immediately infer that "No dogs are cats" is not only true as well, but it also communicates the same thing as "No cats are dogs." Categorical logic provides us with a set of tools that not only explains why these inferences are valid but helps us reason about more complicated categorical relationships. To begin, we need to know a bit about what categories are.

Humans are natural classifiers, sorting all kinds of things into categories so as to better understand, explain, predict, and control reality. A **category** is a class, group, or set containing things (**members**, instances, individuals, elements) that share some feature or characteristic in common. We can construct a category of things that are dogs, a category of things that are humans, a category of things that are red, a category of things that are left shoes, a category of things that are red left shoes, and on and on. In fact, it's possible to classify anything you can think of into one category or another.

Consider this claim: **"I think I saw a black cat sitting on the window sill of that vacant house."** It is possible to categorize the various things in this claim like this. There is the category of:

- **things I think I saw**

  e.g., I think I saw water on the road, I think I saw a mouse scurry, etc.
- **things that are black**

  e.g., black cats, black bats, black rats, black rocks, black socks, black blocks, etc.
- **things that are cats**

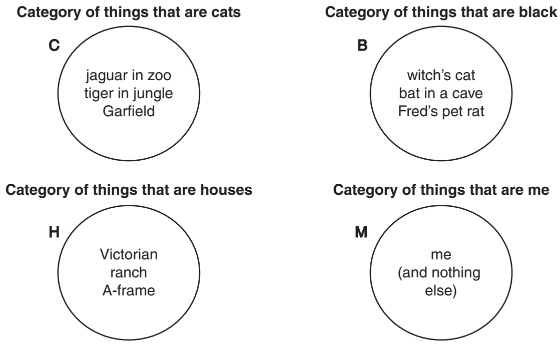
  e.g., Garfield, Morris, Fluffy, Xantippe (Jamie's cat), etc.
- **things that are black cats**

  e.g., Grover (my friend's black cat), Jolli (my other friend's black cat), etc.
- **things that are vacant houses**

  e.g., this vacant house, that vacant house, etc.
- **things that are window sills**

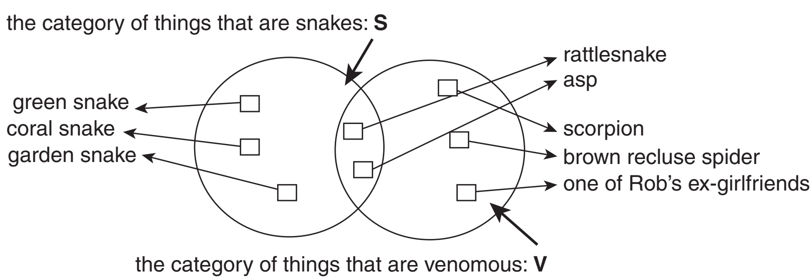
There is also the category of **things that are *that* vacant house,** which contains only one thing, namely, that particular vacant house. There is the one-member category of **things that are *me***, which is doing the thinking.

An easy way to visualize categories of things is to draw a circle, which represents the category, and then to write the members inside. Also, we can use a capital letter to represent the category itself as in, say, C for the category of cats, B for the category of black things, H for the category of houses, and so on. Usually, people will choose the first letter of the word that designates the category. Just be sure you know what category the letter symbolizes.



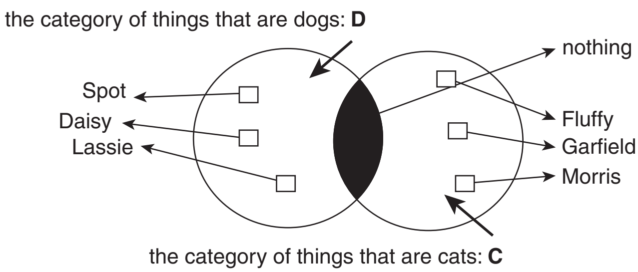

## Relating Categories to One Another

Not only do we categorize things, we make claims about the relationships between and among categories. For example, consider the category of things that are snakes and the category of things that are venomous. Now, think of all the things that are snakes, such as pythons, boa constrictors, and vipers, and all of the things that are venomous, such as jellyfishes, stingrays, and spiders. In trying to represent reality accurately, we might assert that some members of the category of snakes belong in, or are in, the category of things that are venomous, which turns out to be true. Think of rattlesnakes or asps, which are venomous snakes. Using circles again to represent categories of things, little rectangles to represent the things or members in the categories, and capital letters to represent categories, we can visualize the claim, "Some snakes are venomous" like this:




Notice that there are other snakes that are non-venomous, like green snakes and garden snakes, and there are other venomous things, like scorpions and one of Rob's ex-girlfriends (so he says—a little critical thinking humor). Further, not only can we say that "Some venomous things are snakes"—and, essentially, we are saying the same thing as "Some snakes are venomous"—but it is also the case that both claims are true when we look at reality. Therefore, the diagram expresses a claim, and, in this case, the claim is true. The diagram we use is modeled after what are known as **Venn diagrams**, named after the famous logician, John Venn (1834–1923). We will continue to talk more about Venn diagrams as this chapter progresses.

We can also assert that two categories of things have nothing to do with one another, that is, they have no things (instances, individuals, members, elements) in common. For example, consider the claim, "No dogs are cats." Using circles again to represent categories of things, little rectangles to represent the members in the categories, capital letters to represent categories, and adding a shaded black area to represent a void or nothing, we can visualize the claim "No dogs are cats" like this:




Notice D and C intersect one another in a football-shaped area (an American football, i.e., not a soccer ball). Notice also that the shaded black area in that intersection of D and C pictorially represents the fact that nothing in the category of dogs is in the category of cats, and vice versa. We blank that section out like a barrier; nothing crosses from one category into the other. Further, not only can we show "No dogs are cats"—and, essentially, we are saying the same thing as "No cats are dogs"—but it is also the case that they represent reality. That is, both claims are true. In this case, as before, the diagram expresses a true claim.

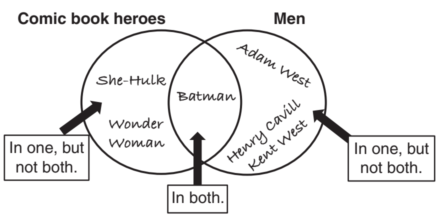
## Getting familiar with … categories

**A. For each of the following claims, identify as many categories of things as you can, by using the "things that are ________" format, as we have done above.**

1. Aristotle was an Ancient Greek philosopher who wrote many treatises.
2. Rob has seen a few mailboxes painted like R2-D2, but most are blue.

3. Dinosaurs, like the *Stegosaurus*, roamed the Earth during the Jurassic Period.
4. People who are not handicapped but who take handicapped persons' parking spots belong in jail.
5. There are seven chimpanzees in that tree.

**B. In each of the following, we list two categories. For each, identify one thing that is a member of both categories and one thing that is a member of each category that is not a member of both. To answer each item, draw two circles, and write the thing that is a member of both in the overlap, and write the thing that not in both outside the overlap. If there is nothing that is in both, or nothing that is in one but not both, write "nothing." For example, if the categories are comic book heroes and men, your answer might look like this:**




1. Things that are buildings. Things that are in Paris.
2. Things that are pets. Things that are dogs.
3. Things that are mammals. Things that are cats.
4. Things that are black. Things that are white.
5. Things that are round. Things that are toys.
6. Things that are vehicles. Things that are cars.
7. Things that are stars. Things that are the sun.
8. Things that are men. Things that are bachelors.
9. Things that are mortal. Things that are humans.
10. Things that are round. Things that are square.

## Standard-Form Categorical Claims

Recall from Chapter 1, we introduced the concept of *quantifiers*: all, some, and none. In Western history, the famous Greek philosopher Aristotle (384–322 BCE) is usually credited with reformulating typical categorical claims into what is known as **standard-form categorical claims** in his famous texts, *De Interpretatione* and *Prior Analytics*. The idea behind standard-form categorical claims is that any categorical claim can be translated into one of four basic types of claim: **A-claim**, **E-claim**, **I-claim**, and **O-claim**. These claims correspond to four ways of using our quantifiers:

A-Claim: **All** *A*s **are** *B*s.

E-Claim: **No** *A*s **are** *B*s.

I-Claim: **Some** *A*s **are** *B*s.

O-Claim: **Some** *A*s **are not** *B*s.

We'll explain each type, give several examples of claims translated into each type, and then show how each example can be represented with a Venn diagram. To avoid confusion, and following classical presentations, we will drop the plural "s" on *A*s and *B*s, and just write "All A are B," which means *all things that are A are things that are B*.

## Parts of Categorical Claims

There are four parts to every categorical claim: a **quantifier**, a subject, a copula, and a predicate or object. When translating natural language claims, the first thing to do is identify which elements of the claim correspond to which part of a categorical claim:

| Quantifier | Subject | Copula | Predicate / Object |
|---|---|---|---|
| All / No / Some | category of things | are / are not | some other category of things |

Begin by identifying the categories involved and distinguishing the subject from the predicate. If we take the claim "Junk food is healthy" we can fill in the formula as follows:

| Quantifier | Subject | Copula | Predicate / Object |
|---|---|---|---|
| All / No / Some | things that are junk food | are / are not | things that are unhealthy for people |

Depending on what we ultimately want to express, our categorical claim will look like one of the following:

| Quantifier | Subject | Copula | Predicate / Object |
|---|---|---|---|
| All | things that are junk food | are | things that are healthy for people. |
| Some | things that are junk food | are | things that are healthy for people. |

| | | | |
|---|---|---|---|
| Some | things that are junk food | are not | things that are healthy for people. |
| No | things that are junk food | are | things that are healthy for people. |

As with “Junk food is healthy,” people don’t usually speak in sentences of standard categorical form. Consider these common claims:

1. Junk food is unhealthy.
2. Abortions are immoral actions.
3. Metal music rocks.
4. Country music is terrible.

So, how do we know which quantifier to use? There aren’t strict rules for translating, but there are some useful guidelines. For instance, in “Junk food is unhealthy,” does the speaker mean *all* junk food or just *some*? If you cannot ask the speaker to be more specific, this is a judgment call. The standard default is to treat it as *all*, since it seems to refer to junk food generally. But this is not always the most charitable reading, since *all* is a very strong quantifier that is difficult to justify. But for our purposes, treat all claims without explicit quantifiers categorically (as “all” or “none”). We’ll say more about translating as we go through the material.

## Translating Singular Expressions and Proper Nouns

Singular expressions are expressions that refer to a single thing, like “this cat,” “that dog,” or “the house right there on 1st Ave. and Main Street,” while proper nouns refer to even more single things that have been named, things that begin with a capital letter like the state of Georgia, Michael Jackson, Kleenex, and Oxford University. When translating a singular expression or a proper noun, consider the singular or specific thing to be *something in a category all by itself*. Thus, the following are translated:

“This cat lives in the neighborhood” =

- “All things that are *this cat* are things that live in the neighborhood”

“Michael Jackson is no longer alive” =

- “No things that are *Michael Jackson* are things that are alive”

“Hey, these brownies are awesome!” =

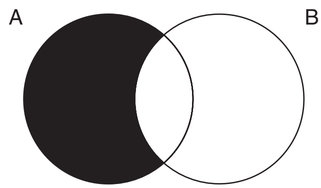
- "All things that are these brownies (just them) are things that are awesome"

"There are people in that house" =

- "Some people are things in that house"

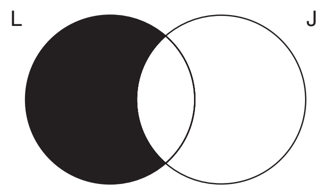
## A-claim: All A are B

A standard-form categorical A-claim has this form: **All A are B** (all things that are A are also things that are B), and its diagram is drawn like this:



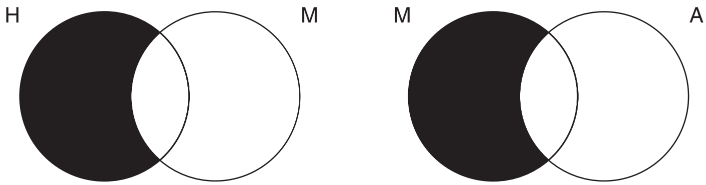

Notice that the football-looking intersection between A and B is left unshaded, while the rest of the A circle is shaded in. This expresses that there is no member (instance, individual, element) of A (shaded area = nothing) that *is not* a member of B; all of the *A*s are *B*s.

Consider the following A-claim which may or may not be true (another attempt at humor): "All lawyers are jerks." Its diagram would look like this:



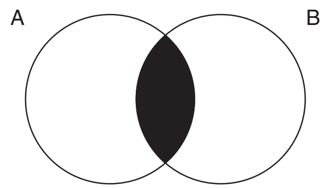

The shaded area indicates that nothing in the category of lawyers is not in the category of jerks; in other words, everything in the category of lawyers is also in the category of jerks. Note that the diagram merely pictorially represents the categorical claim—it does not indicate whether the claim is true or not. We're obviously joking (a bit) about all lawyers being jerks. We know one or two lawyers who aren't jerks.

Now consider the taxonomic ranking of organisms that is used by biologists all over the world, the one that goes from domain, down to kingdom, phylum, class, order, family, genus, and species. We know that humans are mammals, and mammals are animals. We use A-claims normally to speak about these relationships when we say, "All humans are mammals" and "All mammals are animals," and we can Venn diagram these claims like this:



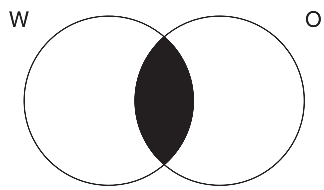

## E-claim: No A are B

A standard-form categorical E-claim has this form: **No A are B** (there are no things that are A that are also things that are B), and its diagram is drawn like this:



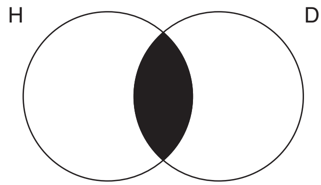

Notice that the football-looking intersection between categories A and B is shaded. This diagram expresses that there is no member of A (shaded area = nothing) that is a member of B. In addition, saying that No A are B is saying the same thing as No B are A, so you can switch the subject and predicate in an E-claim and preserve the meaning, as well as whether the claim is true or false.

Consider the E-claim "No women are one-thousand feet tall." The Venn diagram for this claim looks like this:




The shaded area indicates that there are no women in the category of things that are one-thousand feet tall, and it just so happens that this claim is true. Further, to say, "No things in the category of one-thousand feet tall are women" is saying the same thing as, "No women are one-thousand feet tall," and it is, likewise, true. Finally, the Venn diagram for "No things in the category of one-thousand feet tall are women" looks exactly like the one for "No women are one-thousand feet tall."

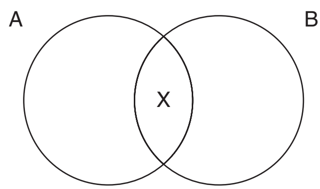
Considering again the taxonomic ranking of organisms, we know that humans are a different species from dogs, and we might even state this using an E-claim form, "No humans are dogs." The Venn diagram looks like this:




Again, given that “No humans are dogs” is true, “No dogs are humans” is also true, “No humans are dogs” is saying the exact same thing as “No dogs are humans,” and the Venn diagram for both claims looks exactly the same.

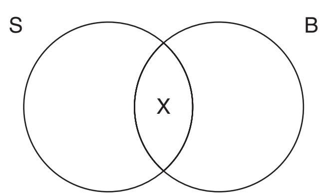
## I-claim: Some A are B

A standard-form categorical I-claim has this form: **Some A are B** (there is at least one thing—maybe more—in the A category that is a B), and its diagram is drawn like this:




Notice that the football-looking intersection between A and B has an X in it, indicating that there is at least one member of A that is also a member of B. When we say “Some” here, we mean “at least one”—however, there could also be more than one. We also mean that there is at least one in existence, referred to as the **existential assumption** (something we’ll talk about again at the end of this chapter). There is no shading because we do not know whether there are any *B*s that are not *A*s or whether there are any *A*s that are not *B*s. I-claims tell us *only* that *some A*s are *B*s. In addition, just like with an E-claim, saying that Some A are B is saying the same thing as Some B are A, so you can switch the subject and predicate in an I-claim and preserve the meaning, as well as whether the claim is true or false.

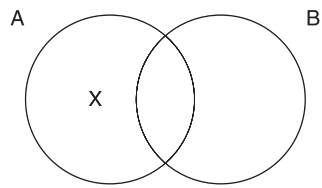
Consider the I-claim “Some snakes are brown colored.” The Venn diagram for this claim looks like this:



The X in the football-shaped area indicates that there is at least one snake that is brown colored, and it just so happens that this claim is true. The speckled brown snake is indigenous to South Australia and packs quite a venomous punch. Further, to say, "Some snakes are brown colored" is saying the same thing as, "Some brown-colored things are snakes," and it is also true. Finally, the Venn diagram for "Some snakes are brown colored" looks exactly like the one for "Some brown-colored things are snakes."

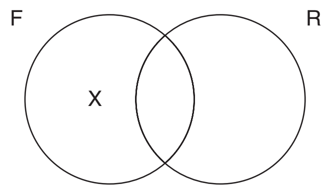
## The O-claim: Some A are not B

A standard-form categorical O-claim has this form: **Some A are not B** (there is at least one thing—maybe more—in the A category that is not a B), and its diagram is drawn like this:




Notice that the category A has an X in it, but there is no X in the area where A and B intersect (the football-shaped area), indicating that there is at least one A that is *not* a B.

Consider the O-claim, "Some fire hydrants are not red." In fact, many fire hydrants are yellow or gray, and some places paint them to look like R2-D2 from Star Wars. The Venn diagram for this claim looks like this:




### Getting familiar with … standard-form categorical claims

**Rewrite each of the following claims as an A-, E-, I-, or O-claim, and draw their Venn diagrams.**

1. All cats are mammals.
2. All Catholics are Christians.

3. No voters in the United States. are under eighteen years old.
4. No things made by humans are eternal.
5. C'mon, at least some Mormons are rational.
6. There are no US Civil War veterans still living.
7. Some like it hot!
8. Some Muslims are not violent.
9. At least some of our students are not rational.
10. No Catholics are Hindu.
11. Shelly and Zoe are not Hindu.
12. Lani, Mona, and Sue are women.
13. I know one man who likes Lady Gaga, and that's me.
14. Some of those grapes did not taste sweet.
15. There are lots of human men that are brown-haired.
16. Some women are firefighters.
17. Items in this bin are on sale.
18. No Christians are polytheists.
19. Dinosaurs are extinct.
20. Neera is Catholic.

## The Traditional Square of Opposition

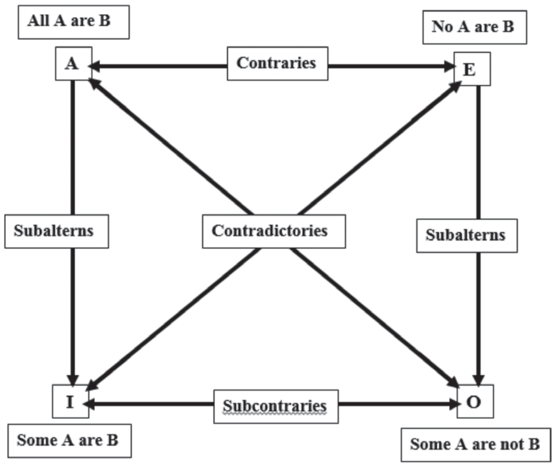
It is possible to give another kind of visual representation of categorical relationships, called the **square of opposition**. This visual representation, also given to us by Aristotle, helps us to understand intuitively certain relationships among categorical claims. When those relationships are laid out visually, they naturally form a square. A version of this square is presented in Figure 3.1.

## The Contrariety of A-Claims and E-Claims

A-claims and E-claims that correspond with one another (have the exact same subject and predicate) are called **contrary claims**, meaning they are never both true at the same time. If "All rooms in this motel are vacant" is true, then "No rooms in this motel are vacant" has to be false, and if "No rooms in this motel are vacant" is true, then "All rooms in this motel are vacant" is false. If "No people are adults" is true, then "All people are adults" is false.

But an interesting feature of contrary claims is that both claims might in fact be false. It might not be true that all rooms are vacant or no rooms are vacant. *Some* might be filled, making both claims false. "All people are

**Figure 3.1** The Traditional Square of Opposition




adults" and "No people are adults" are both false; some people are, and some aren't. This means that, when reasoning with contraries, if we know one of the contrary claims is false, we can't draw any conclusion about the other claim—it is **undetermined** as to whether the other is true or false. If we know that "All students at this school are on a scholarship" is false, we still can't say for sure whether "No students at this school are on a scholarship" is true or false. There could be some students who are on scholarship. Also, if we know that "No stop signs are red" is false, we still can't say for sure whether "All stop signs are red" is true or false. There could be stop signs that are not red (they were yellow in the United States for a time).

> **In a nutshell:**
>
> Contrary claims are never both true.
>
> Contrary claims can both be false.
>
> If one contrary claim is false, it is undetermined whether the other is true or false.

## The Subcontrariety of I-Claims and O-Claims

I-claims and O-claims that correspond with one another are called **subcontrary claims**, and they are never both false. If "Some rooms in this motel are vacant" is false, then "Some rooms in this motel are not vacant" has to be true, and vice versa. If "Some bachelors are not single" is false, which it is, then "Some bachelors are single" is true. (This sounds strange, we know. But recall that "some" means at least one. We know that a bachelor is a single man, so it's true that at least one bachelor is single, given that they're all single, by definition.)

Another thing about subcontrary claims is that both claims might in fact be true. "Some cats are black" and "Some cats are not black" both happen to be true. Also, "Some players in National League Baseball are not American born" and "Some players in National League Baseball are American born" both happen to be true.

However, if we know one of the subcontrary claims is true, we can't draw any conclusion about the other claim—it is undetermined as to whether it's true or false. If we come to a school campus for the first time and bump into two female students coming out of the library, then we know that "Some students at this school are female" is true; however, we still can't say for sure whether "Some students at this school are not female" is true or false. It could be that it's an all-girls school. Also, if we know that "Some stop signs in this town are red" is true, we still can't say for sure whether "Some stop signs in this town are not red" is true or false. It could be that all of the stop signs in this town are red.

**In a nutshell:**

Subcontrary claims are never both false.

Subcontrary claims can both be true.

If one subcontrary claim is true, the other is undetermined.

## The Contradiction of A- and O-claims, and E- and I-claims

Corresponding A-claims and O-claims, as well as corresponding E-claims and I-claims are **contradictory claims**, meaning that they have opposite truth values. If an A-claim is true, then an O-claim is false, and vice versa, while if an E-claim is true, then an I-claim is false, and vice versa. But unlike contrary claims, both claims cannot be false; and unlike subcontraries, both cannot be true. If one is false, the other must be true.

## The Super/Subalternation of A- and I-claims, and E- and O-claims

Look at the left and right sides of the square in the diagram. A- and I-claims and E- and O-claims are in a relationship of **superalternation** and **subalternation**. This means the following. If an A-claim is true, then the corresponding I-claim is true as well. "All cats are mammals" is true, as is "Some cats are mammals" (here, again, *some* meaning there is at least one thing that is a cat and it's a mammal). If an A-claim is false, then the corresponding I-claim is undetermined. If "All students here are male" is false because we met a female student, we can't say for sure that "Some students here are male" is true or false. It may be that all of the students are female. If an I-claim is true, then the corresponding A-claim is undetermined. From "Some people are taxpayers" we can't determine whether "All people are taxpayers" or not. If an I-claim is false, then the corresponding A-claim is false as well. "Some cats are dogs" is false, as is "All cats are dogs."

Likewise, if an E-claim is true, then the corresponding O-claim is true as well. "No cats are dogs" is true, as is "Some cats are not dogs" (we know, it doesn't quite sound right, but *some* means at least one, right?). If an E-claim is false, then the corresponding O-claim is undetermined. If "No students here are female" is false because we met a female student, we can't say for sure that "Some students here are not female" is true or false. It may be that all of the students are female. If an O-claim is true, then the corresponding E-claim is undetermined. If "Some people in this city are not taxpayers" is true, we can't determine whether "No people in this city are taxpayers" is true or false. If an O-claim is false, then the corresponding E-claim is false as well. "Some cats are not mammals" is false, as is "No cats are mammals."

Now, when you have a *true* A-claim or E-claim, you can infer the truth values of all corresponding claims in the square. For example, we know that:

"All vixens are female foxes" is true.

So, we also know:

"No vixens are female foxes" (its contrary) is false.

"Some vixens are not female foxes" (its contradictory) is false.

"Some vixens are female foxes" (its subalternate) is true.

We also know that "No tables are chairs" is true, so we know:

"All tables are chairs" (its contrary) is false.

"Some tables are chairs" (its contradictory) is false.

"Some tables are not chairs" (its subalternate) is true.

Further, when you have a *false* I-claim or O-claim, you can infer the truth values of all corresponding claims in the square. For example, we know that "Some people are immortal" is false, so:

"Some people are not immortal" (its subcontrary) is true.

"No people are immortal" (its contradictory) is true.

"All people are immortal" (its superalternate) is false.

And if "Some kings are not royalty" is false, then:

"Some kings are royalty" (its subcontrary) is true.

"All kings are royalty" (its contradictory) is true.

"No kings are royalty" (its superalternate) is false.

### Getting familiar with … the square of opposition

**For each of the following, answer *true* or *false*.**

1. If an A-claim is true, then an E-claim is false.
2. If No A are B is true, then All A are B is false.
3. If No A are B is false, then All A are B is true.
4. It's not possible for corresponding A-claims and E-claims to be false.
5. It's not possible for corresponding A-claims and E-claims to be true.
6. If All A are B is false, then No A are B is undetermined.
7. If an I-claim is true, then an O-claim is false.
8. If Some A are not B is true, then Some A are B is false.
9. If Some A are B is false, then Some A are not B is true.
10. It's not possible for corresponding I-claims and O-claims to be false.
11. It's not possible for corresponding I-claims and O-claims to be true.
12. If Some A are B is false, then Some A are not B is undetermined.
13. We know that "No cats are dogs" is true, so "Some cats are dogs" is obviously false.
14. If Some A are not B is true, then All A are B is false.
15. If Some A are B is false, then No A are B is true.
16. If an A-claim is false, then the corresponding I-claim is false.
17. If "Some fricks are not fracks" is false, then "No fricks are fracks" is false too.
18. If Some A are B is true, then All A are B is true.
19. If an A-claim is true, then the corresponding O-claim is undetermined.
20. If "Some snakes are not yellow" is false, then "No snakes are yellow" is false too.

## Conversion, Obversion, and Contraposition

Along with the square of opposition, there are three operations that help us draw immediate inferences from categorical claims: conversion, obversion, and contraposition.

## Conversion

Conversion is simply the process of taking one of the standard-form categorical claims and switching the subject and the predicate:

All A are B becomes All B are A (the converse of All A are B)

No A are B becomes No B are A (the converse of No A are B)

Some A are B becomes Some B are A (the converse of Some A are B)

Some A are not B becomes Some B are not A (the converse of Some A are not B)

The converses of E-claims (No A are B) and I-claims (Some A are B) are logically equivalent to one another in that they preserve their truth value: "No cats are dogs" is true and implies the truth that "No dogs are cats"; and "Some snakes are black things" is also true and also implies truly that "Some black things are snakes."

However, the converses of A-claims (All A are B) and O-claims (Some A are not B) are *not* equivalent to one another in that they *do not* preserve their truth value: "All cats are mammals" is true, but "All mammals are cats" is false, and, not incidentally, communicates something completely different. Also, if "Some students on scholarship are not sophomores" is true, then we can't say whether "Some sophomores are not students on scholarship" is true or not, and it communicates something completely different.

## Obversion

Obversion is the process of taking one of the standard-form categorical claims, changing it from the affirmative to the negative (A-claim becomes E-claim and vice versa, and I-claim becomes O-claim and vice versa), and replacing the predicate term with its **complementary term** (the term that names every member that is not in the original category, or the "non" of the term):

All A are B becomes No A are non-B (the obverse of All A are B)

No A are B becomes All A are non-B (the obverse of No A are B)

Some A are B becomes Some A are not non-B (the obverse of Some A are B)

Some A are not B becomes Some A are non-B (the obverse of Some A are not B)

All standard-form categorical claims are equivalent to their obverses:

"All cats are mammals" is true and means the same as "No cats are non-mammals"

"No cats are dogs" is true and says the same thing as "All cats are non-dogs"

"Some snakes are cows" is false and means the same as "Some snakes are not non-cows"

"Some snakes are not cows" is true and means the same as "Some snakes are non-cows"

## Contraposition

Contraposition is the process of taking one of the standard-form categorical claims, swapping the subject and the predicate, and replacing both with their complimentary terms:

All A are B becomes All non-B are non-A (the contrapositive of All A are B)

No A are B becomes No non-B are non-A (the contrapositive of No A are B)

Some A are B becomes Some non-B are non-A (the contrapositive of Some A are B)

Some A are not B becomes Some non-B are not non-A (the contrapositive of Some A are not B)

The contrapositives of A-claims (All A are B) and O-claims (Some A are not B) are equivalent to one another in that they preserve their meaning and truth value: "All cats are dogs" is true and says the same thing as "All non-dogs are non-cats," while "Some snakes are not black things" is also true and says the same thing as "Some non-black things are not non-snakes." (That's a mouthful and makes your head hurt … we know.)

However, the contrapositives of E-claims (No A are B) and I-claims (Some A are B) are *not* equivalent to one another in that they *do not* preserve their meaning and truth value: "No cats are dogs" is true, but "No non-dogs are non-cats" is not only false, but also communicates something completely different. And if "Some students on scholarship are sophomores" is true, then we can't say whether "Some non-sophomores are non-students on scholarship" is true or not, and it communicates something completely different.

## Translation Tips

You've already had a little practice translating various English phrases into categorical claims, but there are certainly more complicated English phrases to translate. In this section, we will explain how to translate some potentially difficult phrases.

## "Most"

What happens when a speaker means *most* instead of just *some*? Most is a strong quantifier, and we saw in the second chapter that the difference in meaning between *most* and *some* can determine the difference between a strong and a weak inductive argument. However, for the purpose of categorical logic, most and some will look the same on a Venn diagram. Since we don't know exactly how many there are, the best we can do is indicate that some are, recognizing that some is consistent with most. For instance, if we know that *most* Labour Party members are liberal, then we know that *some* are. Thus, for the purposes of categorical logic, "Most A are B" is categorically equivalent to "Some A are B." The same does not hold true going the other direction. If we know that some Labour Party members are conservative, we do not know whether most are. It is still *possible* that most are, but we cannot tell just from know that *some* are.

## Time and Place

When talking about a time (sometimes, always, never, every time, when), think in terms of the category of All, No, or Some "*times that* are BLANK" as in:

> "There are times when I am sad" becomes "Some times are times when I am sad"
>
> "At no time should he be allowed in" becomes "No times are times when he should be allowed in"
>
> "Whenever I eat, I usually burp" becomes "All times when I eat are times when I usually burp"
>
> "Every time I call her, she hangs up" becomes "All times I call her are times when she hangs up"

When talking about a place (some place, everywhere, nowhere, wherever, where), think in terms of the category of All, No, or Some "*places where* BLANK" as in:

> "Ghosts don't exist" becomes "No places are places where ghosts exist"
>
> "Gravity is everywhere" becomes "All places are places where there is gravity"
>
> "The keys are someplace" becomes "Some place is/are place(s) where the keys are"
>
> "Here is where we are on the map" becomes "All places that are here are places where we are on the map"

## Conditional Claims

Conditional claims have the "If …, then …" format, as in "If it is a cat, then it is a mammal." The way to translate these claims is fairly straightforward: They are translated as A-claims with the antecedent taking the "All A" spot, and the consequent taking the "…are B" spot. So, the claim, "If it is a bluegill, then it is a fish" becomes "All things that are bluegills are things that are fish."

This does not always work with events, though. For instance, the claim, "If it is raining, then the sidewalk is wet" becomes "All events that are raining are events in which the sidewalk is wet." This does not express what we would like, since the event of its raining *is not the same kind of event* as the sidewalk's being wet. Be cautious of categorical event claims. This is one of the limitations of categorical logic.

## Syllogisms and Testing for Validity with Venn Diagrams

Now that you have a clear sense of how to diagram categorical claims using Venn diagrams, we can finally see how to use categorical logic to test arguments for validity. Consider the following argument:

1. All squirrels are rodents.
2. <u>All rodents are mammals.</u>
3. Therefore, all squirrels are mammals.

Both premises are A-claims and it is fairly easy to see that, if the premises are true, the conclusion must be true, so the argument is deductively valid. But what happens when the quantifiers aren't so clear? Consider this next argument:

1. No dogs are meowers.
2. <u>All cats are meowers.</u>
3. No dogs are cats.

To evaluate arguments like this, we'll use a method called the **Venn diagram method** of testing for validity, named after logician and mathematician John Venn. We can use the Venn diagram method to evaluate arguments that meet exactly two conditions:

1. **There are three standard categorical claims.**
2. **There are three and only three categories.**

If an argument does not meet these conditions, the traditional Venn diagram method cannot be used to test for validity. Some logicians have devised more complex diagramming methods to test other arguments, but we will not discuss them here.

## Condition 1: There are three standard categorical claims

All the arguments we can evaluate with traditional Venn diagrams are *syllogisms*. A syllogism is an argument made up of exactly *one* conclusion and exactly *two* premises. If all the claims in the syllogism meet the conditions for a standard-form categorical claim, the argument is called a **categorical syllogism**. Recall that all arguments are either valid or invalid, since a conclusion will either follow necessarily from the premises (a valid argument) or it will follow with some degree of probability (an invalid argument). There are a whopping 256 possible types of syllogisms that can be constructed out of standard-form categorical claims; most of them are invalid.

## Condition 2: There are three and only three categories

It is also important to notice that the traditional Venn diagram method works *only* for arguments that include three categories of things. In our first two examples above, the first has the three categories: squirrels, rodents, and mammals. The second has dogs, cats, meowers. If there are only *one* or *two* categories, we can determine with a regular Venn diagram the truth of any claim we could derive from these premises; we wouldn't need the Venn diagram method. In addition, if there are *four or more* categories, any syllogism will be invalid. The following examples illustrate these difficulties:

1. All dogs are mammals.
2. <u>No turtles are amphibians.</u>
3. Therefore, … ?

   We can't conclude anything here except by applying the square of opposition to the premises. For example, "No turtles are amphibians" entails that "No amphibians are turtles."

1. No humans are Martians.
2. <u>No Martians are humans.</u>
3. Thus, … ?

The square of opposition tells us that these premises are equivalent to one another—recall conversion—but there is nothing much else we can say.

And don't let someone convince you that this next conclusion follows, because it doesn't:

1. All great artists are well-trained individuals.
2. <u>All persons are human-born.</u>
3. So, all great artists are human-born.

There are actually four categories of things here: (1) great artists, (2) well-trained individuals, (3) persons, and (4) human-born things. We don't know whether all well-trained individuals are persons—especially in the burgeoning era of AI—so, the conclusion does not follow validly.

Once you discover that your argument meets the two conditions of a categorical syllogism, you can evaluate it using a Venn diagram. The Venn diagram method has two steps:

1. **Diagram both premises (but not the conclusion).**
2. **Check to see if the conclusion is *already* depicted in the resulting diagram. If it is, then the argument is valid; if the conclusion isn't depicted, the argument is invalid.**

Consider, again, this argument:

**D M**

1. No dogs are meowers.

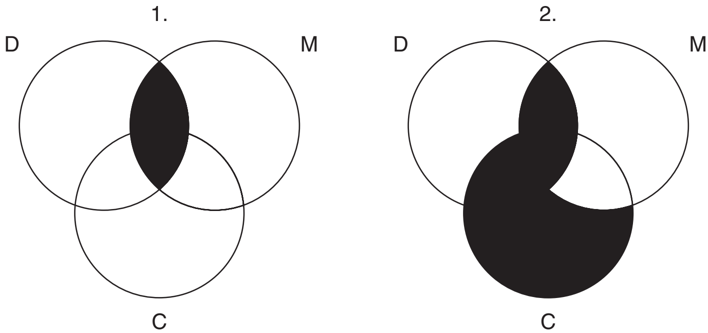
**C M**

2. <u>All cats are meowers.</u>

**D C**

3. No dogs are cats.

In order to evaluate this argument with the Venn diagram method, begin by drawing three overlapping circles, one for each category, D, M, and C. Then diagram both premises:




For the first premise, we black out the space between D and M. C is affected, but don't worry about that yet. For the second premise, everything that is a cat is pushed into M. Yes, part of M is already blacked out, but that's okay. That just means everything that is a cat is in the M circle, and not in the C or the D circles.

Now that both premises are diagrammed, check to see whether the conclusion ("No dogs are cats.") is diagrammed. DO NOT diagram the conclusion if it is not diagrammed. If the argument is valid, then the conclusion will already be diagrammed.

Is the conclusion diagrammed above? Yes. The football-shaped area between D and C is completely blocked out, indicating that there is no member of the dog category that is a member of the cat category; thus, no dogs are cats. Since diagramming the premises results in the diagram of the conclusion, the argument is valid. If diagramming the premises does not result in the diagram of the conclusion, the argument is invalid. Don't be thrown off by the fact that all of C and the rest of the football-shaped area between D and M are shaded in. All that matters is whether the football-shaped area between D and C is completely shaded, which it is.

Now consider this argument. We can Venn diagram it to check if it's valid or not.

**M** **U**

1. All mothers are people with uteruses.

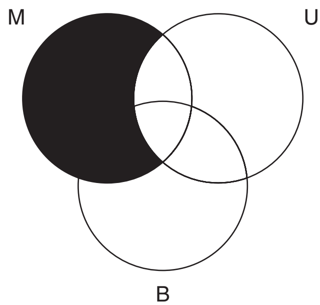
**U** **B**

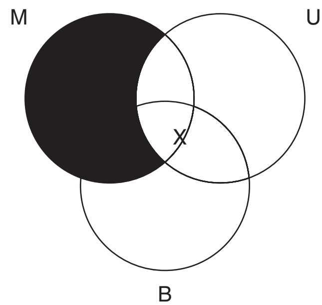
<u>2. Some people with uteruses are bankers.</u>

**M** **B**

3. Some mothers are bankers.

Begin, as before, by diagramming the first two premises:



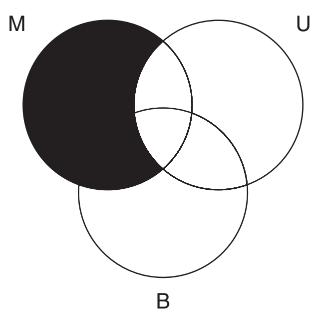



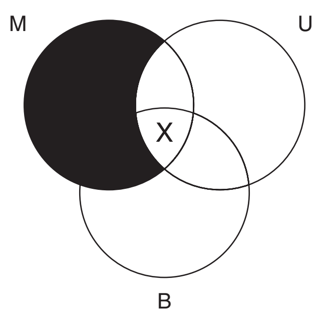

Now we ask whether the conclusion is diagrammed. In this case, the answer is no. Even though some people with uteruses are bankers—indicated by the X—we have no idea whether the X applies just to women with uteruses or also people with uteruses who are mothers. This is indicated by placing the X on the M line. Since the conclusion is not clearly diagrammed, this argument is invalid.

Another way to think about this visually by looking at the Venn diagram is like this: Given that half of the football-shaped area that intersects M and U is *not* shaded, we must place the X on the line. Let's do another diagram of a valid argument to explain what is meant here.

1. All mothers are people with uteruses.
2. Some bankers are mothers.
3. Some bankers are people with uteruses.

Diagram of the first two premises:



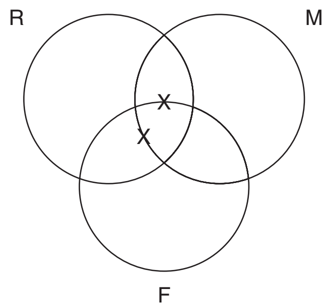




Since the half of the football-shaped area that intersects M and B *is* shaded, we must place the X in the part of the football-shaped area that is not shaded. Thus, we can see from the diagram that "Some bankers have uteruses" is indeed diagrammed, so that conclusion does in fact follow and the argument is valid.

Let's look at one more example:

1. Some rodents are mammals.
2. Some mammals have fins.
3. Some rodents have fins.

Begin by diagramming both premises:




In this argument, we cannot tell whether the rodents in the mammal category are also included in the fin category—so we put an X on the line in the football-shaped area where R and M intersect. Similarly, we cannot tell whether the mammals in the fin category are also included in the rodent category—so we put an X on the line in the football-shaped area where R and F intersect. Since these questions are not answered by the diagram, the conclusion is not clearly diagrammed; therefore, the argument is invalid.

## Valid Syllogisms, A-claims and E-claims, and the Distributed Middle Term

We've also learned something else from the diagram above. Anytime you see an argument where both premises use "Some" you can automatically conclude it will be invalid. In other words, if a syllogism has two premises that are two I-claims, two O-claims, or one of each, then it's invalid. If a syllogism is going to be unconditionally valid, then it *must* have at least one A-claim or E-claim. The valid syllogism we diagrammed used above is an example of this rule:

1. All mothers are people with uteruses (A-claim).
2. Some bankers are mothers (I-claim).
3. Some bankers are people with uteruses (I-claim).

The other important point to mention in a valid syllogism is the fact that the middle term is always "distributed." The **middle term** is the subject or predicate in both of the premises of the syllogism, but not in the conclusion. Here's an example:

1. All Christians are *monotheists*.
2. All *monotheists* are believers in one god.
3. Therefore, all Christians are believers in one god.

Here, *monotheists* (we italicized it) is the middle term. Our example above about mothers, bankers, and people with uteruses shows that the term *mothers* is the middle term:

1. All *mothers* are people with uteruses.
2. Some bankers are *mothers*.
3. Some bankers are people with uteruses.

A **distributed term** is one where *all* members of the term's class (not just some) are affected by the claim. Another way of saying this is that, when a term X is distributed to another term Y, then all members in the category denoted by the term X are located in, or predicated as a part of the category denoted by the term Y. So:

- An A-claim "distributes" the subject term to the predicate term, but not the reverse. "All cats are mammals" means that all members in the category of cats are distributed to (located in, predicated as a part of the category of) mammals, but not the reverse.
- An E-claim distributes the subject term to the predicate term, and vice versa—it's bi-directional in its distribution. "No cats are dogs" means that all members in the category of cats are *not* distributed to all members in the category of dogs, and vice versa.
- Both of the terms in an I-claim are undistributed. "Some democrats are conservative" means exactly what it says; some *but not all* members of the category of democrats are distributed to the category of conservatives, and vice versa. (They might be, since some is consistent with all, but some, by itself, doesn't imply all.)
- In an O-claim *only* the predicate is distributed. "Some fire hydrants are not red things" means that all members in the category of red things are *not* distributed to some of the members in the category of fire hydrants (we know, this sounds strange, but it's true).

**See the inside cover for a list of all fifteen unconditionally valid syllogism forms.**

### Getting familiar with … testing categorical arguments with Venn diagrams

**Test each of the following arguments for validity using the Venn diagram method.**

1. All frigs are pracks. All pracks are dredas. So, all frigs are dredas.
2. Some birds are white. White things are not black. Therefore, some birds are not black.
3. A few rock stars are really nice people. Alice Cooper is a rock star. Hence, Alice Cooper is a really nice person.
4. Democrats are liberals. Some liberals are not environmentalists. Therefore, some Democrats are environmentalists.
5. All CFCs (chlorofluorocarbons) deplete ozone molecules. CFCs are things that are produced by humans. Therefore, some things produced by humans deplete ozone molecules.
6. Black holes produce intense gravity. We haven't been able to study any black holes closely. Therefore, we haven't been able to study closely anything that produces intense gravity.
7. No drugs that can be used as medical treatment should be outlawed. Marijuana can be used as a medical treatment. Thus, marijuana should not be outlawed.
8. No genetically engineered foods are subsidized by the government. Some traditional foods are not subsidized by the government. Hence, some traditional foods are genetically engineered foods.
9. People who trust conspiracy theories are not good witnesses. A few clinically sane people trust conspiracy theories. So, some clinically sane people are not good witnesses.
10. Some lies are not immoral acts. Some immoral acts are fairly harmless. So, some lies are fairly harmless.

## The Limitations of Categorical Logic

There are a few major limitations of categorical logic that worry philosophers. First, as we have noted, categorical logic cannot be used to evaluate arguments including more than three categories. For example, we know that all domestic cats are cats, and all cats are mammals, which are animals, which are multicellular organisms; thus, we can conclude almost immediately that domestic cats are multicellular organisms. Yet, there are four categories of things mentioned and, so, it is not possible (without a computer) to use a single categorical syllogism to reason to this conclusion. We would need to use three categorical syllogisms, like this:

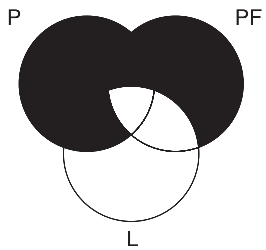
All DC are C
All C are M
All DC are M

All DC are M
All M are A
All DC are A

All DC are A
All A are MO
All DC are MO

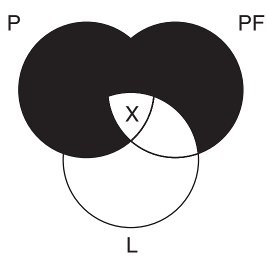
Another major limitation is that the quantifier "some" is ambiguous between "some are" and "some are not." For instance, does the claim, "Some politicians are liars," imply that some are not? If it doesn't, the following argument is invalid:

1. All politicians are public figures.
2. All public figures are liars.
3. Thus, some politicians are liars.




Since the conclusion is not diagrammed, the argument is invalid. We cannot infer that there really are any politicians who are liars (i.e., we can't tell from these premises; we may know for other reasons). The premises tell us something about the members of the categories "politicians," "public figures," and "liars." But what if there aren't any members? For instance, "All unicorns have one horn," can be diagrammed, but this doesn't tell us whether there *are* any unicorns. The same goes for, "All goblins are over 100 years old," "All Martians are aliens," and the like.

Nevertheless, the father of categorical logic, Aristotle, argued that we *should* assume there are some members in the categories we pick out. This is called an *existential assumption* (the assumption that something exists), and we mentioned briefly when we introduced the I-claim above. Without the existential assumption, the above argument is invalid. But *with* the existential assumption, we get the following diagram:



But can we put an X here, even though the premises do not indicate one? Aristotle argued that the premises *implicitly* indicate the existence of at least one member in the category. If it is true that "All politicians are public figures," there must be some politicians and some public figures in existence.

The problem is that it is not clear that we should ever make an existential assumption. You might think it is irrelevant. To test for validity, we simply assume the premises are true, so even if our claims are about mythical creatures, we assume they are true in order to test for validity. In this case, we make the existential assumption, then show that one of the premises is false. But this does not always work. Consider this argument:

**F** **P**

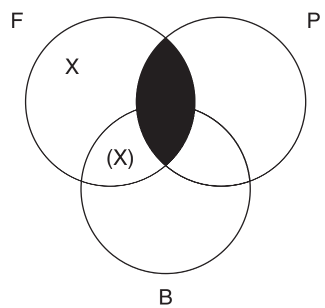
1. No professional football players have PhDs.

**F** **B**

2. Some professional football players are not ballet dancers.

**F** **B**

3. Some professional football players are ballet dancers.

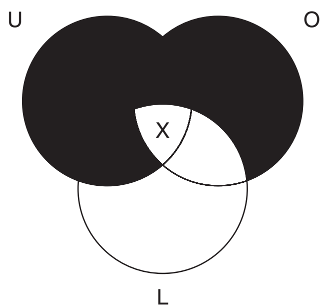



In this argument, both premises may be true. The conclusion is not explicitly diagrammed. But if we make an existential assumption, we must conclude that "Some football players are not ballet dancers" implies that some are. We would need to put an X in the overlap between F and B.

But, surely this does not follow necessarily from the premises. The claim "Some diamonds are valuable" is consistent with "All diamonds are valuable." Both can be true because "some" just means "at least one." Therefore, "Some diamonds are valuable" doesn't imply that "Some diamonds are not valuable." Similarly, just because some professional football players are not ballet dancers, we cannot infer that some are. That some professional football players are not ballet dancers is consistent with both, "Some professional football players are ballet dancers," and "No professional football players are ballet dancers." There is no principled way to decide whether to make an existential assumption. Because of this, philosophers largely reject the existential assumption.

Let's look at one final problem associated with the existential assumption. Take this argument:

1. All unicorns **(U)** are one-horned creatures **(O)**.
2. All one-horned creatures **(O)** live in Fairyland **(L)**.
3. So, some unicorns **(U)** live in Fairyland **(L)**.




Have you ever seen a real unicorn? Have you ever been to Fairyland? You get the point.

Despite its limitation to arguments with three categories and its ambiguity about existential assumptions, categorical logic can still be useful. We must simply recognize and compensate for these limitations. Propositional logic can help with this, as we will see in the next two chapters.

## Exercises

**A. Translate each of the following claims into one of the four standard-form categorical claims: *A*-claim, *E*-claim, *I*-claim, or *O*-claim, then Venn diagram.**

1. Hey, there are a few non-religious conservatives.
2. Marco, Diego, and Jim (all men) are firefighters.
3. Some CEOs are not greedy.
4. Everyone in Virginia is in the Eastern Time Zone.
5. We've heard that no one in England works past 3:00 p.m.
6. All AC/DC songs are songs that rock.
7. Every male fox cannot give birth.
8. Some voters in the UK are over ninety years old.
9. There are fire hydrants that are painted yellow.
10. Some Christians are Presbyterian.

11. Every human is an air-breather.
12. No cats are fish.
13. Some members of the Labour Party are not very liberal.
14. Liliana and Sheri (both women) are firefighters.
15. All things that are living are things that need water.
16. The internet is everywhere.
17. My computer gets a virus every time I go to that site.
18. If you give a mouse a cookie, he'll ask for milk.
19. If it's a unicorn, then it has one horn.
20. Most people enjoy sex.

**B. Answer *true* or *false* for each of the following questions about the square of opposition, conversion, obversion, and contraposition.**

1. If Some A are B is true, then Some A are not B is true.
2. If an E-claim is false, then the corresponding O-claim is false as well.
3. If an O-claim is true, then the corresponding I-claim is false.
4. Some A are not B becomes Some B are not A through obversion.
5. "All clouds are things with water" becomes "No things with water are not non-clouds" through obversion.
6. Some A are B becomes Some B are A through conversion.
7. Some A are not B is equivalent to Some non-B are non-A.
8. Some A are not B is equivalent to Some non-B are not non-A.
9. Contraries can both be false.
10. Contradictories can both be false.

**C. Test each of the following arguments for validity using Venn diagrams.**

1. Teens are not professional drivers. Some teens, however, are people who are good at simulated driving. Therefore, some people who are good at simulated driving are not professional drivers.
2. There are bears that aren't brown. Bears are hibernating animals. Thus, there are hibernating animals that aren't brown.
3. Minds calculate. Computers calculate. Therefore, minds are computers.
4. Exercising is good for you. Some activities are not exercising. So, some exercising is not good for you.
5. Catholics are not Muslims. Some Muslims are Shiite. Some Shiites are not Catholic.
6. Starbucks serves coffee. Some coffee is decaf. So, Starbucks serves decaf coffee.
7. Most airplanes have a transponder. All airplanes are winged vehicles. Therefore, some winged vehicles have a transponder.
8. No news is good news. Good news travels fast. Thus, no news travels fast!

9. No voters are persons under eighteen. All infants are persons under eighteen. Thus, no infants are voters.
10. All cats are mammals. Some mammals are not indigenous to Africa. So, some cats are not indigenous to Africa.
11. Idiots make bad choices. There are a few idiots who are living next door. So, I guess some people living next door make bad choices.
12. Dinosaurs are extinct. Some extinct things are not fossilized. Hence, some fossilized things are not dinosaurs.
13. Metallica rocks. If it rocks, it rolls, too. Metallica does not roll.
14. There are a few cats that are tabby cats. All cats are sweet. So, there are a few sweet things that are tabby cats.
15. Atheists are unbelievers, and some unbelievers are baptized persons; so, some baptized persons are atheists.
16. All killing is immoral. Abortion is killing. So, abortion is immoral.
17. All killing is immoral. Some abortions are killings. So, some abortions are not immoral.
18. Nothing that is purely material can think. Humans can think. Therefore, humans are not purely material.
19. Humans are purely material. Humans can think. Therefore, some things that are purely material can think.
20. All humans are morally responsible for their actions. Some things that are morally responsible for their actions have free will. Thus, some humans have free will.

## Real-Life Examples

## 1. The Anti-Vaccination Debate

**Political issues lend themselves to categorical claims, where one side wants to categorize everyone in the other camp as holding the same positions or beliefs. "All conservatives believe X!" "All liberals want Y!" The question of whether the government should require children to be vaccinated is a common political question. It came up again in 2015, with a measles outbreak in the United States. Numerous articles defending a variety of positions proliferated in intellectual publications like *Huffington Post*, *Slate*, and *The Atlantic*. Read the following excerpt from an article in *The Atlantic* and fill in the blanks in the categorical syllogisms below.**

* * * * *

The ignorance and poor judgment of anti-vaccine parents put their own children and the general public at significantly increased risk of sometimes deadly diseases. Anger is a reasonable response, and efforts should certainly be made to persuade all parents to vaccinate their kids save in rare cases of medical exceptions.

But I part with the commentators who assume that insulting, shaming, and threatening anti-vaccination parents is the best course, especially when they extend their logic to politicians. For example, Chris Christie is getting flak for “pandering” to anti-vaccination parents.

…

But isn’t Christie’s approach more likely to persuade anti-vaccine parents than likening their kids to bombs?

…

Like [some], I worry about this issue getting politicized. As he notes, there is presently no partisan divide on the subject. “If at some point, vaccinations get framed around issues of individual choice and freedom vs. government mandates—as they did in the ‘Christie vs. Obama’ narrative—and this in turn starts to map onto right-left differences … then watch out,” he writes. “People could start getting political signals that they ought to align their views on vaccines—or, even worse, their vaccination behaviors—with the views of the party they vote for.”

As a disincentive to this sort of thinking, folks on the right and left would do well to reflect on the fact that the ideology of anti-vaxers doesn’t map neatly onto the left or right, with the former willing to use state coercion and the latter opposing it.

…

When it comes to measles, my tentative thought is that the best way forward is to downplay the polarizing debate about coercion, wherever one stands on it, and to focus on the reality that ought to make it unnecessary: the strength of the case for vaccinating one’s kids, as demonstrated by the scientific merits of the matter as well as the behavior of every pro-vaccination elite with kids of their own.

…

Anti-vaxxers should not be pandered to but neither should they be callously abused. Neither of those approaches achieves what ought to be the end goal here: persuading enough people to get vaccinated that measles once again disappears.

* * * * *

1. **All things that are ____________________ are things that put children and the public at risk.**
2. **All things that put children and the public at risk are things we want to avoid.**

**3. Therefore, ….**

**1. Some things that ___________________ are things that are not likely to persuade anti-vaxxers to change their judgment.**

**2. All things unlikely to persuade anti-vaxxers to change their judgment are things we want to avoid.**

**3. Therefore, ….**

Excerpted from Conor Friedersdorf, "Should Anti-Vaxers Be Shamed or Persuaded? *The Atlantic*, February 03, 2015, http://www.theatlantic.com/politics/archive/2015/02/should-anti-vaxxers-be-shamed-or-persuaded/385109/.

## 2. Mexican Holy Week

**Read the following news report. Then, using information from the article, construct and Venn diagram two valid categorical syllogisms, one with the conclusion:**

Some innocent bystanders in Mexico City are at risk from cartel violence.

**(Here's a hint for a first premise:**

**"Some innocent bystanders were injured or killed by the cartels.")**

**and another with the conclusion:**

No Catholic clergy in Mexico city are afraid of cartel violence.

**(Here's a hint for a premise:**

**"No one who doesn't cancel Holy Week events is afraid of cartel violence.")**

* * * * *

**"Mexican clergy in trafficking areas won't change Holy Week activities"**

March 29, 2010 – Catholic News Service

MEXICO CITY (CNS)—Catholic officials in some of the regions hit hardest by the violence attributed to narcotics-trafficking cartels said they have no plans to alter or cancel Holy Week events. They also called on Catholics to work toward spiritual renewal during Holy Week, instead of dedicating the popular Mexican vacation period to leisure activities. Archbishop Felipe Aguirre Franco of Acapulco—the destination for hoards of Mexico City residents during Holy Week—called on visitors to the coastal city to "not fall into excesses (and) not participate in pagan festivals and drunkenness that, instead of honoring the passion and death of Christ, desecrate the sacred and truly Holy Week.” Palm Sunday activities kicked off Holy Week as violence attributed to the cartels escalated. The death toll has reached nearly 2,400 so far this year, the Mexico City newspaper *Reforma* reported, and innocent bystanders increasingly have been caught in the conflict. In Acapulco, which has a population of about 725,000, thirty-two deaths were recorded during the three-day weekend ending March 15. The head of one decapitated victim was left in front of a parish. Still, Father Juan Carlos Flores, spokesperson for the Archdiocese of Acapulco, said Holy Week activities would proceed as planned. In the northern city of Monterrey, Catholic officials also said they would not cancel Holy Week events, even though the region has been plagued by events such as presumed cartel members hijacking vehicles to block expressways and the early morning deaths of two graduate students as soldiers chased criminals cutting through the campus of an elite university. In Ciudad Juarez, where the violence has been most intense, the diocese planned a normal schedule of Holy Week events, although some of the hours were adjusted to coincide with daylight hours, said Father Hesiquio Trevizo, diocesan spokesperson.

# Basic propositional logic

# 4

**Here we introduce propositional logic and explain the basic concepts you will need to work with truth tables (which you will learn in Chapter 5) and for constructing propositional proofs (which you will learn in Chapter 6). We start by taking you all the way back to Chapter 1, expanding on our discussion of formal languages. We then explain how to translate English sentences into the symbolic language of propositional logic.**

## A New Language

As we have seen, categorical logic is useful, but only for a limited number of operations. It is not a sufficient logical system for reasoning about more than four categories, which we often do. And it does not suggest a way to resolve the problem of "some are not." Does "some are not" imply that "some are" or does it leave open the possibility that "all are not"? Both are consistent with the rules of categorical logic, and therefore, nothing about the system can help us resolve the inconsistencies that result. What we need, then, is a more powerful logical system—a system that does not suffer from these deficiencies. Thankfully, logicians in the twentieth century developed such a system.

This more powerful system is called **propositional logic** (also called **sentential logic**, the logic of formal sentences). It is the logic of *claims* or *propositions* rather than the logic of *categories*. It allows us all the power of categorical logic, plus more—though, as we will see, propositional logic is more complicated when it comes to categories. Over the next three chapters, we will cover the basics of propositional logic.

The material in this chapter and the following two is more difficult than anything in the rest of the book, so prepare yourself to spend a lot of time with the exercises. If you are using this book in a course, it might help to think of the classroom as an orientation tool. In class, you'll learn some of the basics of reasoning and watch your instructor work with the concepts. Between classes, you will want to work through the text on your own, trying to understand and apply the concepts using the "Getting familiar with …" exercises. Regardless of whether you are using this book on your own or in a course, you may have to re-read some passages while you are working through the exercises. This is normal; do not be discouraged. Just as you have to work math problems on your own and practice musical instruments to learn them, you must *do* logic to learn it, and that involves working problems over and over until the operations become clear.

Learning propositional logic involves learning a new language. You will learn to translate your natural language (English, Spanish, etc.) into the formal language of propositional logic. Your natural language allows you to use words in new and interesting ways, to introduce unique phrases, to modify grammatical rules as trends come and go, and to make exceptions for pragmatic or artistic purposes. Formal languages, on the other hand, are very rigid; all new phrases must follow the "grammar" (or *syntax*) of the language very strictly. There are rules for substituting forms of expression, but there are no exceptions. Despite their stodginess, the rigidity of formal languages makes them perfect for expressing and reasoning about very precise, technical claims, such as those found in math, philosophy, science, ethics, and even religion.

## Translating English Claims into the Language of Propositional Logic

Let's start with the basics: translating claims expressed in English sentences into claims of propositional logic. In this chapter and the next, we'll be concerned only with translating *whole, simple* claims and *whole, complex* claims, and their logical relationships. A whole, simple claim is just one subject and one predicate: It is a cat; you are a mammal; and the like. A whole, complex claim has an operator, which we will explain below. In Chapter 6, we will introduce ways of expressing parts of claims. In more advanced logic courses, you will translate and reason with more complex relationships: properties, relations, quantifiers, variables, and constants.

Whole, simple claims are translated using single capital letters. You may choose any letter you like as long as you use it consistently. Usually, you will choose a letter that reflects a word in the claim to help you remember which claim is being translated. For instance, the simple claim <It is a cat> may be translated: C, and the simple claim <It is a mammal> may be translated: M. Here are some examples of whole simple claims translated into propositional logic:

| Sentence of English | Sentence of Propositional Logic |
|---|---|
| Diego is a lawyer. | D |
| The company is broke. | C |
| It will be a sad day when the corporations finally collapse. | S |
| It is imperative that we find out who took the company's latest sales reports. | I |

Notice that a simple claim need not be short. But it must convey only one simple claim, that is, *a single subject-predicate couplet that does not include any operator* (recall our five operators: **and**; **or**; **not**; **if**…, **then**…; **if and only if**). If a claim does include an operator, you must translate the operator using its symbol, which we introduced in Chapter 1 and will review in the next section. While you can choose various letters for translating claims, you cannot do this for operators. These symbols are fixed by the system of logic you are using.

Just as in algebra, propositional logic allows you to use empty placeholders for claims, called **variables**. These are expressed in lower case letters, typically taken from the end of the English alphabet: p, q, r, s, t, u, v, w, x, y, z. Once you replace a variable with a meaningful English sentence, you use capital letters. So, a conjunction constructed from variables, might look like this: (p & q), whereas a conjunction of the English claims (It is a dog and it belongs to me), might look like this: (D & M).

## Translating Claims with Operators

The five operators from Chapter 1 help us express relationships among simple claims by allowing us to construct complex claims. Recall Figure 1.2:

**Figure 1.2** Logical Operators

| Operator | Symbol | Example |
|---|---|---|
| and | & | It is a cat **and** it is a mammal. |
| or<br>(sometimes requires "either") | v | It is **either** a cat *or* a skunk. |
| not | ~ | It is **not** raining. |
| if…, then… | ⊃ | **If** it is a cat, **then** it is a mammal. |
| if and only if | ≡ | He is a bachelor **if and only if** he is single. |

If we translate <It is a cat> as C, and <It is a mammal.> as M, the first example in Figure 1.2 becomes:

**(C & M)**

(C & M) is a **complex claim**. The parentheses are not needed in this example, since we can see clearly what the claim expresses. But as complex claims become more complicated, parentheses will help us read them correctly. The claim <Either it is a cat or it is a skunk.> can be translated:

**(C v S)**

If we conjoin (C & M) with (C v S), the parentheses help us see the relationship clearly:

**((C & M) & (C v S))**

Now we can add a new column to our chart:

| Operator | Symbol | Example | Translation |
|---|---|---|---|
| and | & | It is a cat **and** it is a mammal. | (C & M) |
| or<br>(sometimes requires "either") | v | It is **either** a cat **or** a skunk. | (C v S) |
| not | ~ | It is **not** raining. | ~R |
| if…, then… | ⊃ | **If** it is a cat, **then** it is a mammal. | (C ⊃ M) |
| if and only if | ≡ | He is a bachelor **if and only if** he is single. | (B ≡ S) |

## Well-Formed Formulas

Translating becomes more complicated when multiple complex claims are joined with operators. Parentheses help us make sense of claims in logic the way punctuation helps us make sense of claims in English. Consider the following English sentence without punctuation:

> **"tonight we are cooking the neighbors and their kids are stopping by around eight"**

This claim could mean:

> **"Tonight, we are cooking the neighbors. And their kids are stopping by around eight."**

More likely, of course, it means:

> **"Tonight, we are cooking. The neighbors and their kids are stopping by around eight."**

This is the power of punctuation. Parentheses do the same for propositional logic. For instance, consider two complex claims:

$C \supset M$

and

$D \supset B$

And let's let C mean <It is a cat>, M mean <It is a mammal>, D mean <It is a duck>, and B mean <It is a bird>. If we were to conjoin these claims, the result would be a complex claim stated:

$C \supset M \;\&\; D \supset B$

How would we translate this claim? Without parentheses, we would have to make arbitrary decisions about how to understand the meaning. As written in propositional logic, the claim might mean any one of the following:

> **A. If it is the case that, if it is a cat, then if it is a mammal and it is a duck, then it is a bird.**

or:

> **B. If it is a cat, then if it is a mammal and it's a duck, then it is a bird.**

or:

> **C. If it is a cat, then it is a mammal, and if it is a duck, then it is a bird.**

**Figure 4.1** Well-Formed Formulas

**Well-Formed Formulas (WFFs)**

1. Any simple claim or variable that represents a simple claim is a WFF.
   Example: "Pete left"; translation: L.
2. If A is a WFF, then ~A (not-A) is a WFF.
   Example 1: "She did not go"; translation: ~G.
   Example 2: "It did not rain or sleet"; translation: ~(R v S)
3. Any two WFFs joined with an operator and enclosed in parentheses is a WFF.
   Example 1: "It is wet and cold"; translation: W & C
   Example 2: "Either it is wet and cold or my eyes are playing tricks"; translation: ((W & C) v T)

Since only the last expresses what the original claim intends to express, we need to add something to our translation in order to make this clear. To keep your complex claims intelligible, mark off the component claims with parentheses. Translated into propositional logic, A, B, and C would look as follows:

**A. ((C ⊃ (M & D)) ⊃ B)**

**B. (C ⊃ ((M & D) ⊃ B))**

**C. ((C ⊃ M) & (D ⊃ B))**

A sentence of propositional logic that is not ambiguous is called a **well-formed formula (WFF)**. There is *only one way* to interpret a WFF. This is what gives logic its advantage over natural languages; it removes ambiguity. In order to be well-formed, a formula (i.e., sentence of propositional logic) must be constructed according to the following rules:

Notice that our original attempt at translating our claim is not a WFF:

C ⊃ M & D ⊃ B

It contains the WFFs, C, M, D, and B, and these are joined with operators, but since they are not properly enclosed in parentheses, the resulting complex claim is not a WFF. The disambiguated interpretations of this claim (examples A, B, and C above) are all WFFs. Because they are WFFs, it is easy to determine which meaning is intended.

For comparison, none of the following is a WFF:

| | |
|---|---|
| ))A v B | &v~A |
| ((A & B( | (A &v B) |

(AB) & (CC)    A v B & C

)A ⊃ B(    ~(A) & (B)

## The Major Operator

When complex claims are joined with operators, the resulting claim is still a complex claim defined by one (and only one) operator. When we say "defined by," we mean what ultimately determines the truth value of the claim. In the next chapter, it will be clearer precisely how the major operator performs this function. For now, simply note that the operator that determines the truth value of a complex claim is called the **major operator**.

For example, the truth of the complex claim ~F is defined by its only operator, a negation. In this case, its only operator is also its major operator. Alternatively, the claim ((C ⊃ M) & (D ⊃ B)) is defined by the "&," so despite the fact that it has conditionals as conjuncts, the resulting complex claim is a conjunction. The two "if…, then…" claims are minor operators. Remember that a conjunction is simply two claims joined with the "&" operator:

(p & q)

This is true for whatever claims stand in for *p* and *q*, no matter how complex. For example, although each of the following three claims is more complex than (p & q), each is still a conjunction. On the left you will see a conjunction; on the right, we have underlined each conjunct and highlighted the major operator in boldface type:

((A v B) & (C & D)) ⟶ ((A v B) **&** (C & D))

(((A & B) v C) & (D ⊃ (E v C))) ⟶ (((A & B) v C) **&** (D ⊃ (E v C)))

(A & (B ⊃ ((C v D) & B))) ⟶ (A **&** (B ⊃ ((C v D) & B)))

Here are three examples of complex claims with the conditional as the major operator:

(~A ⊃ B) ⟶ (~A ⊃ B)

((A & B) ⊃ (B v ~C)) ⟶ ((A & B) ⊃ (B v ~C))

(((A ⊃ B) v C) ⊃ D) ⟶ (((A ⊃ B) v C) ⊃ D)

Remember, every complex claim has a single (unique) major operator, and it might be any of our five operators. For instance, the following claim is a negation:

$$\sim(((A \vee B) \equiv (C \vee \sim D)) \,\&\, ((A \supset D) \supset ((C \vee D) \vee \sim A)))$$

The negation operator at the beginning ultimately determines the truth value of this claim, and so it is its major operator. However complex the claim, if there is a negation on the outside of all the parentheses, the claim is defined as a negation; that is its major operator.

> TIP for identifying major operators:
> The operator enclosed in the least number of parentheses is the major operator.

## Basic Translation

In many cases, English lends itself to propositional translations. "And," "or," and "not" commonly express what is meant by "&," "v," and "~." Commas are good indicators that one claim has ended, and another is about to start. This is not always the case, as we will see in the next section. But for now, consider these examples of how to translate English sentences into claims of propositional logic. Use these to help you work through the exercises in the "Getting familiar with … translation" box at the end of this section.

## Examples

1. If I ride with Tim, he will take the long route and stop for coffee.

| *Right* | *Wrong* | *Wrong* | *Wrong* |
|---|---|---|---|
| **$(R \supset (T \,\&\, S))$** | **$(R \supset S)$** | **$(R \supset T)$** | **$((T \,\&\, S) \supset R)$** |

2. The sun will not rise tomorrow.

| *Right* | *Wrong* | *Wrong* | *Wrong* |
|---|---|---|---|
| **$\sim S$** | **$(S \,\&\, R)$** | **$N$** | **$\sim(S \,\&\, R)$** |

3. Either he will do a good job and get a raise, or he will remain in middle-management forever.

| *Right* | *Wrong* | *Wrong* | *Wrong* |
|---|---|---|---|
| **$((G \,\&\, R) \vee M)$** | **$(G \,\&\, R \vee M)$** | **$(G \vee M)$** | **$(G \,\&\, (R \vee M))$** |

4. An object is gold if and only if it has atomic number 79.

| *Right* | *Wrong* | *Wrong* | *Wrong* |
|---|---|---|---|
| $(G \equiv A)$ | $(A \supset G)$ | $(G \supset A)$ | $(G)$ |

5. If it will either rain or snow, then I will either need an umbrella or a parka.

| *Right* | *Wrong* | *Wrong* | *Wrong* |
|---|---|---|---|
| $((R \vee S) \supset (U \vee P))$ | $(R \vee S \supset U \vee P)$ | $(R \supset U)$ | $(R \supset (U \vee P))$ |

6. Oil prices are astronomical.

| *Right* | *Wrong* | *Wrong* | *Wrong* |
|---|---|---|---|
| $O$ | $(O \supset A)$ | $(O \,\&\, A)$ | $(O \equiv A)$ |

7. Jim was born with male genitalia if and only if he has a Y chromosome.

| *Right* | *Wrong* | *Wrong* | *Wrong* |
|---|---|---|---|
| $(M \equiv Y)$ | $(M \supset Y)$ | $(Y \supset M)$ | $(M)$ |

8. Either I go to John's and she goes home, or I go to her house and she stays at John's.

| *Right* | *Wrong* | *Wrong* | *Wrong* |
|---|---|---|---|
| $((J \,\&\, G) \vee (H \,\&\, S))$ | $(J \vee S)$ | $(J \,\&\, G \vee H \,\&\, S)$ | $(J \,\&\, (G \vee H) \,\&\, S)$ |

9. She hasn't called in hours.

| *Right* | *Wrong* | *Wrong* | *Wrong* |
|---|---|---|---|
| $\sim S$ | $S$ | $\sim(S \,\&\, H)$ | $(\sim S \supset H)$ |

10. If God exists, then there is no unnecessary evil in the world.

| *Right* | *Right* | *Wrong* | *Wrong* | *Wrong* |
|---|---|---|---|---|
| $(G \supset \sim U)$ | $(\sim G \vee \sim U)$ | $(U \supset G)$ | $(\sim U \supset G)$ | $(G \supset U)$ |

## Getting familiar with … translation

**A. Translate the following simple and complex English sentences into claims of propositional logic. If the claim is complex, also identify the major operator.**

1. It is either a cat or a skunk.
2. It flies.
3. If it flies, it is either a bird or a plane.
4. It looks very strange for a bird or plane.
5. Either it is a bird and it is deformed or it is a plane and it's very small.
6. If it is a bird and it is deformed, then someone either burned it or painted it.

7. It is not a plane.
8. If someone burned it, it would not be hopping around so happily.
9. It is hopping around happily.
10. If it was not burned, then someone must have painted it.
11. Gold was discovered this morning in Buenos Aires.
12. Gold was not discovered this morning in Buenos Aires.
13. If there are five of us, then we will either need to pull up a chair or sit at adjacent tables.
14. There are ten things on my desk; one of them is a pen and one of them is a book.
15. Either there are ten things on my desk or I miscounted, or you stole something off of it.
16. If I am thirty and you are thirty-five, then both of us (both you and I) are old enough to have seen episodes of Cheers.
17. There are no sandwiches left in the kitchen, and if there were, you could not have any.
18. The *Magnificent Seven*, the Western, is an adaptation of Kurusawa's classic film, *Seven Samurai*.
19. If I am awake and it is three o'clock in the morning, then either tomorrow is going to be a terrible day, or I will drink a lot of coffee.
20. If you drink a lot of alcohol and then try to drive, you not only increase your chances of an accident, you also increase your chances of hurting someone.

**B. Using the interpretations provided, translate the following claims of propositional logic into English.**

1. [T = I throw the ball; W = The window will break.] (T ⊃ W)
2. [R = You're a Republican; D = You're a Democrat.] (((R v D) & ~R) ⊃ D)
3. [R = It is raining; S = The sidewalks are wet.] (((R ⊃ S) & R) ⊃ S)
4. [S = It snowed; R = The roof collapsed.] (((S ⊃ R) & ~R) ⊃ ~S)
5. [R = It is raining; B = I bring my umbrella; W = I get wet.] ((R & ~B) ⊃ W)
6. [B = The dog will bite; F = The dog is friendly; P = I will pet the dog.] ((B v F) & ((F ⊃ P) & (B⊃ ~P)))
7. [P = I pay for the ticket; K = I get kicked out.] (~(~P ⊃ K) ⊃ ~P)
8. [P = I am a professor; D = I have a Ph.D.; T = I have teaching experience.] (P ≡ (D & T))
9. [P = He went to the park; R = He went to the restaurant; S = He is on the swings; J = He is on the jungle gym.] ((P v R) & ((P ⊃ (S v J)))
10. [D = She is a (medical) doctor; M = She went to medical school; L = She is licensed; I = She is immoral; H = She is a hack.] ((D ≡ M) & (~L ⊃ (I v H)))

# Tips for Translating More Difficult Phrases

When English words express operators explicitly (and, or, not, etc.) translation is fairly straightforward. But English is an incredibly diverse language that offers many ways of expressing these operators. Study the following alternatives, and use them to help you work through the exercises in the "Getting familiar with … more difficult translations" box at the end of this section.

**Alternative ways to say "&":**

**but**

| | |
|---|---|
| p but q. | (p & q) |
| He is a nice guy but he is a liar. | (N & L) |
| She went to the station but she didn't take her dog. | (S & ~T) |

**however**

| | |
|---|---|
| p, however, q. | (p &q) |
| He went there after work. However, he drove the company truck. | (A & D) |
| She didn't go to the store; however, she did stop to get the mail. | (~S & M) |

**furthermore**

| | |
|---|---|
| p. Furthermore, q. | (p & q) |
| It's not right. Furthermore, it has bad consequences. | (~R & B) |
| The policy was fast-tracked through the committee. Furthermore, it was approved. | (F & A) |

**moreover**

| | |
|---|---|
| p. Moreover, q. | (p & q) |
| The roof is leaking. Moreover, the wall is cracked. | (L & C) |
| The door does not block sound; moreover, it doesn't keep out cold. | (~B & ~ K) |

**in addition**

| | |
|---|---|
| p. In addition, q. In addition to p, q. | (p & q) |
| She wants the TV. In addition, she wants both chairs. | (T & C) |
| In addition to the cooler, bring some ice. | (C & I) |

**yet**

| | |
|---|---|
| p, yet q. | (p & q) |
| He is bitter, yet tolerable. | (B & T) |
| It was a long winter. Yet, it was an enjoyable one. | (L & E) |

**although**

| | |
|---|---|
| p, although q. Although p, q. | (p & q) |
| Although she was angry, she was nice to me. | (A & N) |

The door was locked although I told you not to lock it.
(L & T)

**An alternative way to say "v":**

| | |
|---|---|
| **unless** | |
| p unless q. | (p v q) |
| She's going to leave unless you say something. | (L v S) |
| You should stop doing that unless you want a knuckle sandwich. | (S v K) |

**Alternative ways to say "~":**

| | |
|---|---|
| Not p. | ~p |
| It is not the case that space is two-dimensional. | ~S |
| He isn't buying your argument. | ~B |
| She didn't win. | ~W |

**Alternative ways to say "⊃":**

| | |
|---|---|
| **if** | |
| p if q. | (q ⊃ p) |
| The cab is available if the light is on. | (L ⊃ A) |
| The sidewalks are wet if it has been raining. | (R ⊃ S) |
| It is a person with a uterus if it is a mother. | (M ⊃ F) |
| **only if** | |
| p only if q. | (p ⊃ q) |
| The cab is available only if the light is on. | (A ⊃ L) |
| It has been raining only if the sidewalks are wet. | (S ⊃ R) |
| It's a cat only if it is a mammal. | (C ⊃ M) |
| **so** | |
| p, so q. | (p ⊃ q) |
| I'm taller than six feet, so I can touch the door frame. | (S ⊃ T) |
| You're wrong, so I'm right. | (W ⊃ R) |
| **necessary condition** | |
| p is necessary for q | (q ⊃ p) |
| Being a mammal is necessary for being a cat. | (C ⊃ M) |
| It is necessary that she complete the course in order to move on. | (M ⊃ C) |
| **sufficient for** | |
| p is sufficient for q. | (p ⊃ q) |
| Being a cat is sufficient for being a mammal. | (C ⊃ M) |
| Being a tree is sufficient for being a plant. | (T ⊃ P) |

**Alternative ways to say "≡":**

| | |
|---|---|
| **just in case** | |
| p just in case q. | (p ≡ q) |
| He's a bachelor just in case he is an unmarried man. | (B ≡ U) |
| A person is born with female genitalia just in case she has two X chromosomes. | (W ≡ X) |
| **just if** | |
| p just if q. | (p ≡ q) |
| I'm going to the party just if she goes. | (I ≡ S) |
| He's a lawyer just if he's been to law school and has passed the bar. | (L ≡ (S & B)) |

| **necessary and sufficient** | |
|---|---|
| p is necessary and sufficient for q. | $(p \equiv q)$ |
| The cab's light's being on is necessary and sufficient for the cab's being available. | $(A \equiv L)$ |
| Being a single man is necessary and sufficient for being a bachelor. | $(S \equiv B)$ |

**Other difficult English expressions:**

| **neither…nor… / not… and not…** | $(\sim p \; \& \sim q)$ |
|---|---|
| It's both not round and not green. | $(\sim R \; \& \sim G)$ |
| She is neither happy nor rich. | $(\sim H \; \& \sim R)$ |
| It's not raining or snowing. | $(\sim R \; \& \sim S)$ |
| It's not easy or painless. | $(\sim E \; \& \sim P)$ |

| **not both / it is not the case that p and q** | $\sim(p \; \& \; q)$ |
|---|---|
| You cannot have both ice cream and a candy bar. | $\sim(I \; \& \; C)$ |
| You either get it or you don't. | $\sim(G \; \& \sim G)$ |
| It is not both cool and warm at the same time. | $\sim(C \; \& \; W)$ |

| **not p and q** | $(\sim p \; \& \; q)$ |
|---|---|
| It's not easy and she likes it. | $(\sim E \; \& \; L)$ |
| It's not fun but it's a paycheck. | $(\sim F \; \& \; P)$ |
| You shouldn't look, but you should duck. | $(\sim L \; \& \; D)$ |

| **p unless q / if not p, then q** | $(p \vee q)$ or $(\sim p \supset q)$ |
|---|---|
| She won't go unless he does. | $(\sim S \vee H)$ or $(\sim\sim S \supset H)$ |
| The sign is on unless we're closed. | $(S \vee C)$ or $(\sim S \supset C)$ |
| The glass will break unless he grabs it. | $(B \vee G)$ or $(\sim B \supset G)$ |

| **except when (same as "p unless q")** | $(p \vee q)$ or $(\sim p \supset q)$ |
|---|---|
| She teaches except when she is sick. | $(T \vee S)$ or $(\sim T \supset S)$ |
| The door is open unless I am out. | $(D \vee O)$ or $(\sim D \supset O)$ |
| Students don't fail except when they skip class. | $(\sim F \vee S)$ or $(\sim\sim F \supset S)$ |

## Getting familiar with … more difficult translations

**Translate each of the following into propositional logic.**

1. The tide is coming in. Moreover, it's getting dark.
2. Unless you want to spend the night in jail, you should come home.
3. Passing 130 semester hours of courses in the right distribution is necessary and sufficient for graduating college.
4. You can have candy or bananas, but not both.
5. He's a lawyer, but he is also a nice guy, and if you ask nicely, he might even work for free.
6. You are an alcohol drinker just if you drink alcohol, but you're legally allowed to drink alcohol just in case you're over 21.
   (Caveat: In the United States, the legal drinking age is 21.)

7. If it is not the case that I'm held accountable for my actions, then there is no real reason to care about morality.
8. You shouldn't lie. However, if an innocent person's life is at stake and lying would prevent her death, then you should lie.
9. Number 8 contains a contradiction. It cannot be the case that both "You should lie" and "Sometimes, you should lie."
10. The president of the company is neither good nor prudent. Furthermore, if he doesn't stop complaining, we will replace him.
11. You are not safe traveling to Brazil unless you are with a group.
12. Unless you move out of the city, you will not really be able to enjoy all the country life has to offer.
13. There are no meals served aboard this flight; however, it is very short.
14. Neither are we tired from our trip, nor are we hungry. Although we would be happy to have a drink unless you would rather start the tour.
15. There are three fallacies in your argument and no sources cited. Moreover, your spelling is atrocious.
16. "If perception were just unembellished sensation, we would experience a chronic lacuna where this nerve interrupts our visual field. But we do not, because our brain automatically corrects the problem through a process known as coherencing." (from Kathryn Schulz, *Being Wrong: Adventures in the Margin of Error* (New York: Ecco, 2010), p. 57.)
17. "Competitive cultures train their members to compete, but the training is not the same for everyone." (from Alfie Kohn, *No Contest: The Case Against Competition*, revised edition (Boston: Houghton Mifflin, 1992), p. 168.)
18. "A belief can be unsafe because the subject might too easily become disabled, or because the conditions might too easily become inappropriate." (from Ernest Sosa, *A Virtue Epistemology*, Vol. 1 (Oxford: Oxford University Press, 2007), p. 82.)
19. "Without such a hierarchy, neither rational conduct nor considered value judgments nor moral choices are possible." (from Ayn Rand, "The Ethics of Emergencies," in *The Virtue of Selfishness* (New York: Signet, 1964), p. 50.)
20. "The situation may look even worse if one considers that the traditions, institutions and beliefs mentioned not only fail to meet the logical, methodological, and epistemological requirements stated, but that they are also often rejected by socialists on other grounds too." (from F. A. Hayek, *The Fatal Conceit: The Errors of Socialism* (Chicago: University of Chicago Press, 1988), p. 67.)

# Translating Arguments

What does learning how to translate do for us? It does two important things. First, it helps us make our claims clear and precise. Second, it helps us evaluate an important dimension of arguments, namely, the relationship between the premises and the conclusion, without the meaning of English words distracting or misleading us.

In Chapter 2, we introduced some intuitive cases where a conclusion follows from a premise or set of premises with certainty. For example:

| | |
|---|---|
| 1. If it is raining, then the sidewalk is wet. | 1. Either it is the starter or the battery. |
| 2. It is raining. | 2. It is not the battery. |
| 3. Therefore, the sidewalk is wet. | 3. Therefore, it is the starter. |

If we translate these arguments, we get:

| | |
|---|---|
| 1. (R⊃ S) | 1. (S v B) |
| 2. R | 2. ~B |
| 3. S | 3. S |

Of course, in these examples, it is easy to see that the conclusions follows with certainty from the premises. But *why* do they follow with certainty? Consider some alternatives:

| **1.** | **2.** | **3.** | **4.** |
|---|---|---|---|
| 1. (R ⊃ S) | 1. (R ⊃ S) | 1. (S v B) | 1. (S v B) |
| 2. S | 2. ~R | 2. S | 2. B |
| 3. R | 3. ~S | 3. ~B | 3. ~S |

Without replacing these symbols with English words, it is difficult to determine whether arguments 1–4 are valid (recall from Chapter 2 that an argument is **valid** if it is not possible for the premises to be true and the conclusion false). As it turns out, none of these four is valid. In addition, the whole motivation for developing a formal language is that it is often just as difficult to determine when a natural language argument is valid. Consider the following:

1. If the experiment yields diphenhydramine or hydrochloric acid, then either we made a mistake in judgment or a mistake in our experimental controls.
2. The experiment did not yield diphenhydramine or hydrochloric acid.
3. We didn't make a mistake in judgment or a mistake in experimental controls.

Is this argument valid? It may be difficult to say if you are unfamiliar with logical forms. Nevertheless, let us translate this English claim into our simple propositional language, call it example 5:

**5.**

1. ((D v H) ⊃ (J v C))
2. ~(D v H)
3. ~(J v C)

Even if you don't know what "diphenhydramine" is, we can look at the argument's form and determine that it is *not valid*. Compare 5 with example 2 above. We told you that 2 is invalid (even though we haven't explained why yet). Notice that, when you look at the major operators, 5 has the same form as 2:

| **5.** | **2.** | |
|---|---|---|
| 1. ((D v H) ⊃ (J v C)) | 1. (R ⊃ S) | ← Both of these are conditionals. |
| 2. ~(D v H) | 2. ~R | ← Both of these are negations and deny the antecedent of premise 1. |
| 3. ~(J v C) | 3. ~S | ← Both of these are negations and deny the consequent of premise 1. |

> To see this comparison more clearly, think of the argument on the right as a simplified version of the one on the left. Let "R" be a replacement for "(D v H)" and let "S" be a replacement for "(J v C)."

Since their forms are identical, if 2 is invalid, then 5 is invalid. This is why argument form is important. It allows us to see clearly the relationship between the premises and conclusion.

So, now the question is: How do we tell whether an argument form is valid? There are a number of methods, and you've already learned how to test simple categorical arguments for validity using the Venn diagram method in the previous chapter. Over the next two chapters, we will introduce two methods for testing validity in propositional logic: the *truth table method* and the *proof method*. In Chapter 5, we will explain truth tables and the truth table method of testing for validity. In Chapter 6, we will explain the most common rules of inference, which you will use to derive proofs in propositional logic.

## Exercises

**A. Translate the following complex claims into propositional logic:**

1. There will be a lunar eclipse next week—and it will be the last one for seventy-five years!
2. Eating vegetables is good for you; but eating too many vegetables in a short time might have negative consequences.
3. The Royals will either win their opening day game or lose it—and that will either put them in first place or some other place in the standings.
4. The detective has either caught the culprit or accused an innocent person of a crime they didn't commit, but it is not the case that the detective failed to catch the culprit.
5. Number 4 could be a false dilemma. It might be the case that the detective did catch a culprit for some other crime, but not the *specific* culprit for the *specific* crime the detective was looking for. So, although the detective failed to catch the murderer, for example, the detective still caught the shoplifter.
6. According to the popular streaming platform, Twitch, VTubers are AI. However, VTubers who are not AI claim that they, along with most other VTubers they know, are, in fact, not AI. So, VTubers are either AI or they are not, but they cannot be both AI and not-AI simultaneously.
7. If I do not have my car keys on me at this moment, then I either left them in my office or they were stolen.
8. In order to pass this class, it is both necessary and sufficient that you score at least a C- on all three exams for the semester.
9. If you want to run for president, you must be both at least thirty-five years old and a naturally born citizen of the United States.
10. The writing is on the wall and the check is in the mail, and if this is true, then you only have two choices: pack it in now or stick around for the long haul.
11. You shouldn't be telling me what to do unless you think you can take responsibility for my running this company into the ground or for turning it into a Fortune 500 company.
12. If it's not the case that you're sick and it is not the case that your kids or spouse is sick, then you should be getting dressed for work or risk not getting that promotion.

13. If Aren quits soccer, then Tony will quit, too; but, if Shay quits soccer, then Nishen *and* Aren will quit, too. Therefore, if Shay quits soccer, then Nishen, Aren, and Tony will quit as well.
14. "To be or not to be—that is the question; whether tis nobler in the mind to suffer the slings and arrows of outrageous fortune or to take arms against a sea of troubles and by opposing end them" (from *Hamlet*, Act III: Scene 1, by William Shakespeare).
15. "The proscribing any citizen as unworthy the public confidence by laying on him an incapacity of being called to offices of trust or emolument, unless he profess or renounce this or that religious opinion, is depriving him injudiciously of those privileges and advantages to which, in common with his fellow-citizens, he has a natural right." (From "A Bill for Establishing Religious Freedom," Thomas Jefferson, 1779).
16. "All that up to the present time I have accepted as most true and certain I have learned either from the senses or through the senses; but it is sometimes proved to me that these senses are deceptive, and it is wiser not to trust entirely to anything by which we have once been deceived." (From *Meditations on First Philosophy*, by René Descartes, meditation 1.)
17. "[During the Enlightenment] Opposition to belief in God increased because it was used by princes ruling by God's grace, by cardinals, bishops, and priests as a means of preventing the diffusion of the 'light of reason' and of keeping the people in tutelage and servitude." (From *Does God Exist?* by Hans Küng, §A.II.4.)
18. "If my letters are condemned in Rome, then what I condemn in them is condemned in heaven." (From *Pensées*, fr. 919, by Blaise Pascal trans. W. F. Trotter.)
19. "The framework of bones being the same in the hand of a man, wing of a bat, fin of the porpoise, and leg of the horse,—the same number of vertebrae forming the neck of the giraffe and of the elephant,—and innumerable other such facts, at once explain themselves on the theory of descent with slow and slight successive modifications." (From *The Origin of Species*, 1st edition, by Charles Darwin, chapter XIV.)
20. "Well, sir, it's surprising, but it well may be a fact that neither of them does know exactly what that bird is, and that nobody in all this whole wide sweet world knows what it is, saving and excepting only your humble servant, Caspar Gutman, Esquire." (From *The Maltese Falcon*, by Dasheill Hammett, chapter 11.)

**B. Using the translation guide, translate the following sentences of propositional logic into English:**

1. [D = It is the dog; B = It is the bird; F = It is the fish.] $(\sim D \supset (B \vee F))$
2. [H = It is hot; S = I am sick; T = The thermostat is working.] $((\sim H \ \& \ S) \vee \sim T)$
3. [A = It is always raining; D = It is at least depressing; F = It is fun.] $((\sim A \supset D) \ \& \ (D \supset \sim F))$
4. [C = I am cleaning the bathroom; W = You are washing dishes; S = You are scrubbing the floors.] $(C \supset (W \vee S))$
5. [B = We're going to Bonnaroo; A = Annie can go; D = You agree to drive half the time.] $(B \supset (A \equiv D))$
6. [T = I throw the ball; W = The window will break.] $(T \supset W)$
7. [R = You're a Republican; D = You're a Democrat.] $(((R \vee D) \ \& \sim R) \supset D)$
8. [R = It is raining; S = The sidewalks are wet.] $(((R \supset S) \ \& \ R) \supset S)$
9. [S = It snowed; R = The roof collapsed.] $(((S \supset R) \ \& \sim R) \supset \sim S)$
10. [R = It is raining; B = I bring my umbrella; W = I get wet.] $((R \ \& \sim B) \supset W)$

**C. For each of the following, construct your own translation guide for each, then translate into English. (Don't worry about finding words that start with the capital letters given.)**

1. $((P \supset Q) \ \& \ R)$
2. $((S \vee L) \supset \sim H)$
3. $((A \supset B) \vee (C \supset D))$
4. $((A \ \& \ B) \supset \sim(P \vee Q))$
5. $((P \supset \sim R) \ \& \ (\sim R \supset (Q \ \& \ S)))$

**D. Reformulate the following arguments, removing extraneous material and rhetorical devices, then translate them into propositional logic:**

1. It was a dark and stormy night. The wind blew relentlessly against the house. All the elves were sleeping. If all the elves were sleeping, then the caves were silent. If the caves were silent, the air would be thick like mud. Therefore, the air was thick like mud. It smelled really bad.
2. You seem to get into arguments with Steve pretty often. Steve is kind of a hot head. You should step lightly, but only if you don't want to be taken seriously. But if you know what's good for you, you want to be taken seriously. You know what's good for you, therefore you should step lightly.
3. Do you know what really makes me mad? Government programs. Take government-sponsored health care, for example. A government-sponsored health-care program requires heavily taxing all citizens.

Excessive taxation is no different than stealing from hard-working people. Stealing from people is immoral. Therefore, government-sponsored health care is immoral. We should not vote for anyone who proposes such a policy. I really hate those people.

4. "If within the same church miracles took place on the side of those in error, this would lead to error. The schism is obvious, the miracle is obvious, but schism is a clearer sign of error than a miracle is of truth: therefore the miracle cannot lead to error. But apart from schism error is not as obvious as a miracle; therefore the miracle would lead to error." (From *Pensées*, fr. 878, by Blaise Pascal, trans. A. J. Krailsheimer.)
5. "When we put together three things—first, the natural attraction between opposite sexes; secondly, the wife's entire dependence on the husband, every privilege or pleasure she has being either his gift, or depending entirely on his will; and lastly, that the principle object of human pursuit, consideration, and all objects of social ambition, can in general be sought or obtained by her only through him, it would be a miracle if the object of being attractive to men had not become the polar star of feminine education and formation of character." (From *The Subjection of Women*, by John Stuart Mill, chapter 1.)
[Hint: Mill is arguing that the education system of his day encourages women to be wholly dependent on men. His conclusion has a bit of rhetorical flourish: Given these cultural facts, how could you expect any different?]
6. "Our civil rights have no dependence on our religious opinions, any more than our opinions in physics or geometry; and therefore the proscribing any citizen as unworthy the public confidence by laying on him an incapacity of being called to offices of trust or emolument, unless he profess or renounce this or that religious opinion, is depriving him injudiciously of those privileges and advantages to which, in common with his fellow-citizens, he has a natural right." (From "A Bill for Establishing Religious Freedom," Thomas Jefferson, 1779).
7. (1) "If it could be demonstrated that any complex organ existed which could not possibly have been formed by numerous, successive, slight modifications, my theory would absolutely break down." (Charles Darwin, *The Origin of Species*, 6th edition, p. 154.) (2) "An irreducibly complex system cannot be produced directly…by slight, successive modifications of a precursor system…." (Michael Behe, *Darwin's Black Box*, p. 39.) (3) "The blood-clotting system fits the definition of irreducible complexity." (Michael Behe, *Darwin's Black Box*, p. 86.) (4) "Faced with such complexity beneath even simple phenomena, Darwinian theory falls silent." (Michael Behe, *Darwin's Black Box*, p. 97.)

8. Brigid bought a newspaper called *The Call*, then disappeared. (2) Brigid and Joel Cairo are both after the Maltese Falcon. (3) Joel Cairo had the same copy of *The Call* and had ripped out a section listing the arrival of ships into the local port. (4) The section Cairo had ripped out included a ship called the *La Paloma* and five other ships. (5) The *La Paloma* burned last night. (6) Therefore, a good place to look for clues as to Brigid's disappearance would be the *La Paloma*. (Adapted from *The Maltese Falcon*, by Dasheill Hammett.)
9. "The fact that restricting access to abortion has tragic side effects does not, in itself, show that the restrictions are unjustified, since murder is wrong regardless of the consequences of prohibiting it." (Mary Anne Warren, "On the Moral and Legal Status of Abortion," 1973.)
10. "According to the Humanitarian theory [of punishment], to punish a man because he deserves it … is mere revenge and, therefore, barbarous and immoral. … My contention is that this doctrine … really means that each one of us, from the moment he breaks the law, is deprived of the rights of a human being. The reason is this. The Humanitarian theory removes from Punishment the concept of Desert. Bu the concept of Desert is the only connecting link between punishment and justice. It is only as deserved or undeserved that a sentence can be just or unjust." (C. S. Lewis, "The Humanitarian Theory of Punishment," in *God in the Dock*, pp. 287–8.)

## Real-Life Examples

**People who write legal documents attempt to capture all the formality of formal language in a natural language. They attempt to remove any and all ambiguities from the language by carefully qualifying every term. The result is often a jumble of rigid verbiage with no rhythm or intuitive meaning. Without some training it can be a maddening translation exercise. Thankfully, with a little practice and some propositional logic, you can breeze through many legal documents. And what's more, you can evaluate them for internal consistency.**

## 1. The Rental Agreement

- **Read the following excerpt from a general rental agreement and complete the exercises that follow.**

SECURITY DEPOSIT: Unless otherwise stated, the original Security Deposit is equal to the rent rate and, along with the first month's rent, must be paid by certified funds (money order, cashier's check or certified check). The Security deposit will NOT be refunded unless tenant completes the term of the lease AND meets all other conditions of the lease.

RELEASE FROM LEASE: We may, as a courtesy, release the Tenant from the balance of the lease provided the following conditions are met:

- Tenant forfeits security deposit
- Tenant prepays $250.00 towards the cost of the releasing fee and other expenses incurred in re-leasing which may include, but is not limited to, advertising, re-keying locks, cleaning, utility, etc. Tenant remains responsible for all re-leasing costs incurred.
- A satisfactory replacement tenant has been approved by Mountain Properties and has paid the security deposit and first month's rent. Existing Tenant is responsible to pay all rent up to the day the Replacement tenant starts paying rent.

1. **Translate the "SECURITY DEPOSIT" section into propositional logic.**
2. **Imagine that you signed the agreement and have been living in the apartment for three months of a twelve-month lease. In addition, imagine that, for whatever reason, you want to be released from the lease and have done everything except find a replacement tenant. From the agreement and these premises, what are your responsibilities to the landlord?**

## 2. The Collective Bargaining Agreement

- **Many workers in corporations are members of unions. A union is a collection of employees (sometimes people with special skills, e.g., the truck driver's union, the lineman's union, etc.) organized to bargain with employers for wages, working conditions, and benefits. When unions and companies agree on provisions for workers, a contract is drawn up called a "collective bargaining agreement." This contract stipulates all the things the employer must do for the employees (pay a certain minimum wage, provide certain types of healthcare, etc.) and all the things the workers must do in return (show up on time, successfully complete annual reviews, etc.). Read the following excerpt from the collective bargaining agreement**

**between Liz Claiborne, Inc. and the union Unite (June 1, 2003–May 31, 2006)[1] and answer the questions that follow.**

When the Employer acquires a new facility by merger, acquisition or consolidation, it shall advise the Union within one (1) year after such merger, acquisition or consolidation whether the facility will be maintained by the Employer or disposed of in some fashion. If the Employer advises the Union that the facility will not be maintained by the Employer, then the Employer either must dispose of the facility within six (6) months from the date of such notice (unless the parties mutually agree to an extension) or Article 5 will apply. If the facility is maintained by the Employer, this Agreement shall become binding on that facility no later than eighteen (18) months from the date that the facility was initially acquired.

1. **If the employer acquires a new facility, but does not tell the union its plan for maintenance until thirteen months after the acquisition, does the union have a justifiable complaint?**
2. **If the employer advises the union that the facility will not be maintained by the employer, but the employer does not dispose of the property within six months, and the parties do not mutually agree to an extension, will Article 5 (whatever that is) apply?**
3. **If the employer does not advise the union that the facility will not be maintained by the employer, and does not dispose of the property within six months, and the parties do not mutually agree to an extension, will Article 5 apply?**
4. **If the facility is maintained by the employer for thirteen months, and then decides to sell the building, do they have to advise the union of the sale?**

[1]Excerpted from Contracts.OneCLE.com, http://contracts.onecle.com/liz/unite.labor.2003.06.01.shtml. Accessed 15 December 2014.

# Truth tables

5

**In this chapter, we explain how to construct truth tables and use them to test arguments for validity. Truth tables express the possible truth values of a claim. They help us understand how operators affect the truth values of claims and help us understand the logical relationships among claims. We explain two truth table methods (what we call the *long method* and the *short method*) for testing arguments for validity.**

## Constructing Truth Tables: The Basics

A **truth table** is a tool for expressing all the possible truth values of a claim, whether simple or complex. For example, since we are working with a bivalent (or "two-valued") logic, every claim is either *true* or *false*, regardless of whether it is simple or complex. And for a simple claim, we already know the only possible truth values are *true* or *false*. But when we combine simple claims with operators, creating complex claims, the possible combinations of truth values increases. And different operators affect truth values in different ways. But why do we need to know all of a claim's possible truth values? Making these possibilities explicit is the first step in one method of testing arguments for validity—**the truth table method** (as opposed to the *proof* method, which we will explain in the next chapter).

In a complex claim, the possible truth values are also called *truth-functional* relations. This is because operators act like mathematical functions, such as addition and subtraction; they change the truth values of the claims to which they are applied. For example, if we apply the addition function to 2 and 2, we get 4. If we apply the subtraction function to 2 and 2, we get 0. Similarly, different logical operators yield different truth values. We'll start with a simple claim to show how it works.

Consider the claim, "It is a cat." Let's translate that into symbolic logic using the constant "C." C can be true or false, and we construct a truth table by listing the possible truth values in a vertical line underneath the claim. Therefore, the truth table for C looks like this:

| C | |
|---|---|
| **T** | (row 1) |
| **F** | (row 2) |
| (column 1) | |

In a truth table, there are *columns*, which are the vertical lines containing truth values (either T or F). And there are *rows*, which are horizontal lines containing truth values. Imagine the rows are possible worlds: in world (row) 1, C is true; in world (row) 2, C is false. Simple enough. But now imagine that C is not alone.

Let's conjoin C with the claim, "It is a mammal," which we will symbolize with "M," so that we now have: (C & M). The truth table for (C & M) shows every possible combination of truth values of C and M. The possible truth values of each simple claim and their conjunction are listed vertically, and the combinations are read horizontally. So we begin by listing all the possible combinations of C and M vertically underneath them:

| C | & | M | |
|---|---|---|---|
| T | **?** | T | (row 1) |
| T | **?** | F | (row 2) |
| F | **?** | T | (row 3) |
| F | **?** | F | (row 4) |
| (column 1) | (column 2) | (column 3) | |

In world (row) 1, C and M are both true. In world 2, C is true, but M is false. And so on for rows 3 and 4. How do we know what truth values to fill in for the question marks? Intuitively, *both C and M* are true, if both C and M are true. So, the conjunction (C & M) is true if and only if C is true and M is true:

| C | & | M |
|---|---|---|
| T | **T** | T |
| T | **F** | F |
| F | **F** | T |
| F | **F** | F |

You might have noticed that, even though we only have two truth values (*T* and *F*), the truth table for (C & M) has two more lines than the truth table for C. Every time we add a new claim to a truth table you will need to add lines. If we had added another C or another M, we would not need to add lines. But if we added a new claim, let's say, "D," we would. Consider the following two truth tables:

**1.** ((C & M)& C)

| C | C | M | & | C |
|---|---|---|---|---|
| T | T | T | **T** | T |
| T | F | F | **F** | T |
| F | F | T | **F** | F |
| F | F | F | **F** | F |

**2.** ((C & M)& D)

| C | & | M | & | D |
|---|---|---|---|---|
| T | T | T | **T** | T |
| T | T | T | **F** | F |
| T | F | F | **F** | T |
| T | F | F | **F** | F |
| F | F | T | **F** | T |
| F | F | T | **F** | F |
| F | F | F | **F** | T |
| F | F | F | **F** | F |

Notice that, in 1, since we already know all the possible truth value combinations of C, we only need to repeat them under the second C. Remember, rows are like possible worlds; C could not be both true and false at the same time in the same world. Therefore, if C is true in one place on a row, it is true at every place on that row. If it is false in one place on a row, it is false at every place on that row.

In 2, since we have added a constant, we need a new set of truth values to make sure we cover all the options. This suggests we need a pattern that will show us every possible combination of truth values. To construct this pattern, we need to first know how many rows of truth values we need. To know how many rows to add for each new variable, use the formula $2^x$, where *x* stands for the number of distinct simple, unrepeated claims (again, don't count repeated claims):

2the number of simple claims

So the truth table for a single, simple claim has just two rows:

| C |
|---|
| **1. T** |
| **2. F** |

Inserting 1 for $x$ in $2^x$ gives us $2^1$ (= 2), which tells us we need two lines, one for true and one for false. In the truth table for a complex claim comprising two simple, unrepeated claims, we need four rows:

| C & M | | C v M | | C ⊃ M | |
|---|---|---|---|---|---|
| T | T | T | T | T | T |
| T | F | T | F | T | F |
| F | T | F | T | F | T |
| F | F | F | F | F | F |

Inserting 2 for $x$, we get $2^2$ ($= 2 \times 2 = 4$), which tells us we need four lines. And when we conjoin D, we have $2^3$ ($= 2 \times 2 \times 2 = 8$), which tells us we need eight lines:

| ((C & M) & D) | | |
|---|---|---|
| T | T | T |
| T | T | F |
| T | F | T |
| T | F | F |
| F | T | T |
| F | T | F |
| F | F | T |
| F | F | F |

This is the basic structure of a truth table—the structure we build before applying the operators. There are two more things to know about constructing truth tables before we apply the operators. The first is how to organize your list of truth values underneath claims so that our basic structure is comprehensive—that is, so that you don't miss any possible combinations. All of your truth tables will have an even number of lines, so start with the far left column and label the first half of the lines as true and the second half as false. In the next column to the right, cut the pattern in half, labeling the first ¼ as true, the second ¼ as false, the third ¼ as true, and so on. In the next column to the right, cut the pattern in half again. Continue decreasing the pattern by half until you reach a column where the lines alternate T, F, T, F, and so on.

> TIP: An alternative method is to start with a column of alternating truth values (T, F, T, F, etc.), and then double the Ts and Fs for each additional simple proposition (second proposition: T, T, F, F, T, T, F, F; third proposition: T, T, T, T, F, F, F, F; etc.). Both methods yield all possible combinations of truth values.

The second thing to know about constructing truth tables is which operators to start with after completing the basic structure. Begin by locating the major operator. Remember the major operator is the operator that determines what the complex claim is called, for example, a "conjunction," a "disjunction," and a "conditional." It is also the operator enclosed in the least number of parentheses (even possibly zero in the case of a negation). When completing your table, you will end with the major operator. Consider our conjunction of C, M, and D again:

| ((C | & | M) | & | D) |
|---|---|---|---|---|
| T | T | T | **T** | T |
| T | T | T | **F** | F |
| T | F | F | **F** | T |
| T | F | F | **F** | F |
| F | F | T | **F** | T |
| F | F | T | **F** | F |
| F | F | F | **F** | T |
| F | F | F | **F** | F |

The major operator is the second "&"; it conjoins (C & M) and D, that is, the column under the first "&" and the column under D. Therefore, in order to apply the second "&," you need to know the truth values in the column under the first "&." So, in this case, you would start by filling in the column under the first "&," that is, the (C **&** M) column. Then fill in the column under the second "&," that is, the ((C &M) **&** D) column. Once you've constructed a few truth tables, this process will become clearer. Notice that you couldn't fill in the column under the second "&" without knowing what is in the column under the first "&."

In the next section, we'll see how operators affect truth tables. After that, we'll see how to use truth tables to test short arguments for validity. In the final section, we'll see how to test long arguments for validity.

## Getting familiar with … constructing truth tables

**For each of the following, construct the basic structure of a truth table. Ignore the operators for this set. (Save these; you will use them again later in this chapter.)**

1. (P v Q)
2. (P ⊃ R)
3. ((A v B) & A)
4. ((A v A) & A)

5. ((A ⊃ B) v C)
6. (Q ⊃ ((R v P) & R))
7. (Q ⊃ ((R v P) & S))
8. ((B ≡ C) ⊃ (D ≡ E))
9. (~(C & F) v ~(F & C))
10. ~((D v L) ≡ (M v L))

## Truth Tables for Operators

Once we have the basic structure of a truth table for a complex claim, we can see how operators affect those truth values. Let's start with the truth table for the simple claim A:

| A |
|---|
| **T** |
| **F** |

If we apply the negation (~) operator to this simple claim, all of A's possible truth values change to their opposite:

| ~ | A |
|---|---|
| **F** | T |
| **T** | F |

This is obvious when you consider any claim ("It is a cat," "Submarines are boats," "The sky is black") and its negation ("It is not a cat," "Submarines are not boats," "The sky is not black"). So, for any claim, no matter how complex, if a negation is added to that claim, change all of its possible truth values. For instance, consider the claim:

((((A v B) & (C & D)) ⊃ E) ≡ F)

The major operator of this monster is the bi-conditional (≡). Imagine that the truth values under the bi-conditional begin, T, F, F, F…:

| ((((A v B) & (C & D)) ⊃ E) | ≡ | F) |
|---|---|---|
| | **T** | |
| | **F** | |
| | **F** | |
| | **F** | |
| | … | |

If we then add a negation to the claim (which then becomes the major operator), we change all the truth values to their opposites (also called their *contradictories*):

| ~((((A v B) & (C & D)) ⊃ E) ≡ F) | |
|---|---|
| **F** | T |
| **T** | F |
| **T** | F |
| **T** | F |
| **…** | … |

TIP: For simple claims that are operated on, for example, with a negation, always list the truth values for a simple claim first, then change it according to the operator. Don't try to guess ahead and list only the truth values for the negated claim, leaving out the column for the simple claim. You'll almost certainly lose track and get confused, especially in longer claims and arguments.

We've seen several examples of the truth table for the conjunction (&), but we have yet to explain why it has the truth values it has:

| A | & | B |
|---|---|---|
| T | **T** | T |
| T | **F** | F |
| F | **F** | T |
| F | **F** | F |

Conjunctions are true if and only if both conjuncts are true. If either, or both, of the conjuncts is/are false, the conjunction is false. So, in a world where both conjuncts are true (row 1), the conjunction is true. In any other world (where at least one conjunct is false, rows 2–4), the conjunction is false.

Disjunctions are much more forgiving than conjunctions. With a disjunction, as long as one of the disjuncts is true, the disjunction is true:

| A | v | B |
|---|---|---|
| T | **T** | T |
| T | **T** | F |
| F | **T** | T |
| F | **F** | F |

This is most intuitive when one disjunct is true and one is false (lines 2 and 3 of the table). For instance, "Either the sky is blue or the moon is made of green cheese," or "Either pigs fly or you did not win the lottery." Also, "Either Texas is on the west coast or California is on the west coast."

It is also pretty easy to see that a disjunction is false if both disjuncts are false. For example, the disjunction, "Either the moon is made of green cheese or Texas is on the west coast," is clearly false because neither disjunct is true. The same goes for: "Either pigs fly or grass is blue."

Things are less clear when we consider a disjunction where both disjuncts are true. For instance, "Either Texas is on the west coast or California is on the west coast." Some people might say this disjunction is false, because true disjunctions *require* that one disjunct be false. But whether this is true depends on whether you interpret the "or" (v) as *inclusive* or *exclusive*.

An ***exclusive or*** requires that one disjunct is false. An ***inclusive or*** allows that both disjuncts can be true. There are reasons for preferring the exclusive *or*, for instance, because there are disjunctions where it is impossible that both disjuncts are true. In the disjunction, "Either it is raining or it isn't," both disjuncts cannot be true. The same goes for any claim and its negation: "Either it is a cat or it isn't," "Either you will win the lottery or you won't," "Either God exists or he doesn't."

But logicians prefer the inclusive *or*. In most cases, it is possible for both disjuncts to be true: "He's either a dad or he's a soccer player, and he might be both," "Either she really likes cookies or she's a surfer, and she might be both." In addition, the inclusive *or* can accommodate the cases where the disjuncts are mutually exclusive. For instance, "Either it is raining or it isn't, and it can't be both," and "He's either insane or a liar, but he isn't both," can be translated using the inclusive "or" as follows:

((R v ~R) & ~(R & ~R))          ((I v L) & ~(I & L))

In this book, all disjunctions are treated inclusively.

Conditionals are probably the most difficult operator to understand. We use them constantly in our natural language, but in logic, they have some characteristics that are not intuitive. In fact, one common bias that leads to erroneous reasoning (a version of the confirmation bias) is partly a result of misunderstanding the conditional. Getting a good grasp of the conditional's truth table will help you avoid a number of mistakes in reasoning.

As with the disjunction, there is only one combination of truthvalues that make the conditional false. With the disjunction, it was when both disjuncts were false. With the conditional, it is when the antecedent is true and the consequent is false. Here is the truth table for the conditional:

| A | ⊃ | B |
|---|---|---|
| T | **T** | T |
| T | **F** | F |
| F | **T** | T |
| F | **T** | F |

The only combination where the conditional is false.

It is easy to see why a conditional is true if both the antecedent and the consequent are true: If that animal is a dog, then it is a mammal. If it is true that part of what makes an animal a dog is that it is a mammal, then if the antecedent is true, the consequent is true, and therefore, the conditional is true.

But things are less obvious with the other combination. Consider the claim, “If you are caught stealing, you are sentenced to jail time.” Both the antecedent and consequent may be true. But there are other possibilities as well. You could be sentenced to jail without having been caught stealing, for instance, if you started a fight or sold drugs or were wrongly accused of murder. This would be an instance of row 3 on the truth table for the conditional (the consequent is true and the antecedent is false). It remains true that if you are caught stealing, then you are sentenced to jail. But it turns out that you can be sentenced to jail for some other reason.

It’s also possible that both the antecedent and the consequent are false. If you were neither caught stealing and you are not sentenced to jail, the conditional is still true. You *are* sentenced to jail *if* you *are* caught stealing. You are neither; but, the conditional is still true.

However, if it is possible that you are caught stealing but are not sentenced to jail, then the conditional is false. It may be that there is some exception that prevents the conditional from being true. Perhaps the officer knows you and your family and decides to let you off this time. If this is the case, the conditional is false. It might be true for most people most of the time, but since it is not true in your case, the conditional is false.

Consider this claim: “If it snows, the roof on the shed will collapse.” This conditional is true if, given that it snows, the roof collapses. It is also true if a strong wind collapses the roof, but it doesn’t snow. It is also true if it neither snows nor the roof collapses. It is a conditional, in a literal sense; the truth of one claim is conditional upon another.

This leads to an important distinction in logic: the difference between a **necessary condition** and a **sufficient condition**. In the theft case, “getting caught stealing” is *sufficient* for “being sentenced to jail,” but it isn’t *necessary* for being sentenced to jail, since you could be sentenced for any number of reasons. In the snow case, “snowing” is *sufficient* for “the roof’s collapsing,” but not *necessary*, since lots of other events could cause the roof to collapse. However, if the conditionals are true, “being sentenced to jail” and “the roof’s collapsing" are *necessary* for "getting caught" and "snowing," respectively. Here's the trick: the antecedent of any conditional is a sufficient condition; the consequent of any conditional is a necessary condition.

> CAUTION: Do not confuse necessary *conditions* with necessary *claims*. A necessary claim is true no matter what, unconditionally. A necessary condition is a claim on which the truth of another claim depends. Any claim could be a necessary condition; just place it in the consequent of a conditional. But not just any claim is necessary. Some classic possibilities are: 2 + 2 = 4; all bachelors are unmarried; everything is self-identical; no claim is both true and false at the same time.

Once you get the hang of conditionals, the bi-conditional (≡) will come naturally. A bi-conditional is a conditional that works in both directions; the antecedent implies the consequent and the consequent implies the antecedent. For instance: (A ≡ B) means the same as ((A ⊃ B) & (B ⊃ A)). A bi-conditional is an "if and only if" claim. So, the bi-conditional: "An animal is a mammal *if and only if* it is a vertebrate, warm-blooded, has hair, and nourishes its young from mammary glands," means the same as: "*If an animal is a mammal, then it is a vertebrate, warm-blooded, has hair, and nourishes its young from mammary glands*, and *if an animal is a vertebrate, warm-blooded, has hair, and nourishes its young from mammary glands, then it is a mammal*." In addition, the bi-conditional, "An object is an electron *if and only if* it has $-1.602 \times 10^{-19}$ Coulombs charge," means the same as, "*If an object is an electron, then it has it has $-1.602 \times 10^{-19}$ Coulombs charge*, and *if an object has $-1.602 \times 10^{-19}$ Coulombs charge, then it is an electron*."

The truth table for a bi-conditional looks like this:

| A | ≡ | B |
|---|---|---|
| T | **T** | T |
| T | **F** | F |
| F | **F** | T |
| F | **T** | F |

If both sides of a bi-conditional are true, the bi-conditional is true (row 1). If both sides are false, the bi-conditional is also true (row 4). For instance, there are exactly five chairs in the room if and only if the number of chairs in the room equals the positive square root of 25. If there are ten chairs in the room, then, though both sides of the bi-conditional are false, the bi-conditional remains true.

If either side of the bi-conditional is false, the bi-conditional is false. Since a bi-conditional is just two conditionals conjoined, it follows the rules of conditionals and conjunctions. If one side of a bi-conditional is false, it is equivalent to one of the following truth tables:

| ((A⊃ B) & (B⊃ A)) | or | ((A⊃ B) & (B⊃ A)) |
|---|---|---|
| F T T **F** T F F | | T F F **F** F T T |

In either case, (A ≡ B) is false.

Now that you know the truth tables for all of the operators, use them to figure out the truth value of the following claims. See the inside cover of this book for a chart of all the truth tables for operators.

## Getting familiar with … truth tables for operators

Refer back to your answers to "Getting familiar with … constructing truth tables." For each of those, construct a complete truth table, then construct one for each of the following. Start with the claims enclosed in the most number of parentheses, and move to the next most enclosed until you get to the main operator. Two examples have been provided.

**Example 1:**

| ~ | (P | v | Q) |
|---|---|---|---|
| F | T | T | T |
| F | T | T | F |
| F | F | T | T |
| T | F | F | F |

**Example 2:**

| ~ | ((A v B) | & | (C v A)) |
|---|---|---|---|
| F | T T T | T | T T T |
| F | T T T | T | F T T |
| F | T T F | T | T T T |
| F | T T F | T | F T T |
| F | F T T | T | T T F |
| T | F T T | F | F F F |
| T | F F F | F | T T F |
| T | F F F | F | F F F |

Notice that the main operator of this claim is the negation (~), so don't forget to change all the values under the conjunction (&) column.

1. (A & ~B)
2. ~(C v D)
3. ~(A ⊃ ~B)
4. (P ≡ (Q ⊃ R))
5. ~(~W & ~P)
6. (~Q ⊃ R)
7. ~(P & Q)
8. (W v (A v B))
9. (A v (B ⊃ C))
10. ~(T ≡ (U & ~V))

## Using Truth Tables to Test for Validity: The Long Method

So far, we've constructed truth tables only for single claims. But the real power of truth tables is that they allow us to evaluate an argument's validity. Remember that validity means: If the premises are true, the conclusion cannot be false. Thinking of rows like possible worlds, we can say, an argument is valid if and only if there is no world in which all the premises are true and the conclusion is false.

Consider the following argument:

1. If Ichiro is a liberal, then either he will vote for the Democratic candidate or he will not vote.
2. Ichiro is a liberal.
3. <u>Ichiro will vote.</u>
4. Therefore, Ichiro will vote for the Democratic candidate.

To evaluate this argument using truth tables, first translate each of the simple claims into propositional logic, using capital letters:

1. If Ichiro is a liberal (L), then either he will vote for the Democratic candidate (D) or he will not vote (V).
2. Ichiro is a liberal (L).
3. <u>Ichiro will vote (V).</u>
4. Therefore, Ichiro will vote for the Democratic candidate (D).

Dropping the natural language and adding the operators (remember, the "nots" are operators), we have:

1. (L ⊃ (D v ~V))
2. L
3. ~~V
4. D

> This premise has two negation signs. If Jim always votes, then it is *not* the case that he will *not* vote. We will explain this double negation in greater detail in the next chapter.

Now we have fully translated the argument. Next, list the premises side by side horizontally, separating them with a semicolon (;). Then list the conclusion at the far right after the conclusion sign (/.:):

(L ⊃ (D v ~V)) ; L ; ~~V /.: D

Now, construct the truth table. There are only three unique simple claims, L, D, and V. Therefore, you will need $2^3$ rows, which is 8. Even though we have more than one claim comprising our argument, we apply the pattern for operators from the very first section in this chapter, just as we would with individual claims. And that gives us the following basic structure:

| (L ⊃ | (D v | ~V)) ; | L ; | ~~V /.: | D |
|---|---|---|---|---|---|
| T | T | T | T | T | T |
| T | T | F | T | F | T |
| T | F | T | T | T | F |
| T | F | F | T | F | F |
| F | T | T | F | T | T |
| F | T | F | F | F | T |
| F | F | T | F | T | F |
| F | F | F | F | F | F |

Then, fill in the truth values for the complex claims, according to the relationships set out in the second section (Truth Tables for Operators):

| (L ⊃ (D v ~V)) ; | L ; | ~~V /.: | D |
|---|---|---|---|
| T **T** T T FT | **T** | **T**FT | **T** |
| T **T** T T T F | **T** | **F**TF | **T** |
| T **F** F F FT | **T** | **T**FT | **F** |
| T **T** F T TF | **T** | **F**TF | **F** |
| F **T** T T FT | **F** | **T**FT | **T** |
| F **T** T T TF | **F** | **F**TF | **T** |
| F **T** F F FT | **F** | **T**FT | **F** |
| F **T** F T TF | **F** | **F**TF | **F** |

The truth values in boldface type are the possible truth values for each of the claims in the argument.

## The Long Method of Testing for Validity

With this truth table complete, we can now evaluate the argument for validity. To evaluate the argument, simply *check to see if there is any row where all the premises are true and the conclusion is false*. If there is *even one row* like that, the argument is *invalid*. If there is not, the argument is valid. You can save time by starting with the conclusion column. Find the rows where the conclusion is false, then look left along that row to see whether all the premises are true. This means you won't need to check every row, only those rows where the conclusion is false. In this argument, check lines 3 and 4 and 7 and 8, since those are the rows where the conclusion is false.

| (L ⊃ (D v ~V)) ; | L ; | ~~V /∴ | D | |
|---|---|---|---|---|
| T T T T F T | T | TFT | T | |
| T T T T T F | T | FTF | T | |
| T **F** F F F T | **T** | **T**FT | **F** | **Row 3** |
| T **T** F T T F | **T** | **F**TF | **F** | **Row 4** |
| F T T T F T | F | TFT | T | |
| F T T T T F | F | FTF | T | |
| F **T** F F F T | **F** | **T**FT | **F** | **Row 7** |
| F **T** F T T F | **F** | **F**TF | **F** | **Row 8** |

The only truth values you need to compare are those of *the major operators of the premises* and *the conclusion*. As we can see, there are no rows where all the premises are true and the conclusion is false. That means *this argument is valid*.

We call this the "long method" of testing for validity because we have constructed every row of the truth table. This becomes unruly when you have more than four operators (an argument with five operators has thirty-two rows). We will explain a shorter method in the following section. But before that, here are three more short arguments to help you understand testing for validity with truth tables:

**Example 1:**

| (A v C) ; | (C v D) /.: | D |
|---|---|---|
| T T T | T T T | T |
| T T T | T T F | F |
| T T F | F T T | T |
| T T F | F F F | F |
| F T T | T T T | T |
| F T T | T T F | F |
| F F F | F T T | T |
| F F F | F F F | F |

We've placed boxes around the rows where the conclusion is false (rows 2, 4, 6, and 8). Looking left, we see that, in rows 2 and 6, all the premises are true and the conclusion is false. There doesn't have to be two rows like that. If even one row has all true premises and a false conclusion, the argument is invalid.

| (A | v | C) ; | (C | v | D) /∴ | D |
|---|---|---|---|---|---|---|
| T | T | T | T | T | T | T |
| T | **T** | T | T | **T** | F | **F** |
| T | T | F | F | T | T | T |
| T | **T** | F | F | **F** | F | **F** |
| F | T | T | T | T | T | T |
| F | **T** | T | T | **T** | F | **F** |
| F | F | F | F | T | T | T |
| F | **F** | F | F | **F** | F | **F** |

*This argument is invalid.*

**Example 2**

| (A | ⊃ | B) ; | (B | v | A) /∴ | ~ | A |
|---|---|---|---|---|---|---|---|
| T | T | T | T | T | T | F | T |
| T | F | F | F | T | T | F | T |
| F | T | T | T | T | F | T | F |
| F | T | F | F | F | F | T | F |

Rows 2 and 3 have false conclusions, and only row 1 also has all true premises. But that is enough to render this argument invalid.

| (A | ⊃ | B) ; | (B | v | A) /∴ | ~ | A |
|---|---|---|---|---|---|---|---|
| T | **T** | T | T | **T** | T | **F** | T |
| T | **F** | F | F | **T** | T | **F** | T |
| F | T | T | T | T | F | T | F |
| F | T | F | F | F | F | T | F |

*This argument is invalid.*

**Example 3**

| ((B | v | D) ; | ~ | B /∴ | D |
|---|---|---|---|---|---|
| T | T | T | F | T | T |
| T | T | F | F | T | F |
| F | T | T | T | F | T |
| F | F | F | T | F | F |

**Rows 2 and 4 have false conclusions in this argument, but in neither case are all the premises true. Since there is no row (possible world) in which all the premises are true and the conclusion is false, this argument is valid.**

| ((B v D) | ; ~B | /∴ D |
|---|---|---|
| T T T | FT | T |
| T **T** F | **F**T | **F** |
| F T T | TF | T |
| F **F** F | **T**F | **F** |

*This argument is valid.*

## Getting familiar with … using truth tables to test for validity

**For each of the following arguments, construct its truth table and test it for validity.**

1. ((P ⊃ Q) & P) /.: Q
2. (L ⊃ ~L) /.: ~L
3. (M ≡ ~N) ; ~(N & ~M) /.: (M ⊃ N)
4. (A ≡ ~B) /.: (B v A)
5. (A ⊃ A) /.: A
6. ((B v D) v E) ; ~B ; ~E /.: D
7. ~R ; (S ⊃ R) /.: ~S
8. ~S ; (S ⊃ R) /.: ~R
9. ((A & B) v (C v D)) ; ~ (C v D) /.: A
10. (H ⊃ I) ; (J ≡ H) ; (~I v H) /.: (J ≡ I)
11. (P ⊃ Q) /.: R
12. (A ⊃ B) ; A /.: C
13. ((M ≡ ~N) & ~(N & ~M)) /.: ~(N v M)
14. ((A ≡ ~B) v (B v A)) /.: (A & ~B)
15. (P v ~Q) ; (R ⊃ ~Q) /.: (~P ⊃ R)
16. (A v B) ; (A ⊃ B) /.: (B ⊃ ~A)
17. (~ (Y & O) v W) /.: (Y ⊃ W)
18. (Y ≡ Z) ; (~Y v ~W) ; W /.: Z
19. (E v F) ; (E ⊃ F) ; (C & D) /.: (F ⊃ ~C)
20. (N & ~Q) ; (~R ≡ ~Q) ; R /.: (N ⊃ R)

## Using Truth Tables to Test for Validity: The Short Method

Any argument that includes more than four simple claims becomes very long and cumbersome. Thankfully, there is a way to abbreviate the truth table method for long arguments, which we'll call "the short method." By the way, the short method works for short arguments, too, but understanding the long method helps explain why the short method works. So, the last section was a hand-cramping, necessary evil.

To begin, remember with the long method that, once we constructed the full truth table for an argument, we were only concerned with the lines where the conclusion was false. So, instead of constructing a full truth table, now we'll just construct the lines where the conclusions are false and then attempt to force all the premises to be true. If we cannot do this, the argument is valid. If we can do this, even once, the argument is invalid.

Begin by constructing all the ways the conclusion of the argument can be false. If the conclusion is a simple claim, just label it false. Consider the following argument that would normally have a short truth table:

((A ⊃ ~B) ; ~(A & B) /.: B

Begin by stipulating that B is false:

((A ⊃ ~B) ; ~(A & B) /.: B
F

If B is false in the conclusion, it is false everywhere else on that row:

((A ⊃ ~B) ; ~(A & B) /.: B
F F F

Now, is it possible to make the premises true? Look at the second premise. If even one conjunct in a conjunction is false, the conjunction is false. This conjunction is negated, so no matter what value we assign to A, premise 2 is true:

((A ⊃ ~B) ; ~(A & B) /.: B
F T _ F F

This means we are free to make A true or false on this row in some other premise in order to try to make that premise true. In this case, that's easy. Look at the first premise. Any conditional with a true consequent is true, and once we apply the negation to B, the consequent is true:

((A ⊃ ~B ; ~(A & B) /∴ B

_ **T** TF **T** _ F **F**

This means that it doesn't matter whether A turns out to be true or false; we know there is at least one row where all the premises are true and the conclusion is false. Therefore, this argument is invalid.

Just to show you this really works and is not just a trick, let's look at the full truth table for this argument:

((A ⊃ ~B) ; ~(A & B) /∴ B

T **F** FT **F** T T T **T**

T **T** TF **T** T F F **F**

F **T** FT **T** F F T **T**

F **T** TF **T** F F F **F**

The columns with the truth tables for the major operators are in boldface type. Using the long truth table method, we look at rows 2 and 4, where the conclusion is false, and then look left to see if all the premises are true. In fact, they are in both cases. And those are exactly the rows we constructed in the short method. If we had rendered A true, we would have constructed row 2. If we had rendered A false, we would have constructed row 4.

Now consider this longer argument:

(((A & B) ⊃ (C v D)) & E) /.: D

The conclusion is, as in the previous example, a simple claim, D. So, begin constructing your truth table by stipulating that D is false. We are only concerned about the rows where the conclusion is false:

(((A & B) ⊃ (C v D)) & E) /.: D

**F**

Since the truth value for D must be consistent throughout the row, go ahead and label any other instance of D with an F:

(((A & B) ⊃ (C v D)) & E) /.: D

**F** F

Now, try to make the premise true. In this case, there is only one premise, with a conjunction (&) as the major operator. In order to be true, a conjunction must have two true conjuncts. Since the second conjunct is a simple claim, E, label E as T:

(((A & B) ⊃ (C v D)) & E) /.: D

F **T** F

The first conjunct is a bit trickier. The first conjunct is a conditional (⊃). We know that the only way a conditional can be false is if the antecedent is true and the consequent is false. So, all we have to do is find one combination of truth values that does not end up in this configuration. As it turns out, any of the following will do:

(((A & B) ⊃ (C v D)) & E) /∴ D

T F F **T** F F F T F

F F T **T** F F F T F

F F F **T** F F F T F

T T T **T** T T F T F

We only needed one row where the left conjunct is true, but there are four. But since we have at least one row where all the premises are true and the conclusion is false, the argument is invalid:

(((A & B) ⊃ (C v D)) & E) /.: D

T F F T F F F **T** T **F**

F F T T F F F **T** T **F**

F F F T F F F **T** T **F**

T T T T T T T **T** T **F**

TIP: Remember, when testing for validity, all you need to find is *one* row where the premises are true and the conclusion is false. Therefore, once you find one, you're done; the argument is invalid. We need not have constructed the last three lines once we constructed the first. Any of the four does the trick.

Now, if you cannot construct a line where the conclusion is false and the premises are true, then the argument is valid. Consider the following example:

~(A v B); (D ⊃ (A v B)) /.: ~D

In this argument the conclusion is complex, but it is easy enough to make false. Just label D as T and apply the negation operator:

~(A v B); (D ⊃ (A v B)) /.: ~D

**F**T

Since the truth value of D must remain consistent throughout the argument, label all other instances of D as T (don't accidentally label it F; it is only the negation operator that does that in the conclusion):

~(A v B); (D ⊃ (A v B)) /.: ~D

**T** FT

Now, attempt to make the rest of the premises true, beginning with the major operator of each. The major operator in the first premise is the negation (~). In order to make a negation true, the operand, in this case (A v B), must be false. The major operator of this claim is a disjunction (v). The only way to make a disjunction false is to have two false disjuncts. Since nothing is preventing us from labeling them both "false," go ahead and do so:

~ (A v B); (D ⊃ (A v B)) /.: ~D

**T** F F F T FT

So, the first premise is true. Now attempt to make the second premise true. Since the second premise includes A and B, and since a claim's truth value must remain consistent throughout a line, we are forced to label A and B as F:

~ (A v B); (D ⊃ (A v B)) /.: ~D

T F F F T F **F** F FT

But now we have a conditional (the major operator of the second premise) with a true antecedent, D, and a false consequent, (A v B), which is false:

~ (A v B); (D ⊃ (A v B)) /.: ~D

**T** F F F T **F** F F F **F**T

So, we can see that there is no way to make the premises true and the conclusion false. This argument is valid. Try working this one again, but this time, start by trying to make the second premise true, then move on to the first premise.

Arguments with complex conclusions are trickier. In those cases, you must construct every possible way the conclusion can be false, then see if the premises could all be true on each line. If the premises cannot all be made true on the first line, move to the next. If the premises can all be made true on the first line, you can stop; the argument is invalid. We'll work three of these together, then we'll list five more for you to work on your own.

((P ⊃ ~Q) & (R & W)) ; (R v W) ; (P & R) /.: (P v W)

With the short method, we always begin by making the conclusion false. When the conclusion is a disjunction this is easy because there is only one way a conclusion can be false, that is, when both disjuncts are false:

((P ⊃ ~Q) & (R & W)) ; (R v W) ; (P & R) /.: (P v W)

F **F** F

Remember, once you've stipulated that P and W are false, they must be labeled false in every other instance on the row:

((P ⊃ ~Q) & (R & W)) ; (R v W) ; (P & R) /.: (P v W)

**F** **F** **F** **F** **F** F F F

Now check to see if it's possible to make all the premises true. In this case, since two premises are conjunctions (the first and third), and since one conjunct of each is already false ((R&W) in the first and R in the third), then at least two of our premises cannot be true. There is no way to make all the premises true if two must be false. Therefore, *this argument is valid*:

((P ⊃ ~Q) & (R & W)) ; (R v W) ; (P & R) /∴ (P v W)

F **F** **F** F F F **F** F F F F

Consider one more argument:

(P ≡ Q) ; W ; (~R & W) /.: ((P v W) ⊃ Q)

Since this argument has a conditional as a conclusion, we know there is only one way it can be false, that is, with the antecedent true and the consequent false. But in this case, the antecedent is a disjunction, and a disjunction can be true in three different ways. You will need to represent all three of these ways to fully evaluate the argument:

(P ≡ Q) ; W ; (~R & W) /.: ((P v W) ⊃ Q)

T T T **F** F

T T F **F** F

F T T **F** F

Now, label the other simple claims, letting the stipulations we made in the conclusion determine the truth values of the simple claims in the premises:

(P ≡ Q) ; W ; (~R & W) /.: ((P v W) ⊃ Q)

T F T T T T T **F** F

T F F F T T F **F** F

F F T T F T T **F** F

Now see if it's possible to make all the premises true. Since we already know the second and third premises on row two are false, we only need to consider lines 1 and 3:

(P ≡ Q) ; W ; (~R & W) /∴ ((P v W) ⊃ Q

T F T T T T T **F** F

~~T F F F F T T F **F** F~~

F F T T F T T **F** F

Looking at row 1, we see that, since the truth values for P and Q were determined by the conclusion, and since a bi-conditional (≡) is true if and only if either both sides are true or both sides are false, we cannot make all the premises on line 1 true:

(P ≡ Q) ; W ; (~R & W) /∴ ((P v W) ⊃ Q)

~~T **F** F T T T T T **F** F~~

~~T **F** F F F F T T F **F** F~~

F T F T T F T T **F** F

Looking, then, at row 3, we see that the first premise is true and the second premise is true:

(P ≡ Q) ; W ; (~R & W) /∴ ((P v W) ⊃ Q

~~T F F T T T T T **F** F~~

~~T F F F F F T T F **F** F~~

F **T** F **T** ? T F T T **F** F

Whether this argument is valid depends on whether we can make the third premise true. The third premise is a conjunction (&), and the only way a conjunction can be true is if both conjuncts are true. We already know the right conjunct is true. Can we make the left conjunct true? Since the truth value is not determined by the conclusion, we are free to stipulate whatever truth value we wish. Therefore, in order to make the conjunction true we only have to make R false, so that ~R will be true:

(P ≡ Q) ; W ; (~R & W) /∴ ((P v W) ⊃ Q)

~~T F F T T T T T F F~~

~~T F F F F F T T F F F~~

F **T** F **T** **TF** **T** T F T T F F

Since there is at least one line where all the premises are true and the conclusion is false, *the argument is invalid.*

## Getting familiar with … the short truth table method to test for validity

**Test each of the following arguments for validity using the short truth table method.**

1. (P v ~Q) ; (R ⊃ ~Q) /.: (~P ⊃ R)
2. (A v B) ; (A ⊃ B) /.: (B ⊃ ~A)
3. (~(Y & O) v W) /.: (Y ⊃ W)
4. (Y ≡ Z) ; (~Y v ~W) ; W /.: Z
5. (E v F) ; (E ⊃ F) ; (C & D) /.: (F ⊃ ~C)
6. ~(P ≡ Q) ; (~P & ~W) ; ~W /.: Q
7. (~(A & B) v C) /.: (A ≡ C)
8. (((A & B) & C) & D) /.: E
9. ((H & I) v L) ; (L & D) ; (D ⊃ ~R) /.: ~L
10. (~W & R) ; (S ⊃ W) ; (S v Q) /.: Q
11. (L⊃ (P & Q)) ; ~R ; (L & (P & O)) /.: P
12. (A ⊃ C) ; (C ⊃ G) ; (R ⊃ S) ; (A v R) /.: (G v S)
13. ((Q v R) ⊃ S) /.: (Q ⊃ S)
14. (Z ⊃ A) ; (Z v A) /.: A
15. ((K v L) ⊃ (M v N)) ; ((M v N) ⊃ O) /.: O
16. (A ⊃ B) ; ((B v D) ⊃ L) ; (G v A) /.: L
17. ((~M & ~N) ⊃ (O ⊃ N)) ; (N ⊃ M) ; ~M /.: ~O
18. ((K v L) ⊃ (M v N)) ; ((M v N) ⊃ (O & P)) ; K /.: O
19. (A ⊃ C) ; (B ⊃ D) ; (C ⊃ B) ; (S v ~D) ; S /.: ~A
20. (A v B) ; (A & (C v D)) ; ~D ; (B ⊃ C) /.: ~((C v D) & (D ⊃ B))

## Exercises

**A. Construct a basic truth table structure for each of the following claims, ignoring the operators.**

1. ((P ⊃ Q) & P)
2. (L ⊃ ~L)
3. ((A v B) v C))
4. ((P ≡ Q) & Q)
5. (P v ~P)
6. ((A & B) ⊃ (B v C))
7. ((C ≡ C) ≡ D)
8. ((S ⊃ ~P) v ~R)
9. ((B & ~C) v C)
10. (~R v ~S)

**B. Without looking at the examples, construct truth tables for each of the five operators.**

1. ∼A
2. (P & Q)
3. (R v S)
4. (X ⊃ Y)
5. (M ≡ N)

**C. Test each of the following arguments for validity using the long method:**

1. (A ⊃ ∼A) /.: A
2. (P ≡ Q) ; (R v ∼Q) /.: (R ⊃ P)
3. (P ≡ ∼Q) /.: (Q v P)
4. ∼(P ≡ Q) ; ∼(R v ∼Q) /.: ∼(R ⊃ P)
5. ∼(∼A ⊃ A) /.: ∼(A v A)
6. H /.: (I ⊃ (H & K))
7. (A ⊃ B) /.: (B ⊃ A)
8. ∼(A ⊃ B) /.: (∼A & ∼B)
9. ∼(P v Q) /.: ∼Q
10. ∼P ; ∼Q ; (P & Q) /.: (∼P v R)

**D. Test each of the following arguments for validity using the short method:**

1. (P v ∼Q) ; (R ⊃ ∼Q) /.: (∼P ⊃ R)
2. (A v B) ; (A ⊃ B) /.: (B ⊃ ∼A)
3. (P v S) ; P /.: ∼P
4. (A ⊃ B) ; (B ⊃ C) /.: (A ⊃ C)
5. (A ⊃ B) ; (B ⊃ C) ; D /.: (A ⊃ C)
6. ∼(A ⊃ B) ; (B ⊃ C) ; (C ⊃ D) /.: (A ⊃ D)
7. ((P v R) & (P v S)) ; ∼S /.: (∼R ⊃ P)
8. (((A & C) v (C & D) ⊃ Q) ; ∼Q /.: ∼(C & D)
9. (((A v C) ≡ (C v D) ⊃ Q) ; ∼Q /.: ∼(C v D)
10. (A ≡ B) ; (B ≡ C) ; (C ⊃ D) /.: (A ⊃ D)
11. ((Q v R) & ∼(Q v ∼S)) ; S /.: ∼(∼R ⊃ Q)
12. ((P v S) v (R v P)) ; R /.: ∼(R v P)
13. (A ⊃ (B & C)) ; (B ⊃ (C ⊃ D)) /.: (A ⊃ D)
14. (∼(Y & O) v W) /.: Y ⊃ W
15. (Y ≡ Z) ; (∼Y v ∼W) ; W /.: Z
16. (A & B) ; (∼A v C) ; (∼D ⊃ ∼C) /.: (D & B)
17. (P ⊃ A) ; (Q ⊃ B) ; (P v Q) /.: (A v B)
18. (P ⊃Q) ; (Q ⊃ R) ; (R ⊃ S) /.: ((P ⊃ S) v W)
19. (∼A v ∼B) ; (C v D) ; ∼(∼A v C) /.: (∼B & D)
20. (((P & Q) v W) ⊃ R) ; (∼R & ∼W) ; ∼Q /.: (P & Q)

**E. Translate each of the following arguments into propositional logic, then test for validity using the short method:**

1. You should step lightly only if you don't want to be taken seriously. But if you know what's good for you, you want to be taken seriously. You know what's good for you, therefore you should step lightly.
2. If you take that particular Jenga piece, the whole stack will fall. If the whole stack does not fall, you did not take that piece. The whole stack fell, so you took that piece.
3. The wind blows heavily only if the night is most wicked. If the full moon is out, the night is most wicked. The night is not very wicked. So, the moon is not full.
4. Vinnie takes money from Frankie only if Frankie doubles his money on the ponies. If Frankie doubles his money on the ponies, he has to give half to his ex-wife. Hence, if Frankie gives half to his ex-wife, Vinnie takes money from Frankie.
5. It's a long way to the top if you want to rock and roll. It's not very far to the top. Therefore, you really don't want to rock and roll. (Thanks to AC/DC for this excellent lyric.)
6. It's a long way to the top only if you want to rock and roll. It's a really long way to the top. Hence, you wanna rock and roll.
7. If you have a headache and take aspirin, your headache will go away and you will feel better. Your headache went away but you didn't feel better. Therefore, you didn't take aspirin.
8. If it is a cat, then it is a mammal. If it is a mammal, then it is warm-blooded. If it is warm-blooded, then it reproduces sexually. If it reproduces sexually, its reproduction can be explained by genetics. If its reproduction can be explained by genetics, then Johnny can explain its reproduction. Therefore, if it is a cat, Johnny can explain its reproduction.
9. If it rains outside and the awning is broken, the sidewalk gets wet and becomes slippery. If the temperature never gets lower than seventy degrees, the sidewalk is slippery if and only if it is wet. We live in Florida and the temperature never gets lower than seventy degrees. Therefore, if the awning is broken, the sidewalk is becoming slippery.
10. You must stop at the intersection if and only if the traffic light is not green unless an emergency vehicle is coming through. If an emergency vehicle is coming through, you must stop at the intersection or you will be cited for reckless driving. Therefore, if you are cited for reckless driving and the traffic light is green, an emergency vehicle is coming through.

## Real-Life Examples

**No matter how abstract logic can be, we're never more than a few steps away from the real world. Below, we've excerpted**

**(1) Read the following excerpts from real-life arguments.**

**<u>(2) Reconstruct the arguments and translate them into symbolic logic.</u>**

**(3) Test them for validity using either the long or short truth table method.**

**Remember, an argument can be good without being valid (all inductive arguments are invalid). But, if an argument is invalid, you have eliminated one way that it can be successful.**

## 1. Former Illinois Governor Rod Blagojevich

**The following argument is excerpted from a speech given by then-Illinois Governor Rod Blagojevich in response to allegations of misconduct on January 29, 2009:**

> "The evidence is the four tapes. You heard those four tapes. I don't have to tell you what they say. You guys are in politics, you know what we have to do to go out and run and run elections.
>
> "There was no criminal activity on those four tapes. You can express things in a free country, but those four tapes speak for themselves. Take those four tapes as they are and you will, I believe, in fairness, recognize and acknowledge, those are conversations relating to the things all of us in politics do in order to run campaigns and try to win elections."[1]

**Don't forget to remove extraneous material:**

> "The evidence is the four tapes. <u>You heard those four tapes. I don't have to tell you what they say</u>. You guys are in politics, you know what we have to do to go out and run and run elections.
>
> "There was no criminal activity on those four tapes. You can express things in a free country, <u>but those four tapes speak for themselves. Take those four tapes as they are and you will, I believe, in fairness, recognize and</u>

[1]From Rod Blegojevich, "Transcript of Gov. Rod Blagojevich's Closing Argument," *Chicago Tribune*, January 29, 2009, http://articles.chicagotribune.com/2009-01-29/news/chi-090129blago-transcripts-story_1_witnesses-senate-trial-united-states-senator/2.

acknowledge, those are conversations relating to the things all of us in politics do in order to run campaigns and try to win elections."

## 2. Political Pundit Rush Limbaugh

**The following is an excerpt from a *Wall Street Journal* article written by conservative political pundit Rush Limbaugh about newly elected President Barak Obama. Be careful: some of the claims (including the conclusion) are implicit and the conclusion is sarcastic, meaning the opposite of what Limbaugh intends to say.**

> "He [Obama] explained that there was no use trying to tighten lending laws because, in Congress, quote, you have 534 massive egos up there. He, of course, built himself a seven million dollar auditorium and cafeteria in his office building and also had a personal tax-payer funded chef hired. There's no ego involved in that."[2]

---

[2]From Rush Limbaugh, "My Bipartisan Stimulus," *Wall Street Journal*, http://online.wsj.com/article/SB123318906638926749.html.

# Rules of deductive inference

6

**We explain how to use propositional logic to test arguments for validity. We introduce rules of inference, rules of replacement, and proof strategies, and we explain how to construct simple proofs for validity in propositional logic. At the end of the chapter, we discuss three of the most common fallacies in deductive reasoning.**

## Deductive Inference

Propositional logic is a formal language, which means that, as long as we reason according to a valid argument form, there is no loss of truth-value when we draw inferences from true premises. But, even assuming all our premises are true, how do we know when we have a valid argument form?

Thankfully, logicians have discovered a set of rules to guide us in determining when a conclusion follows necessarily from a premise or set of premises. Rules that preserve truth-value are called *valid* for the same reasons that a good deductive argument is valid: It is impossible for the premises to be true and the conclusion false. If the premises are true, that truth is preserved through the inference to the conclusion. And so, propositional logic, like mathematics, is a truth-preserving system.

In this chapter, we will introduce you to eight valid **rules of inference**, eleven valid **rules of replacement**, and two valid **proof strategies**.

Remember, the term "validity" applies exclusively to deductive arguments. As we will see in Part Three of this book, all inductive arguments are invalid, that is, it is always possible for the premises to be true and the conclusion false. Therefore, we will need a different set of criteria for evaluating the relationship between the premises and conclusion in inductive arguments. We'll begin with four basic rules of inference, then increase the complexity as we go through the chapter.

## Four Basic Rules of Valid Inference

Simplification
Conjunction
*Modus ponens*
*Modus tollens*

## Simplification

Recall from Chapter 5 that the truth table for a conjunction looks like this:

| **P** | **&** | **Q** |
|---|---|---|
| **T** | **T** | **T** |
| T | F | F |
| F | F | T |
| F | F | F |

A conjunction is true *if and only if* both conjuncts are true. In order to test whether an argument is valid using rules of inference, we assume the premises are true and then try to *derive* (using the rules you will learn in this chapter) a certain conclusion. This is backward from the way we tested for validity with truth tables (assuming the conclusion is false and looking to see if all the premises are true). Here, we will assume all the premises are true, and then apply our rules to determine whether certain conclusions follow.

Because we are assuming the premises are true, if we come across a conjunction, we can assume both conjuncts are true. We can do this because we know that, in a true conjunction, both conjuncts are true. Therefore, from a conjunction such as (P & Q), we are permitted to derive either of its conjuncts:

| | | | |
|---|---|---|---|
| **1.** | | **2.** | |
| 1. (P & Q) | or | 1. (P & Q) | |
| **2. P** | | **2. Q** | **1, simplification** |

The rule that permits this inference is called **simplification**. When you apply a rule, cite the premise number to which you applied the rule and the name of the rule. This allows you (and others) to see, keep track of, and check your reasoning. It may help to see a couple of English examples:

| | | |
|---|---|---|
| **3.** | **4.** | |
| 1. It is snowing and it is cold. | 1. He's a lawyer and he's jerk. | |
| 2. Therefore, it is cold. | 2. Thus, he's a lawyer | 1, simplification |

Regardless of how complicated a claim is, if its major operator is a conjunction, you can derive either of the conjuncts. Here are a few more examples:

| | | | |
|---|---|---|---|
| **5.** | | **6.** | |
| 1. ((A ⊃ B) & (C v D)) | | 1. (P v Q) | |
| **2. (A⊃B)** | **1, simplification** | **2.** C | |
| | | 3. (D & E) | |
| | | **4. E** | **3, simplification** |
| **7.** | | **8.** | |
| 1. (((A v B) ⊃ C) & (P ⊃ Q)) | | 1. (P v Q) | |
| 2. ((B & C) ⊃ Q) | | 2. (P & ~B) | |
| **3. (P ⊃ Q)** | **1, simplification** | 3. (A v B) | |
| | | **4. ~B** | **2, simplification** |

Caution: Notice that, in example 7, you cannot derive B or C from these premises. In premise 2, the major operator is a conditional, not a conjunction. You would need a different rule to break up the conditional before you could apply simplification.

# Conjunction

Since a true conjunction is just a conjunction with true conjuncts, we can also *construct* conjunctions from true claims. For instance, if we already know that some claim S is true and that some claim B is true, it follows that (S & B) is true. Therefore, we can reason as follows:

**1.**

1. A
2. B

**3. (A & B) 1, 2 conjunction**

**2.**

1. P
2. Q

**3. (P & Q) 1, 2 conjunction**

The rule that permits this is, therefore, aptly named **conjunction.** When you apply conjunction to a set of premises, note off to the side both or all the premises you use to derive the conjunction. Here are two English examples:

**3.**

1. It is cloudy.
2. It is cold.

**3. Hence, it is cloudy and it is cold.**

**4.**

1. The president is a man.
2. The president lives in the capital city.

**3. The president is a man and lives in the capital city. 1, 2 conjunction**

Here are three more examples:

**5.**

1. A
2. (P v Q)

**3. (A & (P v Q)) 1, 2 conjunction**

**6.**

1. X
2. Y
3. Z

**4. (X & Z) 1, 3 conjunction**

**5. (Y & (X & Z)) 2, 4 conjunction**

Notice in example 6 that we have drawn an additional inference, 5, using the conclusion we derived in 4. This is perfectly legitimate and will be common practice by the end of this chapter. Since our rules are truth preserving, any claim we drive by applying them will also be true (on the assumption that the premises are true), and therefore, can be used in further inferences.

**7.**

1. ((Y v W) ⊃ (A & B))
2. (Z v X)

**3. (((Y v W) ⊃ (A & B)) & (Z v X)) 1, 2 conjunction**

**8.**

1. ((B & C) v (C v F))
2. D

**3. ((B & C) v (C v F)) & D 1, 2 conjunction**

# *Modus Ponens*

Recall the truth table for the conditional (⊃):

| **P ⊃ Q** |
|---|
| T T T |
| **T F F** |
| F T T |
| F T F |

A conditional is false just in case the antecedent is true and the consequent is false. Remember that when we find a conditional in a set of premises, we assume it is true for the sake of evaluating the argument. Therefore, for whatever conditional we find, if we know its antecedent is true, we also know its consequent is true. So, if we assume a conditional (P ⊃ Q) is true and we *also* discover that its antecedent P is true, the consequent Q is also true. Here it is in standard form:

**1.**

1. (P ⊃ Q)
2. P

**3. Q 1, 2 *modus ponens***

**2.**

1. R
2. (R ⊃ S)

**3. S 1, 2 *modus ponens***

The rule that permits us to draw this inference is called ***modus ponens***, which is short for *modus ponendo ponens*, and is Latin for "mode (or method) that affirms by affirming." Again, cite all the premises you use to apply the rule. Here are some English examples:

**3.**

1. If it is snowing, the air is cold.
2. It is snowing.

**3. Therefore, the air is cold.**

**4.**

1. If God exists, there is no unnecessary suffering
2. God exists.

**3. Thus, there is no unnecessary suffering.**

**1, 2 *modus ponens***

Here are some further examples:

**5.**

1. A
2. (C v D)
3. (A ⊃ (E & F))

**4. (E & F) 1, 3 *modus ponens***

**6.**

1. (B & C)
2. D
3. (D ⊃ E)

**4. E 2, 3 *modus ponens***

TIP: Notice that it doesn't matter what order the premises are in. In example 5, we find the conditional on line 3 and the simple claim is on line 1. Nevertheless, we can still infer the consequent of line 3 using *modus ponens*.

**7.**

1. ~(X v Y)
2. ~Z
3. (~(X v Y) ⊃ (Z v W))

**4. (Z v W) 1, 3 *modus ponens***

**8.**

1. (D & B)
2. (B v ~H)
3. A
4. ((B v ~H) ⊃ ~E)

**5. ~E 2, 5 *modus ponens***

## *Modus Tollens*

Again, look at our truth table for the conditional:

| P | ⊃ | Q |
|---|---|---|
| T | T | T |
| **T** | **F** | **F** |
| F | T | T |
| **F** | **T** | **F** |

Notice that there are only two lines where the *consequent* is false. Notice also that only one of these two expresses a true conditional. If the consequent of a conditional is *denied*, that is, if we discover that the consequent is false (expressed by adding a negation: ~Q), there is only one line that expresses a true conditional, and that is line 4. If Q is false and P is true, the conditional is false. But if Q is false (~Q is true) and P is false (~P is true), the conditional, (P ⊃ Q), is true.

Therefore, if we come across a conditional (assuming, as we have been, that it is true) and discover also that its consequent is false, we can conclude that its antecedent is false, too. The inference looks like this:

**1.**

1. (P ⊃ Q)
2. ~Q

**3. ~P 1, 2 *modus tollens***

The rule that allows us to draw this inference is called ***modus tollens***, which is short for the Latin, *modus tollendo tollens*, which means, "mode (method) of denying by denying." An English example helps make this inference clear:

**2.**

1. If you are caught stealing, you are going to jail.
2. You are not going to jail.

**3. Therefore, you are not caught stealing.**

**3.**

1. We'll call the police only if there's a riot.
2. But there won't be a riot.

**3. Therefore, we won't call the police. 1, 2 *modus tollens***

Notice that there may be many reasons for going to jail and stealing is just one. So, if you're not going to jail, then you are definitely not caught stealing. Similarly, we may do many things if there is a riot, and the first premise tells us that calling the police is one. But if there won't be a riot, we won't call the police. Here are a few more examples:

**4.**

1. (A ⊃ B)
2. (C v D)
3. ~B

**4. ~A 1, 3 *modus tollens***

**5.**

1. P
2. ~Q
3. (R ⊃ Q)

**4. ~R 2, 3 *modus tollens***

**6.**

1. ((R v V) & W)
2. ((W v P) ⊃ (R v S))
3. ~(R v S)

**4. ~(W v P) 2, 3 *modus tollens***

**7.**

1. (~P & ~Q)
2. ((R v W) ⊃ P)

**3. ~P 1, simplification**

**4. ~(R v W) 2, 3 *modus tollens***

TIP: Notice in example 7 that applying simplification makes it possible for us to use *modus tollens*.

## Getting familiar with … basic rules of inference

**For each of the following sets of premises, use simplification, conjunction, *modus ponens*, or *modus tollens* to derive the indicated conclusion.**

**1.**

1. A
2. (A ⊃ B) /.: B

**2.**

1. A
2. B
3. C
4. D /.: (A & D)

**3.**

1. (P & Q)
2. (R & S) /.: P

**4.**

1. (P & Q)
2. (R & S) /.: (P & R)

**5.**

1. ((R v S) & Q)
2. (~Q v S)
3. T /.: (Q & T)

**6.**

1. ((D ⊃ E) & R)
2. (D ⊃ E)
3. D /.: (D & R)

**7.**

1. ((A ⊃ B) ⊃ (C v D))
2. ~(C ⊃ D) /.: ~(A ⊃ B)

**8.**

1. ((A & ~C) & (D ⊃ E))
2. ~E /.: (~D & ~C)

**9.**

1. ((P ⊃ Q) & (S ⊃ R))
2. (~Q & ~R) /.: (~P & ~S)

**10.**

1. (S ⊃ (Q & R))
2. ~(Q & R)
3. T /.: (~S & T)

**11.**

1. ((P &Q) & W)
2. R /.: W

**12.**

1. ((A v B) ⊃ C)
2. (F & D)
3. (A v B) /.: (F & C)

**13.**

1. A
2. (B v C)
3. ((A & (B v C)) ⊃ D) /.: D

**14.**

1. (B & D)
2. (D ⊃ (E ⊃ F))
3. ~F /.: (~E & B)

**15.**

1. ((P v Q) ⊃ (W & ~Y))
2. (~Q & W)
3. (X ⊃ Y)
4. (P v Q) /.: (~X & ~Q)

**16.**

1. P
2. (P ⊃ Q)
3. (Q ⊃ R)
4. (R ⊃ S) /.: S

**17.**

1. ~P
2. (S ⊃ R)
3. (R ⊃ Q)
4. (Q ⊃ P) /.: ~S

**18.**

1. A
2. B
3. ((A & B) ⊃ ~(C v D))
4. ((E v F) ⊃ (C v D)) /.: (E v F)

**19.**
1. ~(B v D)
2. (A ⊃ (B v D))
3. (H ⊃ ((E & F) & G))
4. <u>H</u> /.: (A & E)

**20.**
1. ~~P
2. (Q ⊃ ~P)
3. <u>~R</u> /.: (~R & ~Q)

## Four More Rules of Valid Inference

Disjunctive Syllogism
Addition
Hypothetical Syllogism
Constructive and Destructive Dilemmas

# Disjunctive Syllogism

As we saw in Chapter 3, a syllogism is a valid deductive argument with two premises. The syllogisms we evaluated in that chapter were "categorical" meaning they had a quantifier such as "all," "none," or "some." A disjunctive syllogism is not necessarily categorical, and in this chapter, because we are not yet ready for propositional quantifiers, none will be explicitly categorical.

As you might expect, a disjunctive syllogism includes at least one premise that is a disjunction. We also know that, for a disjunction to be true, at least one disjunct must be true. Therefore, if we find a disjunction in the premises, we can assume that at least one disjunct is true. If, in addition, we discover that one of the disjuncts is false, we can conclude the other disjunct must be true. For example:

| **1.** | | **2.** | |
|---|---|---|---|
| 1. (P v Q) | | 1. (P v Q) | |
| <u>2. ~P</u> | or | <u>2. ~Q</u> | |
| **3. Q** | | **3. P** | **1, 2 disjunctive syllogism** |

Notice that things aren't so simple if we were simply to discover one of the disjuncts (rather than its negation):

| | | |
|---|---|---|
| 1. (P v Q) | | 1. (P v Q) |
| <u>2. P</u> | or | <u>2. Q</u> |
| **3. ?** | | **3. ?** |

We cannot draw any conclusion using disjunctive syllogism from these premises. Why? Remember in Chapter 5, we said that in logic we interpret the "or" *inclusively*, meaning that at least one disjunct must be true and *both might be*. For instance, Rob might say, "He's either a lawyer or he's a nice guy." To which Jamie might respond, "And in some cases, he may be both." To be sure, there are cases where disjunctions contain disjuncts that cannot possibly both be true, for example: "That toy is either round or square," "It's either raining or it is not," "The person singing is either Lady Gaga or it's not." But if we treat all disjunctions inclusively, we won't run into any trouble; though we may need extra information to know when it is exclusive.

To show you how it works out, here are two examples of disjunctive syllogism on an exclusive or:

| **3.** | | **4.** | |
|---|---|---|---|
| 1. (P v ~P) | | 1. (Q v ~Q) | |
| 2. ~P | or | 2. ~~Q | |
| **3. ~P** | | **3. Q** | **1, 2 disjunctive syllogism** |

Notice that, in both C and D, premise 2 means exactly the same thing as the conclusion. This is a consequence of denying one side in an exclusive disjunction; the result is simply the only other possibility, namely, the other disjunct. So, if it's either raining or it's not, and you learn that it is not not raining (~~R), then you learn, by definition, that it is raining. Therefore, treating all disjunctions inclusively works perfectly well even when the disjunction turns out to be exclusive.

Here are two English examples and four more symbolic examples:

**5.**

1. Your aunt is either married to your uncle or she's married to someone else.
2. Since she divorced your uncle, so she's not married to him.
3. Therefore, she must be married to someone else.

1, 2 disjunctive syllogism

**6**.

1. The progress of evolution is either the product of chance or intelligent design.
2. Chance is not the cause of the progress of evolution.
3. Therefore, evolution is a product of intelligent design.

1, 2 disjunctive syllogism

**7.**

1. ((A v B) v D)

<u>2. ~D</u>

**3. (A v B) 1, 2 disjunctive syllogism**

**8.**

1. ((A v B) v D)

2. ~D

<u>3. ~A</u>

**4. (A v B) 1, 2 disjunctive syllogism**

**5. B 3, 4 disjunctive syllogism**

**9.**

1. ~(P & Q)

<u>2. ((P & Q) v (R ⊃ S))</u>

**3. (R ⊃ S) 1, 2 disjunctive syllogism**

**10.**

1. (((X ⊃ Y) & (Z v Q)) v (R & W))

<u>2. ~((X ⊃ Y) & (Z v Q))</u>

**3. (R & W) 1, 2 disjunctive syllogism**

## Addition

This next rule may be one of the easiest to perform, though it is often one of the most difficult to understand—at least, when you first see it. Recall that the truth table for disjunction shows that a disjunction is true just in case one disjunct is true, that is, the only false disjunction is one where both disjuncts are false:

<u>**P v Q**</u>

T T T

T T F

F T T

**F <u>F</u> F**

Given this truth table, as long as we know one disjunct is true, then regardless of what claim is disjoined to it, we know the disjunction will be true. Therefore, if we have a claim we know to be true (or that we are assuming is true), then we can disjoin anything to it and the resulting disjunction will be true. For instance, if we know it is true that "Grass is green," then we also know it is true that "Either grass is green or the moon is made of green cheese." Similarly, if we know that "Humans need oxygen to survive," then we know that "Either humans need oxygen to survive or Martians control my camera."

So, for any claim you know (or assume) to be true, you may legitimately disjoin any other claim to it by a rule called ***addition*** (not to be confused with conjunction).

| 1. | | 2. | |
|---|---|---|---|
| 1. A | | 1. (A & B) | |
| **2. (A v B)** | **1 addition** | **2. ((A & B) v C)** | **1 addition** |

This rule is sometimes helpful when attempting to derive a more complicated conclusion. For example, consider the following argument:

**3.**

1. (P & Y)
2. ~R
3. (W v R)  /.: ((P & W) v Y)

You can derive this conclusion using only the rules we've covered so far. Start by using simplification to isolate P, then use disjunctive syllogism to isolate W. And then use conjunction to conjoin P and W:

**3.**

1. (P & Y)
2. ~R
3. (W v R)  /.: ((P & W) v Y)
**4. P  1 simplification**
**5. W  2, 3 disjunctive syllogism**
**6. (P & W)  4, 5 conjunction**

Now the question becomes: how do I disjoin Y to the claim in 6? Notice that, in this argument, there is a Y in premise 1 that could be simplified:

**3.**

1. (P & Y)
2. ~R
3. (W v R)  /.: ((P & W) v Y)
4. P  1 simplification
5. W  2, 3 disjunctive syllogism
6. (P & W)  4, 5 conjunction
7. Y  1 simplification
**8. ?**

Unfortunately, however, this won't help with our conclusion, which is a disjunction. The only way to reach our conclusion is to ignore the Y in premise 1 and simply use our addition rule to "add" (or disjoin) Y. Since we already know (P & W) is true, it doesn't matter whether Y is or whether we already have Y somewhere in the premises:

**3.**

| | |
|---|---|
| 1. (P & Y) | |
| 2. ~R | |
| 3. (W v R) | /.: ((P & W) v Y) |
| 4. P | 1 simplification |
| 5. W | 2, 3 disjunctive syllogism |
| 6. (P & W) | 4, 5 conjunction |
| **7. ((P & W) v Y)** | **6 addition** |

Since this rule is a more technical tool of logic, English examples do not tend to make the rule clearer. But just in case, here are two English examples and three more symbolic examples:

**4.**

1. He's a Republican.

2. So, he's either a Republican or a Libertarian. **1 addition**

**5.**

1. Tom is a state representative.

2. Thus, he's either a state representative or a farmer **1 addition**

**6.**

| | |
|---|---|
| 1. P | |
| 2. ((P v Q) ⊃ Y) | |
| **3. (P v Q)** | **1 addition** |
| **4. Y** | **2, 3 *modus ponens*** |

**7.**

| | |
|---|---|
| 1. ((A v B) ⊃ C) | |
| 2. (D ⊃ E) | |
| 3. A | |
| **4. (A v B)** | **3 addition** |
| **5. C** | **1, 4 *modus ponens*** |
| **6. (C v (D ⊃ E))** | **5 addition** |

**8.**

| | |
|---|---|
| 1. P | |
| **2. (P v Q)** | **1 addition** |
| **3. ((P v Q) v (V v W))** | **2 addition** |
| **4. (P v ((Q v (V v W)))** | **1 addition** |

Notice in example 8 that line 3 cannot be derived without first deriving line 2. Notice also that line 4 can be derived from line 1 without reference to line 2 or 3.

## Hypothetical Syllogism

Our next rule allows us to derive a conditional claim from premises that are conditionals. This one is fairly intuitive. Consider the following two premises:

1. If it is a cat, then it is a mammal.
2. <u>If it is a mammal, then it is warm-blooded.</u>

From these two premises, regardless of whether "it" is actually a cat or a mammal or warm-blooded, we can, nevertheless, conclude:

3. If it is a cat, then it is warm-blooded.

We can't conclude that it definitely is warm-blooded because we don't yet know whether it is a cat. We don't know what it is. But one thing is for sure: If it is a cat, given these premises, it is also warm-blooded.

The rule that allows you to draw this inference is called *hypothetical syllogism*. To help you remember how this one goes, think about when someone says, "Hypothetically speaking, if I were to ask you to go out to dinner, what would you say?" An adequate response would not be, "Yes (or, sadly, no), I will go with you," because, technically, the question is not, "Will you go out to dinner," but, "*If* I were to ask, what *would* you say?" So, an adequate answer would be, "If you were to ask, I would say yes (or no)."

For any two conditionals, if the antecedent of one is the consequent of the other, you can use hypothetical syllogism to derive a conditional:

| **1.** | **2.** | |
|---|---|---|
| 1. (P ⊃ S) | 1. (H ⊃ B) | |
| <u>2. (S ⊃ R)</u> | <u>2. (B ⊃ L)</u> | |
| **3. (P ⊃ R)** | **3. (H ⊃ L)** | **1, 2 hypothetical syllogism** |

Notice in argument 1, the claim S is the consequent of premise 1 and the antecedent of premise 2. Similarly, in argument 2, the claim B is the consequent of premise 1 and the antecedent of premise 2. Here are two more English examples and four more symbolic examples:

**3.**

1. If the levies break, the town floods.
2. If the town floods, we will have to evacuate.
3. If the levies break, we will have to evacuate.

**4.**

1. If the dog barks, there is something in the yard.
2. If there is something in the yard, I need to get out of bed.
3. If the dog barks, I need to get out of bed.

**1, 2 hypothetical syllogism**

**5.**

1. ((A v B) ⊃ (D & E))
2. ((D & E) ⊃ B)
3. **((A v B) ⊃ B)**

**1, 2 hypothetical syllogism**

**6.**

1. (A ⊃ (D v F))
2. (B ⊃ A)
3. **(B ⊃ (D v F))**

**1, 2 disjunctive syllogism**

**7.**

1. ~P
2. (P v (R ⊃ S))
3. (S ⊃ (X v Y))
4. **(R ⊃ S)**

**1, 2 disjunctive syllogism**

5. **(R ⊃ (X v Y))**

**3, 4 hypothetical syllogism**

**8.**

1. ((X v Y) & ((W v Q) ⊃ Z))
2. (Z ⊃ (P v Q))
3. **((W v Q) ⊃ Z)** **1 simplification**
4. **((W v Q) ⊃ (P v Q))**

**2, 3 hypothetical syllogism**

# Constructive and Destructive Dilemmas

Our final rule of inference is not intuitive without a bit of explanation. The term "dilemma" often refers to an argument whose conclusion leaves us with two unpalatable or irrational options. We might use the phrase "between a rock and a hard place" and "That's quite a dilemma" interchangeably. Similarly, logical paradoxes are often dilemmas. In more than one of Zeno's famous paradoxes of motion, we are supposed to be stuck with either giving up the belief that motion exists or giving up common-sense beliefs, such as that one can walk across a room or that a human runner cannot run faster than a tortoise.

## Constructive Dilemma

In logic, however, the term dilemma is much more innocuous, referring only to using a disjunction to derive another disjunction. For example, if you know two conditionals are true, the disjunction of their antecedents logically implies the disjunction of their consequents. This is called the *constructive dilemma*. Here are two basic forms:

| **1.** | **2.** |
|---|---|
| 1. ((P ⊃ Q) & (R ⊃ S)) | 1. (P ⊃ Q) |
| <u>2. (P v R)</u> | 2. (R ⊃ S) |
| 3. (Q v S) **1, 2 constructive dilemma** | <u>3. (P v R)</u> |
| | **4. (Q v S) 1-3 constructive dilemma** |

Colloquially, we might encounter an example like this:

**3.**

1. My choices are either to take this job or to go to college.
2. <u>If I take this job, I will have extra spending money now, but if I go to college, I will have an opportunity to make more money in the long run.</u>
3. So, I will either have extra spending money now or the opportunity to make more money in the long run.

The constructive dilemma preserves truth for the same reason that *modus ponens* does. In fact, some logic texts describe the constructive dilemma as a combination of two *modus ponens* operations. If P implies Q, then if P is true, Q is true. And if R implies S, then if R is true, S is true. So, if we also know that either P is true or R is true, since at least one of them must be true, we also know that either Q is true or S is true. Here are two more examples:

| **4.** | **5.** |
|---|---|
| 1. (A v B) | 1. ((~B ⊃ ~R) & ((P & Q) ⊃ ~S)) |
| <u>2. ((A ⊃ P) & (B ⊃ Q))</u> | <u>2. (~B v (P & Q))</u> |
| 3. (P v Q) | 3. (~R v ~S) |

## Destructive Dilemma

The *destructive dilemma* is similar; however, it makes use of the operation behind *modus tollens* instead of *modus ponens*:

| **1.** | **2.** |
|---|---|
| 1. ((P ⊃ Q) & (R ⊃ S)) | 1. (P ⊃ Q) |
| <u>2. (~Q v ~S)</u> | 2. (R ⊃ S) |
| **3. (~P v ~R)** | <u>3. (~Q v ~S)</u> |
| **1, 2 destructive dilemma** | **4. (~P v ~R) 1-3 destructive dilemma** |

If we know that at least one of the consequents of the conditionals is false, then we know at least one of the antecedents is false. Colloquially, we might hear a version like the following:

**3.**

1. If the cronies get their way, you'll vote for Thatcher's policy, and if the bleeding hearts get their way, you will vote for Joren's policy.
2. So, either you won't vote for Thatcher's policy or you won't vote for Joren's.
3. Either way, the cronies are not getting their way or the bleeding hearts are not getting theirs.

Here are two more examples:

**4.**

1. (((A v B) ⊃ C) & ((D v E) ⊃ S))
2. (~C v ~S)
3. ((~(A v B) v ~(D v E)) **1, 2 destructive dilemma**

**5.**

1. (B ⊃ C)
2. (A ⊃ D)
3. (~C v ~D)
4. (~B v ~A) **1-3 destructive dilemma**

## Getting familiar with … more rules of inference

**A. For 1–10, use disjunctive syllogism, addition, hypothetical syllogism, or constructive dilemma to derive the indicated conclusion:**

**1.**

1. ((A v B) ⊃ C)
2. (F & D)
3. (C ⊃ (E v H)) /.: ((A v B) ⊃ (E v H))

**2.**

1. (H v P)
2. ((H v A) ⊃ C)
3. ~P /.: (H v A)

**3.**

1. (~P v (D v Z))
2. (~(D v Z) v B)
3. ~B /.: (~P)

**4.**

1. (~S ⊃ R)
2. (R ⊃ B)
3. (B ⊃ ~Q) /.: (~S ⊃ ~Q)

**5.**

1. ((P v Q) v (~R v ~S))
2. ~(P v Q)
3. ~~S /.: ~R

**6.**

1. (M v N)
2. (A & R)
3. (B v S) /.: (((M v N) v (O & P)) v (Q v R))

**7.**
1. (((P v Q) & (R & S)) & (T v U))
2. (A & B) /.: (B v P)

**8.**
1. (R ⊃ Q)
2. (Q ⊃ (W v X))
/.: ((R ⊃ (W v X)) v P)

**9.**
1. A
2. ((A v B) ⊃ ~C)
3. (~C ⊃ F) /.: ((A v B) ⊃ F)

**10.**
1. ((X v Y) v ~Z)
2. (W v ~~Z)
3. ~Y
4. ~W /.: X

**B. For 11–20, derive the stated conclusion using one or more of all eight rules you've learned so far.**

**11.**
1. (~S ⊃ Q)
2. (R ⊃ ~T)
3. (~S v R) /.: (Q v ~T)

**12.**
1. ((F v E) ⊃ (G & H))
2. (G v ~F)
3. (~R & ~J) /.: (U & ~T)

**13.**
1. ((H ⊃ B) & (O ⊃ C))
2. (Q ⊃ (H v O))
3. Q /.: (B v C)

**14**
1. (H ⊃ (D & W))
2. (D ⊃ K)
3. H /.: (H & K)

**15.**
1. ((B ⊃ (A v C))
2. (B & ~A) /.: C

**16.**
1. ((A v B) ⊃ C)
2. ((C v D) ⊃ (G v F))
3. (A & ~G) /.: F

**17.**
1. ((A & B) ⊃ ~C)
2. (C v ~D)
3. (A ⊃ B)
4. (E & A) /.: ~D

**18.**
1. ((~A v ~L) ⊃ ~G)
2. (~A ⊃ (F ⊃ G))
3. (A ⊃ D)
4. ~D /.: (~F v H)

**19.**
1. (F ⊃ (G ⊃ ~H))
2. ((F & ~W) ⊃ (G vT))
3. (F & ~T)
4. (W ⊃ T) /.: ~H

**20.**
1. (P ⊃ (Q ⊃ (R v S)))
2. (P & Q)
3. (S ⊃ T)
4. (~T v ~W)
5. W /.: (R v W)

# Eleven Valid Rules of Replacement

In addition to drawing valid inferences, there are ways of preserving truth value that requires only rearranging the terms and operators in a claim. Rather than inferring a claim from others, one can simply replace a claim with one that is truth-functionally equivalent (the etymology of "equivalent" helps here: *equi-* means "the same" and *valent* means "value"—recall we are using a bivalent, or two-valued, logic, where the two values are "true" and "false").

## Reiteration

The simplest replacement rule, a rule called *reiteration*, doesn't even require that we rearrange anything: For any claim, P, if it is a premise or derived validly, it can be reiterated at any point in the argument without loss of truth value:

| **1.** | **2.** | **3.** | |
|---|---|---|---|
| <u>1. P</u> | <u>1. (P v Q)</u> | <u>1. (A ⊃ (B v C))</u> | |
| 2. P | 2. (P v Q) | 2. (A ⊃ (B v C)) | 1 reiteration |

In the case of reiteration, it is obvious why truth value is preserved; it's the same claim! So, the rule of reiteration is stated like this:

**Reiteration: P ≡ P**

But there are alternative ways of expressing claims that are not as obviously equivalent. But after you see how replacement works, further examples will make sense. So, rather than explaining how each rule of replacement works, we will explain three more replacement rules and then provide ample examples of the rest. Once you understand what a rule of replacement does, all that is left is to memorize and practice using them. You can find the complete list of these rules on the inside cover of this book.

> Note: Some logic textbooks treat reiteration as a rule of inference rather than as a rule of replacement: From any true claim, you may validly infer that claim. This makes no difference in the practice of constructing proofs. We place it among rules of replacement for teaching purposes; we find that it makes the role of replacement rules clearer.

# Double Negation

Something you may have already guessed from working with truth tables is that another way of expressing P, apart from simply restating it, is to add two negation operators: ~~P. This makes sense on a truth table: if P is true, and ~P changes the truth value to F, then ~~P changes it back to true:

| | |
|---|---|
| **1.** | **2.** |
| ~~P | ~~(A v B) |
| **T**FT | **T**F T T T |
| **F**TF | **T**F T T F |
| | **T**F F T T |
| | **F**T F F F |

So, any claim is truth-functionally equivalent to its double-negation, and the rule of replacement called double-negation is as follows:

**Double Negation: P ≡ ~~P**

| | | | |
|---|---|---|---|
| **3.** | | **4.** | |
| 1. P | | 1. ~~~~P | |
| **2. ~~P** | **1 double negation** | **2. ~~P** | **1 double negation** |
| | | **3. P** | **2 double negation** |

# Transposition (Contraposition)

The rule of replacement known as transposition (also called contraposition) preserves truth for the same reason that *modus tollens* does. For any conditional, if you know the negation of its consequent, you can derive the negation of its antecedent:

***modus tollens***

1. (P ⊃ Q)
2. ~Q
3. ~P

Transposition says, if you know (P ⊃ Q), then, even if you don't know ~Q, you do know that if ~Q is true, then ~P is true: (~Q ⊃ ~P). So, any conditional is truth-functionally equivalent to a conditional in which its antecedent and consequent are flipped and negated. The rule looks like this:

**Transposition: (P ⊃ Q) ≡ (~Q ⊃ ~P)**

## DeMorgan's Laws

Logician Augustus DeMorgan (1806–1871) identified the next set of replacement rules for whom they are now named. If it is true that P is not true and Q is not true (~P & ~Q) then the disjunction of P and Q (P v Q) cannot be true, since neither conjunct is true: ~(P v Q). This means that (~P & ~Q) is truth-functionally equivalent to ~(P v Q).

Similarly, if it is true that either P is not true or Q is not true (~P v ~Q), then the conjunction of P and Q (P & Q) cannot be true, because at least one conjunct is false: ~(P & Q). This leaves us with two very handy versions of the same replacement rule called DeMorgan's Laws:

**DeMorgan's Laws: (~P & ~Q) ≡ ~(P v Q)**

**(~P v ~Q) ≡ ~(P & Q)**

## The Remaining Rules of Replacement

**Commutativity**

**(P v Q) ≡ (Q v P)**

**(P & Q) ≡ (Q & P)**

**(P ≡ Q) ≡ (Q ≡ P)**

**Associativity**

**((P v Q) v R) ≡ (P v (Q v R))**

**((P & Q) & R) ≡ (P & (Q & R))**

**Distribution**

**(P & (Q v R)) ≡ ((P & Q) ∨ (P & R))**

**(P v (Q & R)) ≡ ((P v Q) & (P v R))**

**Conditional Exchange (Material Implication)**

**(P ⊃ Q)≡ (~P v Q)**

**Material Equivalence**

**(P ≡ P) ≡ ((P ⊃ Q) & (Q ⊃P))**

**(P ≡ Q) ≡ ((P & Q) v (~P & ~Q))**

**Exportation**

**((P & Q) ⊃ R) ≡ (P ⊃ (Q ⊃ R))**

**Tautology**

**P ≡ (P v P)**

**P ≡ (P & P)**

## Getting familiar with … rules of replacement

**For 1–10, show which rule of replacement was applied.**

**1.**
1. $\underline{(\sim(P \equiv R) \vee \sim(Q \,\&\, S))}$
2. $\sim((P \equiv R) \,\&\, (Q \,\&\, S))$

**2.**
1. $\underline{(Q \,\&\, (R \vee S))}$
2. $((Q \,\&\, R) \vee (Q \,\&\, S))$

**3.**
1. $\underline{\sim\sim(A \,\&\, B) \vee (Q \supset R)}$
2. $(A \,\&\, B) \vee (Q \supset R)$

**4.**
1. $\underline{((P \supset Q) \equiv (R \,\&\, T))}$
2. $((R \,\&\, T) \equiv (P \supset Q))$

**5.**
1. $\underline{(P \,\&\, Q) \supset R)}$
2. $\sim R \supset \sim(P \,\&\, Q)$

**6.**
1. $\underline{(P \vee T)}$
2. $\sim\sim(P \vee T)$

**7.**
1. $\underline{(R \,\&\, Z)}$
2. $(R \,\&\, Z) \vee (R \,\&\, Z)$

**8.**
1. $\underline{(P \supset Q) \supset (\sim P \vee Q)}$
2. $\sim (P \supset Q) \vee (\sim P \vee Q)$

**9.**
1. $\underline{(Q \vee (R \,\&\, S))}$
2. $((Q \vee R) \,\&\, (Q \vee S))$

**10.**
1. $\underline{(P \equiv P)}$
2. $((P \supset Q) \,\&\, (Q \supset P))$

# Two Valid Proof Strategies

**Conditional Proof**
Indirect Proof / *reductio ad absurdum*

One of the advantages of deductive logic is that it allows us to construct **proofs** for claims, much like we do in mathematics. So far, we have seen how valid rules of inference allow us to derive conclusions from premises in a way that preserves truth. That is, if we use a rule properly, we know that, if our premises are true, so are our conclusions. Proofs are powerful tools that extend this truth-preserving feature of our valid rules. We will introduce you to two common proof methods of propositional logic: the conditional proof and the indirect proof, also called *reductio ad absurdum* (reduction to absurdity).

# Conditional Proof

A *conditional proof* allows us to construct a conditional from a set of premises that may or may not include a conditional. Here's the trick: Since one sufficient condition for a true conditional is that it has a true consequent (every conditional with a true consequent is true), then, for any claim we know to be true, we can construct a conditional with that claim as the consequent. We can see this more clearly seen by recalling the truth table for a conditional:

| P | ⊃ | Q | |
|---|---|---|---|
| **T** | **T** | **T** | ➡ |
| T | F | **T** | |
| **F** | **T** | F | ➡ |
| F | T | F | |

This means that, if we know B is true, we can construct the following true conditional: (A ⊃ B). Regardless whether A is true or false, the conditional is true. Now, consider the following argument:

**1.**

1. (A & B)

2. C /.: (D ⊃ A)

We are asked to derive a conditional claim. To do this, we have to make an assumption, namely, that our antecedent, D, is true. We do this by adding a vertical derivation line, to indicate that F is only an assumption and, therefore, may or may not be true. We also note off to the side that it is an assumption:

**1.**

1. (A & B)

2. C /∴ (D ⊃ A)

**3. | D** **assumption for conditional proof**

Now, on the assumption that D is true, can we derive A using valid rules of inference? If we can, then we can conclude that the conditional claim (D ⊃ A) is true. And it turns out that we can derive A:

**1.**

1. (A & B)

2. C /∴ (D ⊃ A)

3. | D **assumption for conditional proof**

**4. | A** **1 simplification**

To complete this proof, close off the derivation line as shown below. Write your conclusion, then indicate to the right all the lines involved in the proof:

**1.**

| | |
|---|---|
| 1. (A & B) | |
| 2. C | /∴ (D ⊃ A) |
| 3. │D | **assumption for conditional proof** |
| 4. │A | **1 simplification** |
| **5. (D ⊃ A)** | **3–4 conditional proof** |

Here's a more complicated example:

**2.**

| | |
|---|---|
| 1. ((~P v ~Z) & (X v Y)) | |
| 2. ~~Z | |
| 3. (W v P) | /.: (X ⊃ W) |

Consider, first, whether there is any way to derive the conditional using only your rules of inference. In this case, there is not. X is in premise 1, but it is not obviously connected with W. Therefore, you will need to construct a conditional proof, assuming X is true:

**2.**

| | |
|---|---|
| 1. ((~P v ~Z) & (X v Y)) | |
| 2. ~~Z | |
| 3. (W v P) | /∴ (X ⊃ W) |
| **4. │X** | **assumption for conditional proof** |

Now consider whether you can derive W from the premises given. As it turns out we can:

**2.**

| | |
|---|---|
| 1. ((~P v ~Z) & (X v Y)) | |
| 2. ~~Z | |
| 3. (W v P) | /∴ (X ⊃ W) |
| 4. │X | **assumption for conditional proof** |
| **5. │(~P v ~Z)** | **1 simplification** |
| **6. │~P** | **2, 5 disjunctive syllogism** |
| **7. │W** | **3, 6 disjunctive syllogism** |

Now we see that, on the assumption that X, we can derive W. Now we are ready to close off our derivation line, and draw our conclusion:

**2.**

| | | |
|---|---|---|
| 1. | ((~P v ~Z) & (X v Y)) | |
| 2. | ~~Z | |
| 3. | (W v P) | /∴ (X ⊃ W) |
| 4. | X | **assumption for conditional proof** |
| 5. | (~P v ~Z) | **1 simplification** |
| 6. | ~P | **2, 5 disjunctive syllogism** |
| 7. | W | **3, 6 disjunctive syllogism** |
| **8.** | **(X ⊃ W)** | **4–7 conditional proof** |

Here are two English examples and two more symbolic examples:

**3.**

1. If Henry was at the station, the alarm sounded.
2. If the alarm sounded, then either the guard saw the thief or the thief threatened someone.
3. The thief didn't threaten anyone.
4. If the guard saw him, he can give us a description.

/∴ If Henry was at the station, the guard can describe him.

| | | |
|---|---|---|
| **5.** | **Henry was at the station.** | **assumption for conditional proof** |
| **6.** | **The alarm sounded.** | **1, 5 *modus ponens*** |
| **7.** | **Either the guard saw him or the thief threatened someone.** | **2, 6 *modus ponens*** |
| **8.** | **The thief didn't threaten anyone.** | **3 simplification** |
| **9.** | **The guard saw the thief.** | **7, 8 disjunctive syllogism** |
| **10.** | **The guard can give us a description.** | **4, 9 *modus ponens*** |
| **11.** | **If Henry was at the station, the guard can give us a description.** | **5–11 conditional proof** |

**4.**

1. If it is raining, the sidewalks are wet.
2. If the sidewalks are wet, they are uncovered.
3. If those awnings are five feet wide, they cover the sidewalk.

/∴ If it is raining, those awnings are not five feet wide.

| | | |
|---|---|---|
| **4.** | **It is raining.** | **assumption for conditional proof** |
| **5.** | **The sidewalks are wet.** | **1, 4 *modus ponens*** |
| **6.** | **The sidewalks are uncovered.** | **2, 5 *modus ponens*** |
| **7.** | **Those awnings are not five feet wide.** | **3, 6 *modus tollens*** |
| **8.** | **If it is raining, those awnings are not five feet wide.** | **4–8 conditional proof** |

**5.**

1. ((A v B) ⊃ C)
2. (F & D)
3. A
4. (C ⊃ (E v H)) /∴ ((A v B) ⊃ (E v H))

| | | |
|---|---|---|
| **5.** | **(A v B)** | **assumption for conditional proof** |
| **6.** | **C** | **1, 5 *modus ponens*** |
| **7.** | **(E v H)** | **4, 6 *modus ponens*** |
| **8.** | **((A v B) ⊃ (E v H))** | **5–8 conditional proof** |

**6.**

1. ((S & K) ⊃ R)
2. K /∴ (S ⊃ R)

| | | |
|---|---|---|
| **3.** | **S** | **assumption for conditional proof** |
| **4.** | **(S & K)** | **2, 3 conjunction** |
| **5.** | **R** | **1, 4 *modus ponens*** |
| **6.** | **(S ⊃ R)** | **3–5 conditional proof** |

# Indirect Proof/*reductio ad absurdum*

For some arguments, our first eight rules of inference will be inconclusive. You may apply rule after rule and see no clear way to derive a conclusion. When you run into this problem, it is time to try our next proof method, *Indirect Proof*, also called *reductio ad absurdum* (reduction to absurdity).

You may have heard the phrase, "Let's assume, for the sake of argument, that *X*," only to discover that the arguer is really trying to prove that *X* is false. One way to do this is to show that *X* entails some sort of absurdity, like a contradiction. This is precisely what a *reductio ad absurdum* attempts to show. If some proposition, *P*, entails a contradiction, *P* is false. For example, consider the following argument for the claim, "There are no married bachelors":

**1.**

| | |
|---|---|
| 1. If someone is a bachelor, that person is unmarried. | premise (definition of "bachelor") |
| **2. There is at least one person who is married and a bachelor.** | **assumption for indirect proof** |
| **3. Someone, X , is a bachelor.** | **2 simplification** |
| **4. X is unmarried.** | **1, 3 *modus ponens*** |
| **5. X is married.** | **2 simplification** |
| **6. X is both married and unmarried.** | **4, 5 conjunction** |
| **7. Therefore, there are no married bachelors.** | **2–6 indirect proof** |

From the definition of "bachelor" and the assumption that there is at least one person who is married and a bachelor, we can derive the contradiction that someone is both married and unmarried. Since our assumption entails a contradiction, we must conclude that it is false.

How do we know that a claim that entails a contradiction is false? There are two reasons; one that is generally intuitive and one that is more rigorous. First, logically we may derive the truth of any claim from a contradiction. For instance, from the contradiction, "God exists and doesn't exist" (G & ~G), we can derive anything we want, including farfetched claims like "Satan rocks" (S) and "Def Leppard is the greatest band of all time" (D). Here's how:

**2.**

| | |
|---|---|
| 1. (G & ~G) | assumption |
| 2. G | 1 simplification |
| 3. (G v S) | 2 addition |
| 4. ~G | 1 simplification |
| 5. S | 3, 4 disjunctive syllogism |

So, if God both exists and doesn't exist, we may derive that Satan rocks. And we may continue:

6. (G v D) 1 simplification
7. D 4, 6 disjunctive syllogism

And we could just keep going. Contradictions entail the truth of every claim. But surely this is wrong. Every claim cannot be true. Therefore, any claim that entails a contradiction must be false.

The second, more rigorous, reason to think claims that entail contradictions are false is that our definition of truth entails that contradictions are false. A claim is true if and only if its negation is false. This is evident from our truth table for the conjunction. If one or both sides of a conjunction are false, the conjunction is false:

| P & Q | P & ~P |
|---|---|
| T T T | T **F** FT |
| T **F** F | F **F** TF |
| F **F** T | |
| F **F** F | |

Therefore, any claim that entails a contradiction necessarily entails a false claim. But why also say that the claim that entails it must be false? Remember, valid arguments preserve truth, so that if some premise is true, anything it validly entails is true. If, on the assumption that a claim, *P*, is true, we validly derive a contradiction (a false claim), it follows that *P* is false.

We can see this clearly using *modus tollens*. Assume that P entails a contradiction:

1. (P ⊃ (Q & ~Q)) assumption

The truth table for conjunction entails that the consequent is false:

2. ~(Q & ~Q) premise (definition of truth)

Therefore, by *modus tollens*, the antecedent is false.

3. ~P 1, 2 *modus tollens*

Here is another English example and two symbolic examples:

**3.**

1. If Goering was a Nazi, then either he was evil or he was an idiot.
2. If he was evil, then he should be punished.
3. Goering was not an idiot (He had an IQ of 138).
4. Goering was a Nazi.
5. If someone should be punished, that person is morally responsible for his actions.

| | | |
|---|---|---|
| 6. | No one is morally responsible for his actions. | assumption for indirect proof |
| 7. | Goering was either evil or an idiot. | **1, 4 *modus ponens*** |
| 8. | Goering was evil. | **3, 7 disjunctive syllogism** |
| 9. | Goering should not be punished. | **5, 6 *modus tollens*** |
| 10. | Goering was not evil. | **2, 9 *modus tollens*** |
| 11. | Goering was and was not evil. | **8, 10 conjunction** |
| 12. | It is not the case that no one is morally responsible for his actions | **6–11 indirect proof** |

**4.**

| | | |
|---|---|---|
| 1. | $((G \& R) \supset (I \& D))$ | |
| 2. | $(R \supset \sim D)$ | $/\therefore \sim(G \& R)$ |
| **3.** | $\mathbf{(G \& R)}$ | **assumption for indirect proof** |
| **4.** | $\mathbf{(I \& D)}$ | **1, 3 *modus ponens*** |
| **5.** | $\mathbf{D}$ | **4 simplification** |
| **6.** | $\mathbf{R}$ | **3 simplification** |
| **7.** | $\mathbf{\sim D}$ | **2, 6 *modus ponens*** |
| **8.** | $\mathbf{(D \& \sim D)}$ | **5, 7 conjunction** |
| **9.** | $\mathbf{\sim(G \& R)}$ | **3–8 indirect proof** |

**5.**

| | | |
|---|---|---|
| 1. | $(S \supset (P \supset B))$ | |
| 2. | $(S \supset P)$ | |
| 3. | $(C \supset (S \vee B))$ | $/\therefore \sim(C \& \sim B)$ |
| **4.** | $\mathbf{(C \& \sim B)}$ | **assumption for indirect proof** |
| **5.** | $\mathbf{C}$ | **4 simplification** |
| **6.** | $\mathbf{(S \vee B)}$ | **3, 5 *modus ponens*** |
| **7.** | $\mathbf{\sim B}$ | **4 simplification** |
| **8.** | $\mathbf{S}$ | **6, 7 disjunctive syllogism** |
| **9.** | $\mathbf{P}$ | **2, 8 *modus ponens*** |
| **10.** | $\mathbf{(P \supset B)}$ | **1, 8 *modus ponens*** |
| **11.** | $\mathbf{B}$ | **9, 10 *modus ponens*** |
| **12.** | $\mathbf{(\sim B \& B)}$ | **7, 11 conjunction** |
| **13.** | $\mathbf{\sim(C \& \sim B)}$ | **4–12 indirect proof** |

## Getting familiar with … proofs

**Use the rules from this chapter to derive the indicated conclusion:**

**1.**
1. ((A v B) ⊃ C)
2. (F & D)
3. A
4. (C ⊃ (E v H))

/.: ((A v B) ⊃ (E v H))

**2.**
1. (H & P)
2. ((H v A) ⊃ C)
3. D /.: (C & D)

**3.**
1. (~P v D)
2. (~D & B)
3. ((Z ⊃ P) & A) /.: (~Z & A)

**4.**
1. (~S ⊃ R)
2. (~R v Q)
3. ~Q /.: ~~S

**5.**
1. ((A v B) v (~C v ~D))
2. ~(A v B)
3. ~~D /.: ~C

**6.**
1. (M v N)
2. (O & P)
3. (Q v R)

/.: (((M v N) & (O & P)) & (Q v R))

**7.**
1. (((M v N) & (O & P)) & (Q v R))
2. (A & B) /.: (P & B)

**8.**
1. ((R & S) ⊃ Q)
2. (Q ⊃ (P v R))

/.: (((R & S) ⊃ (P v R)) v Z)

**9.**
1. A
2. ((A v B) ⊃ ~C)
3. (D ⊃ ~~C) /.: ~D

**10.**
1. ((X & Y) v ~Z)
2. (W ⊃ ~~Z)
3. (W & V) /.: X

**11.**
1. B
2. ((B v D) ⊃ ~H)
3. (H v F) /.: (C ⊃ F)

**12.**
1. (~P & Q)
2. (Q ⊃ R)
3. (P v ~R) /.: Y

**13.**
1. ((M ⊃ O) v S)
2. ((~S & N) & M)
3. M
4. (P & ~O) /.: (S v B)

**14.**
1. (A ⊃ (D v F))
2. ((D v F) ⊃ H)
3. ((A ⊃ H) ⊃ B) /.: (F ⊃ B)

**15.**
1. (X v Y)
2. ((X & W) ⊃ (Z ⊃ Y))
3. (~Y & W)
4. Z /.: R

**16.**
1. (B & C)
2. (C ⊃ E))
3. ((E v F) ⊃ H) /.: H

**17.**
1. X
2. ((~S v Y) ⊃ Z)
3. (~Z & ~~S)
/.: (W ⊃ (Y v R))

**18.**
1. (P & (Q v R))
2. ((P v R) ⊃ (~S & ~T))
3. ((~S v ~T) ⊃ ~(P & Q))
/.: (Q ⊃ ~(P & Q))

**19.**
1. (A ⊃ (~A v F))
2. ~F /.: ~A

**20.**
1. ((B & P) ⊃ D)
2. ((P ⊃ D) ⊃ H)
3. (~A & B) /.: (H & ~A)

## Three Mistakes to Avoid: Formal Fallacies

Affirming the Consequent
Denying the Antecedent
Affirming the Disjunct

Even after you get the hang of applying valid rules of inference, you may be tempted to draw inappropriate inferences. The most efficient way to avoid this is to be aware of the most common mistakes. A mistake in reasoning is called a **fallacy**. We will discuss fallacies in more detail in Chapter 10, but in this chapter, we will explain three very common mistakes in deductive reasoning.

# Affirming the Consequent

We have seen that, when reasoning from a conditional claim (*P* ⊃ *Q*), if we know the antecedent, *P*, we can derive the consequent, *Q*, using *modus ponens*. But what happens when, instead of learning that the antecedent, *P*, is true, we learn that the consequent, *Q*, is true? For instance:

1. (P ⊃ Q)
2. <u>Q</u>
3. ?

Any inference from these premises would be invalid. An argument of this form commits a fallacy called *affirming the consequent*, because, instead of claiming/asserting/*affirming* the antecedent of a conditional in premise 2, as in *modus ponens*, we are *affirming* the consequent. Nevertheless, because of *modus ponens*, we may be tempted to infer the antecedent of premise 1:

| <u>*modus ponens* (valid)</u> | <u>affirming the consequent (invalid)</u> |
|---|---|
| 1. (P ⊃ Q) | 1. (P ⊃ Q) |
| <u>2. P</u> | <u>2. Q</u> |
| 3. Q | 3. P |

This is a mistake if we are attempting to construct a *valid* argument. From 1 and 2, we cannot know anything conclusively about *P*. An English example shows why:

**1.**

1. If it is raining, then the sidewalk is wet.
2. <u>The sidewalk is wet.</u>
3. 

Now, what might we conclude about the claim, "It is raining"? That the sidewalks are wet makes it more likely that it is raining than no wet-sidewalk-making event. But we cannot rule out other wet-sidewalk-making events, such as a sprinkler system, someone with a water hose, melting snow, a busted water pipe, a water balloon fight, and so on. Since "It is raining" does not follow necessarily from the premises, the argument is invalid.

It is important to remember that an invalid argument is not necessarily a bad argument. All inductive arguments are invalid and we rely heavily on those in many fields of great importance, including every scientific discipline. Therefore, affirming the consequent is a *formal* fallacy in that, its *form* does not preserve truth from premises to conclusion, and so must not be employed in deductive arguments. Nevertheless, it is a useful tool in scientific reasoning, as we will see in Chapter 8.

Here are two more English examples:

**2.**

1. If it rained before midnight, the bridge is icy this morning.
2. The bridge is icy this morning.
3. Therefore, it rained before midnight. [Not necessarily. Even if the premises are true, it might have rained *after* midnight to the same effect. Or perhaps it snowed before midnight, melted, and then became icy in the early morning hours.]

**3.**

1. If he's coming with us, I'll get sick.
2. I'm getting sick.
3. Therefore, he's with us. [Not necessarily. Even if the premises are true, he might not be coming with us. This is because there are many other reasons to be sick: bad sushi, a Leonardo DiCaprio film, the flu, etc.]

## Denying the Antecedent

Just as we cannot derive the antecedent, *P*, of a conditional, (*P* ⊃ *Q*), from its consequent, *Q*, we cannot derive the *denial* of the consequent, ~*Q*, of a conditional from a *denial* of its antecedent, ~*P*. We may be tempted to do so because *modus tollens* tells us we can derive the denial of the antecedent, ~*P*, from the denial of the consequent, ~*Q*; but it is important to see that the implication does not move validly in the other direction:

| *modus tollens* (valid) | denying the antecedent (invalid) |
|---|---|
| 1. (P ⊃ Q) | 1. (P ⊃ Q) |
| 2. ~Q | 2. ~P |
| 3. ~P | 3. ~Q |

Premise 1 of both arguments tells us that, if *P* is true, *Q* is also true. So if *Q* turns out to be false, we can be sure that *P* is, too. However, if *P* turns out to be false, what could we know about *Q*? Is *P* the only reason *Q* is true? Premise 1 doesn't tell us this.

For instance, if you graduate college, then you have taken at least some number of credit hours; let's say 120 credits are required in order to graduate. From this claim, we know that if you haven't taken 120 hours, then there's no chance you have graduated. But does the inference go the other way: you haven't graduated, so you haven't taken at least 120 credit hours? Surely not. You may have taken some strange combination of courses that guarantees you *won't* graduate.

Therefore, learning the denial of the antecedent of a conditional does not allow us to draw any *valid* conclusion about the consequent. Here are two more English examples to clarify:

**1.**

1. If she's going to the party, Kwan will not be there.
2. She's not going to the party.
3. Thus, Kwan will be there. [Not necessarily. Even if she's not going, Kwan might have gotten sick or crashed his car, etc. There are lots of reasons Kwan might not be there even if the premises are true.]

**2.**

1. If the bulbs are lit, they are getting electricity.
2. The lights aren't lit.
3. Hence, they are not getting electricity. [Not necessarily. The bulbs might be burned out. Even though they are getting electricity, they would not be lit.]

## Affirming the Disjunct

Our first two fallacies highlight ways that reasoning from conditionals can be tricky. Our third common fallacy highlights a way that reasoning from a disjunction can be tricky. Disjunctive syllogism tells us that, if we know that a disjunction is true, ($P$ v $Q$), and we know that one of the disjuncts is true, say ~$Q$, we can infer the other disjunct, $P$. But there are times when, instead of knowing the negation of one of the disjuncts, we know the affirmation of one of the disjuncts:

1. (P v Q)
2. Q
3. ?

In this case, we cannot infer anything about the other disjunct. This is because, in a true disjunction, at least one disjunct is true and both might be true. So, knowing that one disjunct is true isn't sufficient for inferring the truth or falsity of the other disjunct.

Because of disjunctive syllogism and because we often think of disjunctions as expressing an *exclusive* "or" (either P or Q, and not both), we might be tempted to infer the negation of the other disjunct:

| disjunctive syllogism (valid) | affirming the disjunct (invalid) |
|---|---|
| 1. (P v Q) | 1. (P v Q) |
| 2. ~Q | 2. Q |
| 3. P | 3. ~P |

Replacing P and Q with English sentences helps to show why affirming the disjunct is invalid:

**1.**

1. Either London is the capital of England or Madrid is the capital of Spain.
2. London is the capital of England.
3. Therefore, Madrid is not the capital of Spain.

[Premise 1 is true because at least one disjunct is true. Remember, in logic, we interpret disjunctive claims "inclusively"; both sides can be true. Therefore, learning that London is, in fact, the capital of England does not provide reasons to conclude anything about whether Spain is the capital of Madrid.]

**2.**

1. Toyota is a Japanese company or the earth is not flat.
2. The earth is certainly not flat.
3. Hence, Toyota is not a Japanese company.

[Again, both disjuncts in premise 1 are true, so it is impossible to conclusively derive any claim about Toyota.]

Jamie can relate a personal example of how tempting it can be to affirm the disjunct. One night he walked into the kitchen and noticed one pan near the stove with warm food in it and two stove eyes, either of which could have been hot. Since there was only one pan, he assumed that only one eye was likely to be hot. He held his hand above one eye and felt that it was warm. And then, to his dismay, he reasoned as follows:

**3.**

1. Either the left eye is hot or the right eye is hot.
2. The left eye is hot.
3. Therefore, the right eye is not hot.

On the basis of this fallacious inference, he sat a plate on the right eye and severely burned his finger. The problem, of which he is now painfully aware (literally), is that both sides of a disjunction can be true, and, in this case, both were true. (As it turns out, his wife had used two pans and both eyes.)

## Getting familiar with … formal fallacies

**A. For each of the following fallacious arguments, identify which formal fallacy has been committed and explain your answer:**

**1.**

1. He's the president of the company or I'm a monkey's uncle.
2. Here is the memo announcing that he is president.
3. So, I'm obviously not a monkey's uncle.

**2.**

1. If I flip this switch, the light will come on.
2. I'm not flipping the switch.
3. Therefore, the light will not come on.

**3.**

1. It is either raining or storming.
2. It is certainly raining.
3. Thus, it is not storming.

**4.**

1. If you flip this switch, the light will come on.
2. The light is coming on.
3. Hence, you must be flipping the switch.

**5.**

1. If it drops below 0°C, either the roads will become icy or the water line will freeze.
2. It is -5°C (below 0°).
3. So, either the roads will become icy or the water line will freeze.
4. The roads are icy.
5. Therefore, the water line is probably not frozen.

**B. For each of the following arguments, construct the formal fallacy indicated by filling in the missing premise and conclusion:**

**1. Affirming the disjunct**

1. Either the Bulls will win or the Suns will.
2. _____________
3.

**2. Denying the antecedent**

1. They will break up if she doesn't tell him the truth.
2. _____________
3.

**3. Affirming the consequent**

1. If the road is wet, your tires won't have as much traction.
2. _____________
3.

**4. Affirming the disjunct**

1. Don't spoil it for everyone unless you like being ostracized.
2. _____________
3.

**5. Denying the antecedent**

1. If the bar is close, it will be safer to drive home.
2. _____________
3.

**6. Affirming the consequent**

1. Toyota trucks will outsell Ford trucks only if Ford makes bad financial decisions.
2. _____________
3.

**7. Affirming the consequent**

1. We will win only if we strengthen our defense.
2. _____________
3.

**8. Affirming the consequent**

1. We'll starve if we don't get something to eat.
2. _____________
3.

**9. Affirming the disjunct**

1. They will break up unless she is honest.
2. _____________
3.

**10. Denying the antecedent**

1. If we win, we're going to the state championships.
2. _____________
3.

## Exercises

**A. Use the rules of inference and replacement and proof strategies from this chapter to construct a valid proof for each given conclusion.**

**1.**

$\underline{1.\ (K \,\&\, L)}$ /.: $(K \equiv L)$

**2.**

$\underline{1.\ (A \supset (B \supset C))}$ /.: $((A \,\&\, B) \supset C)$

**3.**

1. ((S & E) & (A v G)) /.: (S v G)

**4.**

1. ((A & B) ⊃ C) /.: ((A & B) ⊃ ((A & B) & C))

**5.**

1. ~(O & P) & (L v Y)
2. L /.: (~O v ~P)

**6.**

1. ((X v Y) ⊃ ~(Z & A))
2. ~~(Z & A) /.: ~(X v Y)

**7.**

1. (P & (Q v R))
2. (P ⊃ ~R) /.: (Q v E)

**8.**

1. (A ≡ B)
2. (B ≡ C) /.: (A ≡ C)

**9.**

1. (~A ≡ (B & C))
2. (H v (D & A))
3. ~H
4. (T ⊃ C) /.: (T ⊃ X)

**10.**

1. ((X & Y) ⊃ Z)
2. ~Z
3. ((T v P) ⊃ X)
4. Y /.: (T ⊃ P)

**B. Use the rules of inference and replacement and proof strategies from this chapter to construct a valid proof for each valid argument below. Note: Not all of these arguments are valid. Mark X if an argument is invalid.**

**1.**

1. (O ⊃ P)
2. ~O /.: ~P

**2.**

1. B /.: (B v (A & (C v B)))

**3.**

1. B /.: (A v ~A)

**4.**

1. B /.: (A v C)

**5.**

1. (X ⊃ (T & P))
2. (T ⊃ X)
3. ~(X & T) /.: ~X

**6.**

1. (~A ≡ (B & C))
2. ((A v B) ⊃ T) /.: T

**7.**

1. ((J v K) ⊃ ~L)
2. L /.: ~J

**8.**

1. (~F ⊃ G)
2. (F ⊃ H) /.: (G v H)

**9.**

1. (A ⊃ (A & ~A)) /.: ~A

**10.**

1. (~(E ⊃ I) ⊃ (E ≡ I))
2. ((I ≡ H) ⊃ (E ≡ I)) /.: ((I ≡ H) ⊃ (E ≡ I))

**11.**

1. $\underline{(B \supset C)}$ /.: $((B \supset C) \vee (B \supset C))$

**12.**

1. $(F \supset (G \& D))$
2. $\underline{((G \& D) \supset \sim X)}$ /.: $(F \supset \sim X)$

**13.**

1. $(A \equiv (\sim B \vee (C \& D))$
2. $\sim(A \equiv (D \& F))$
3. $\underline{(F \vee (C \equiv G))}$ /.: $(A \supset (B \supset G))$

**14.**

1. $(A \vee (B \& G))$
2. $\underline{((B \vee G) \supset F)}$ /.: $(A \& \sim F)$

**15.**

1. $((A \vee B) \supset (C \vee \sim D))$
2. $(A \equiv \sim D)$
3. $\underline{(C \equiv (E \& F))}$ /.: $(A \supset F)$

**16.**

1. $((V \supset R) \supset (\sim F \vee V))$
2. $(F \supset G)$
3. $\underline{\sim G}$ /.: $\sim(V \supset R)$

**17.**

1. $\sim(N \& P)$
2. $\underline{(T \supset (N \& P))}$ /.: $(\sim T \vee (P \supset S))$

**18.**

1. $(N \& P)$
2. $\underline{(T \supset (N \& P))}$ /.: $\sim T$

**19.**

1. $(D \supset B)$
2. $(F \vee \sim B)$
3. $\underline{\sim F}$ /.: $\sim D$

**20.**

1. $(S \supset L)$
2. $((H \& T) \supset (P \& X))$
3. $(L \supset (H \& T))$
4. $\sim( P \& X)$
5. $\underline{(\sim S \supset (A \supset B))}$

/.: $(A \supset (A \& B))$

**C. For each of the following fallacious arguments, identify which formal fallacy has been committed and explain your answer:**

**1.**

1. If the stars are out, you can either see Orion (a winter constellation) or Aquarius (a summer constellation).
2. <u>You can see either Orion or Aquarius (because you can see Orion).</u>
3. Therefore, the stars are out.

**2.**

1. We'll see you this Christmas if God's willing and the creek don't rise.
2. It is not the case that God is willing and the creek don't rise <u>(because of the huge flood this year).</u>
3. Therefore, we won't see you at Christmas.

**3.**

1. There will be a labor strike unless the company changes its benefits plan.
2. I just saw all the factory workers on strike.
3. Hence, the company will change its benefits plan.

**4.**

1. If things don't change, it will either be bad for us or good for your family.
2. But things seem to be changing.
3. Thus, it will either be bad for us or good for your family.
4. These changes aren't looking good for your family.
5. Therefore, they aren't looking good for us.

**5.**

1. Unless Nintendo does something fast, the Wii will be outdated or at least cease to be competitive.
2. Nintendo has announced no immediate plans.
3. So, either the Wii will be outdated or cease to be competitive.
4. No one else can compete with the Wii's design.
5. So, it will be outdated.

## Real-Life Examples

### 1. Is All Theft the Same?

**The following passage is excerpted from Robert Kuttner's article, "America Should Send More People to Prison" (*Huffington Post*, February 01,2015).[1] Taking the title of the article as the conclusion, reformulate the argument in the language of propositional logic, and evaluate whether it is valid. We've started the argument for you below. Notice that the conclusion is prescriptive rather than descriptive (see Chapter 1 for a refresher on the difference).**

> Consider the case of a checkout clerk at Walmart who puts her hands in the till and walks off with a couple of hundred bucks of the company's money.

[1]http://www.huffingtonpost.com/robert-kuttner/america-should-send-more-_b_6591730.html.

> That clerk could expect to face prosecution and jail.
>
> Now consider her boss, who cheats her of hundreds of dollars of pay by failing to accurately record the time she clocked in, or the overtime she worked. Maybe, just maybe, after the worker risks her job to complain, she might get back wages. In rare cases, the company might even pay a fine.
>
> Every year, workers are cheated out of tens of billions of dollars of pay—more than larceny, robbery and burglary combined. …
>
> Even so, no boss ever goes to jail. But tell me, what's the difference between a clerk putting her hands in the till and the boss putting his hands on her paycheck? …
>
> What's the difference between stealing from the company and stealing from the worker? …
>
> Until people are held personally and criminally accountable, banker fraud, like payroll fraud, will continue.

**1. If a checkout clerk steals money from a cash register, the clerk could face prosecution and prison.**

…

**C: Therefore, America should send more people to prison.**

## 2. What Is Real?

**The following is a difficult passage from the Irish philosopher George Berkeley. Berkeley thought it strange that we think there are objects that exist outside of our minds, independently of whether they are perceived in thought. In the passage below, Berkeley argues that what it means to perceive something implies that whatever we are perceiving is essentially bound up with that perception; precisely because of how we understand perceiving, the things we perceive cannot exist independently of perception.**

**I. Do your best to reconstruct Berkeley's argument using propositional logic. Even if you get stuck, this exercise will help you focus on the important parts of the argument and to sift them from the extraneous bits. It will also help you understand the argument better.**

**II. Write a brief essay responding to Berkeley. Assume that you disagree with his conclusion, and challenge the argument. Which premise would you deny? Or which part of his reasoning strategy?**

* * * * *

**George Berkeley, from *A Treatise Concerning the Principles of Human Knowledge*, 1710**

4. It is indeed an opinion strangely prevailing amongst men, that houses, mountains, rivers, and in a word all sensible objects, have an existence, natural or real, distinct from their being perceived by the understanding. But, with how great an assurance and acquiescence so ever this principle may be entertained in the world, yet whoever shall find in his heart to call it in question may, if I mistake not, perceive it to involve a manifest contradiction. For, what are the fore-mentioned objects but the things we perceive by sense? and what do we perceive besides our own ideas or sensations? and is it not plainly repugnant that any one of these, or any combination of them, should exist unperceived?

5. If we thoroughly examine this tenet it will, perhaps, be found at bottom to depend on the doctrine of abstract ideas. For can there be a nicer strain of abstraction than to distinguish the existence of sensible objects from their being perceived, so as to conceive them existing unperceived? Light and colours, heat and cold, extension and figures—in a word the things we see and feel—what are they but so many sensations, notions, ideas, or impressions on the sense? and is it possible to separate, even in thought, any of these from perception? For my part, I might as easily divide a thing from itself. I may, indeed, divide in my thoughts, or conceive apart from each other, those things which, perhaps I never perceived by sense so divided. Thus, I imagine the trunk of a human body without the limbs, or conceive the smell of a rose without thinking on the rose itself. So far, I will not deny, I can abstract—if that may properly be called abstraction which extends only to the conceiving separately such objects as it is possible may really exist or be actually perceived asunder. But my conceiving or imagining power does not extend beyond the possibility of real existence or perception. Hence, as it is impossible for me to see or feel anything without an actual sensation of that thing, so is it impossible for me to conceive in my thoughts any sensible thing or object distinct from the sensation or perception of it.

6. Some truths there are so near and obvious to the mind that a [person] need only open [their] eyes to see them. Such I take this important one to be, viz., that all the choir of heaven and furniture of the earth, in a word all those bodies which compose the mighty frame of the world, have not any subsistence without a mind, that their being is to be perceived or known; that consequently so long as they are not actually perceived by me, or do not exist in my mind or that of any other created spirit, they must either have no existence at all, or else subsist in the mind of some Eternal Spirit- it being perfectly unintelligible, and involving all the absurdity of abstraction, to attribute to any single part of them an existence independent of a spirit. To

be convinced of which, the reader need only reflect, and try to separate in his own thoughts the being of a sensible thing from its being perceived.

7. From what has been said it follows there is not any other Substance than Spirit, or that which perceives. But, for the fuller proof of this point, let it be considered the sensible qualities are colour, figure, motion, smell, taste, and so on, that is, t+he ideas perceived by sense. Now, for an idea to exist in an unperceiving thing is a manifest contradiction, for to have an idea is all one as to perceive; that therefore wherein colour, figure, and the like qualities exist must perceive them; hence it is clear there can be no unthinking substance or substratum of those ideas.

# part three

# Inductive reasoning

**In Chapters 7–10, we will explain inductive reasoning in some depth. In Chapter 7 we will explain the notion of inductive strength by introducing some basic concepts of probabilistic reasoning. We will also discuss a puzzle that plagues all inductive reasoning called the *problem of induction*. In Chapter 8 we will look at three common types of inductive argument—generalization, analogy, and causation—and discuss their strengths and weaknesses. In Chapter 9 you will learn how scientific reasoning works and how it helps to mitigate many of the weaknesses of basic inductive arguments. And finally, in Chapter 10 you will learn many of the ways inductive reasoning can go wrong by learning a number of informal fallacies.**

# Probability and inductive reasoning

# 7

**In this chapter, you will learn the basics of reasoning about probability claims. We will start by expanding on our earlier discussion of inductive strength (Chapter 1) by introducing strength-indicating words and the concept of probability. We will distinguish probability from statistics, explain three types of probability, and then explain some of the ways probability is used in inductive reasoning.**

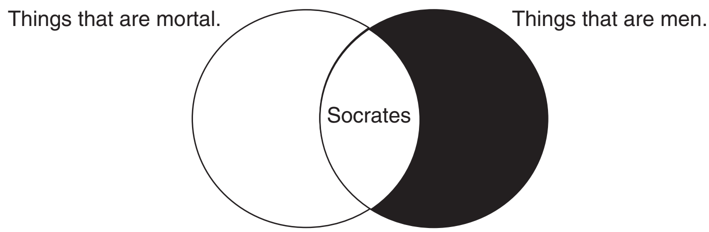
## Inductive Arguments

As with deductive arguments, inductive arguments are defined by their structure. Unlike deductive arguments, no inductive arguments are valid. This means that the conclusion will only follow from the premises with some degree of probability between zero and 99.9999… percent. One way to say it is that an inductive argument is **ampliative** (think, "amplify" in the sense of "to add to"), that is, there is information in the conclusion that is not found in the premises. In contrast, deductive arguments are **non-ampliative**; their conclusions do not include any information that is not already in the premises. To be sure, deductive conclusions may be surprising and lead to new discoveries, but the point is that everything we discover is true wholly because the premises are true. In inductive arguments, our information is, in some sense, incomplete.

Consider these two examples:

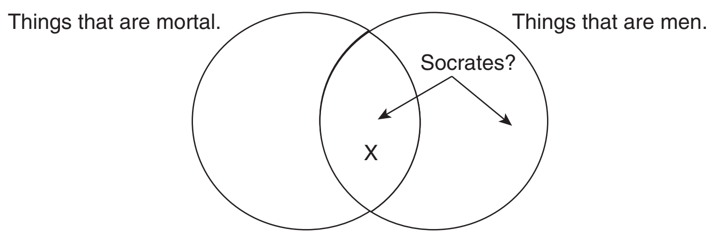
| **Deductive Argument** | **Inductive Argument** |
|---|---|
| 1. All men are mortal. | 1. Most men are mortal. |
| 2. Socrates was a man. | 2. Socrates was a man. |
| 3. Thus, Socrates was mortal. | 3. Thus, Socrates was probably a mortal. |

In the argument on the left, the conclusion does not include any information beyond what can be understood from the premises. We can use a Venn diagram to see this more precisely (see Chapter 3 for more on Venn diagrams):




All the things that are men are within the scope of (inside the circle of) all the things that are mortal (recall from Chapter 3 the blacked-out space means there's nothing there). And all the things that are Socrates are within the scope of (inside the circle of) things that are men. Because of these premises, we know exactly where Socrates fits. In order to draw this conclusion, *we do not have to add anything* to the premises. Therefore, we call this a non-ampliative inference.

In the argument on the right, on the other hand, there is more information in the conclusion than is strictly expressed in the premises. A Venn diagram also makes this clear:




"Most" is logically equivalent to "some" in categorical logic, so we have information that some men fall in the overlap between the categories. But is Socrates in that overlap? In this case, it isn't clear which side of the line Socrates belongs on. Nevertheless, since *most* of the things that are men are found in the category of things that are mortal, we can, with some confidence (because "most" means more are than are not), draw the conclusion that Socrates is *probably* in the overlapping section.

Note that neither categorical logic nor propositional logic can handle this meaning of "most." It is imprecise, but informative: it tells us "more than half." In order to draw this conclusion, *we have to add something* to the premises, namely, a decision about the side of the line on which Socrates is likely to fall. As soon as we have to add information to draw a conclusion, we are in the realm of inductive logic.

In Chapter 2, we explained that a good inductive argument must meet two conditions: (1) the relationship between the premises and the conclusion must be strong, and (2) the premises must be true. If both conditions are met, the argument is *cogent*. But how do we determine whether a conclusion follows *strongly* from a set of premises? *Probability* is the most important measure of inductive strength. In this chapter, we will show how probability is used to construct and evaluate inductive arguments. In the two chapters that follow, we will explain the most common types of inductive argument.

## Inductive Strength

As we saw with the inductive argument about Socrates, there are some imprecise quantifiers that suggest whether an inductive argument is strong, such as "some," "many," and "most." Consider the following two examples:

**1.**

1. Most Americans are communists.
2. <u>Osama Bin Laden is an American.</u>
3. Osama Bin Laden is probably a communist.

**2.**

1. Some Americans are communists.
2. <u>Osama Bin Laden is an American.</u>
3. Osama Bin Laden is probably a communist.

Intuitively, the conclusion of argument 1 is more likely to be true given the premises than the conclusion of argument 2. The difference between 1 and 2 is the quantifier in the first premise. "Most" indicates more than 50 percent of the American population, whereas "some" could indicate anything from 1 American to 99.99999… percent of all Americans. The vagueness of "some" prevents the premises from granting strength to the conclusion.

We can roughly evaluate the strength of an inductive argument by noting whether the quantifier is strong or weak. Here is our list of strong and weak quantifiers from Chapter 2:

| Strong Quantifiers: | Weak Quantifiers: |
|---|---|
| Most | Some |
| Almost all | A few |
| It is likely that | It is possible that |
| Most likely | Somewhat likely |
| The majority | A percentage |
| Almost definitely | Could be |
| Highly probable | Many |
| More often than not | A significant percentage |

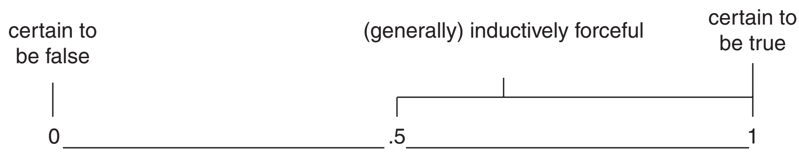
This is a good shorthand for evaluating strength. But how do we evaluate these quantifiers? How do we know when to use "most likely" instead of "somewhat likely," or "could be" instead of "almost definitely"? A precise way, and perhaps the most common, is to evaluate the **probability** that a premise is true.

The probability that a claim is true—in the sense in which we'll be using it—is a function of the evidence we have for that claim given everything else we know about the claim. So, for instance, if we have a two-sided coin (heads and tails) and some background conditions are held constant (e.g., the coin couldn't land on its edge, the coin is not weighted on one side, the coin is flipped fairly), then the *probability* that the coin will land on heads is 50 percent. Probability measurements are expressed as *chances*—in this case, 1 in 2 (or ½) or as *percentages* (50 percent), as we just noted, or as *decimals*—the decimal of 50 percent is 0.5, so we write this: P(0.5). Chances and probabilities are related, as we will see later in this chapter.

When calculating probabilities, decimals are the most common expression. When expressed as a decimal, a probability will always be equal to 0, 1 or some value in between (Figure 7.1).

If an event or claim has a probability of 0, we say it is certain to be false. But we have to qualify what we mean here by "certainty." *Certainty* is a psychological state, and it sometimes has little to do with the way the world is. You could be *certain* that your grandmother is coming to dinner only to find out later that she has the flu and won't be coming after all. If an event or claim has an *objective* probability of 0, it cannot occur or cannot be true under the circumstances. And if all of our *evidence* points conclusively to the idea that it will not occur or won't be true, we say it is *certain not to occur* or *certain to be false*, even if we are wrong. But even strong evidence that an event won't occur or that a claim is false is not sufficient for assigning a

**Figure 7.1** Range of Probability Values




probability of 0 if it is still *possible* that the event occurs or that the claim is true. We reserve P(0) for those events or claims that seem contradictory, that is, logically impossible to be true. These are claims like "there are round squares" and "Jack is taller than himself." Ideally, we want to know the objective probability of an event or claim, but as we will see in the next section, we have no access to the world except through evidence. For that reason, we will use the psychological meaning of certainty to talk about probabilities of 0 and 1.

So, for P(1), if we are talking about the world, an event or claim with a probability of 1 must occur/be true under the circumstances. And if our evidence suggests that it necessarily will occur or must be true, we can say it is *certain to occur* or *certain to be true*, even if we are wrong. But we reserve P(1) for those events or claims that seem necessary, such as "Everything is self-identical" and "All barristers are lawyers." Because impossible events/claims and necessary events/claims are rare, most of our probability claims will fall somewhere between 0 and 1. Where a probability falls in relation to P(0.5) (i.e., whether it is stronger or weaker than 50 percent) is a good shorthand way of determining whether an argument in which a probabilistic claim is a premise is strong or weak; the higher the better. We will explain the difference between objective probability and other types of probability in the next section. If it is greater than 0.5, independently of any other considerations, we say it is generally inductively strong.

Be careful, though. Probabilities are not always evaluated independently of other considerations. For instance, imagine that you have symptoms of a rare, contagious disease. Your doctor may try to console you by pointing out that, precisely because the disease is rare, it is unlikely that you have it. Objectively speaking, that might be true. But imagine you recently traveled to a country where you were close to someone who had that disease. Now, even though the objective probability that you have the disease is low, the conditional probability (the probability that you have it *given that* you were close to someone who had it) is significantly higher. This shows that probabilities also work together with the probabilities of other events to change the actual likelihood of the event. We'll say more about this later in the chapter. The important thing to remember is not to infer more from a probabilistic claim than is warranted.

Because it is cumbersome to try to talk about the probability of *events* and *claims* at the same time, we will drop the reference to claims from here on and talk only about events. But be aware that everything we say about the probability of an event's occurring applies equally to the probability that a claim is true.

A distinguishing feature of probabilities is that they are *forward-looking*, that is, they predict some state of affairs that we cannot or do not have access to. They may predict future events (e.g., tomorrow's weather or the success of a rocket launch) or current states of affairs we simply do not have access to (e.g., how a drug affects all members of a population). This distinguishes probabilities from *statistics*, which are always *backward-looking*. Statistics describe relationships among current or former states of affairs that we have had access to; we've collected the data. For instance, a statistic for a school system in Georgia might be that 53 percent of students in the eighth grade are female. This statistic tells us what is the case, *not* what is *likely* to be the case. In order to determine what will likely be the case, we must draw an inference from this statistical data.

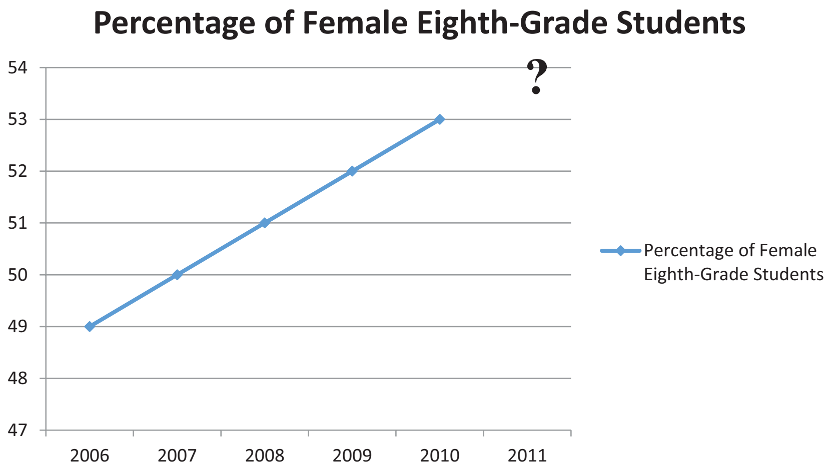
To reiterate, statistical data are not predictions, but claims about what was or is the case. We can, however, make predictions *on the basis of* statistics. Statistics can serve as evidence in probabilistic arguments. For instance, imagine we learn from statistical data that the percentage of females in the eighth grade has risen by one percent each year for the past five years. This data can be organized into a chart so we can more clearly see the relationship between female eighth-grade students and years. If the relationship expresses a certain sort of pattern, we say that the two pieces of data express a *statistical correlation*. Our chart might look like this (Figure 7.2).

From this statistical information we can infer a probabilistic claim. We can predict that, next year, the number of females in the eighth grade will *probably* be one percent higher than this year. But notice: the claim that the number of females will be one percent higher *is not a statistic* (only the data from the past are statistics); it is a *prediction*. How do we measure the likelihood of this prediction? For this, we need to know a bit more about probabilities.

## Types of Probability

Probability is a measure of the plausibility or likelihood that some event will occur given some set of conditions. The three primary sets of conditions that

**Figure 7.2** Example of Statistical Correlation

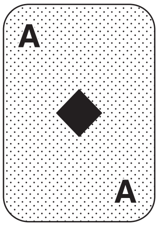



probabilities express are (1) the way the world is (i.e., sets of facts), (2) the evidence we have that the event in question will occur (i.e., sets of data), or (3) our personal assessment of the event's occurrence given the conditions we are aware of and our best judgment. Our goal in the remainder of this chapter is not to explain in any depth how to calculate probabilities (we leave that work for a math class), but to simply explain what sorts of events probabilities allow us to talk about and how to use and evaluate probabilities in arguments.

If we are interested in the probabilities associated with (i), we are interested in the chances or **objective probability** of an event. For instance, the way the world is determines the chances that a normal quarter will land on heads when flipped. If the quarter has a rounded edge, is fairly weighted on both sides, and is landing on a flat surface and gravity remains constant (all of which prevent it from landing on its edge, favoring one side, or not landing at all), then we say the chances of it landing on heads is one out of two, or 50 percent. This *doesn't* mean that every other time I flip a fair coin it will land on heads. The objective probability is simply the chance the coin will land on heads for any single toss. Similarly, if we draw a card from a regular playing deck of fifty-two cards, the distribution of denominations and suits objectively determines that the chances of drawing an ace are four out of fifty-two, or 7.69 percent.

Alternatively, if we are dealt a card from a regular playing deck of fifty-two cards, the world determines the chances the card dealt to us is an ace, namely, 1 in 1 or 0 in 1, 100 percent or 0 percent. This is because the card *either is an ace or it isn't*. Once the card is in our hand, the world dictates that we either have the card or we don't. You may now wonder: if this is the case, why do we bet on the *chances* of a card turned face down making a good hand (as when we are playing a game like Texas Hold 'Em)? Frankly put, that's not what we're betting on. In that case, we bet, not on objective chances of the card in our hand (we already know it either is or isn't the card we want), but on *the evidence we have* about the cards already in play. We call this type of probability: **epistemic probability**.

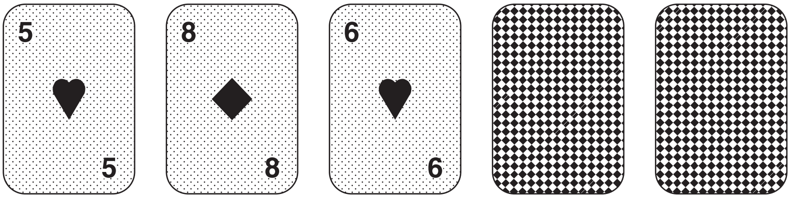
Epistemic probability corresponds to condition (ii), the evidence we have that an event will occur. It is a measure of the likelihood of an event given our current evidence. Let's begin simply, by imagining drawing a playing card from a deck of fifty-two cards. Imagine you draw an ace:




What is the likelihood that the *second* card you draw will be an ace? Once you've drawn, the objective probability that it is an ace is either 1 or 0. The order of the cards in the deck has already been determined by shuffling the cards, so the card you choose is either an ace, P(1), or it isn't, P(0). But, *since you do not know* the order of the cards, you have to make a decision about the likelihood the next card is an ace on the evidence you have about the deck of cards and the card in your hand.

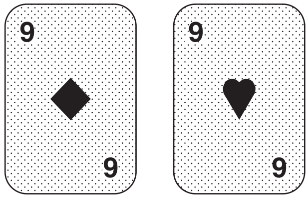
You know there are four aces in the deck (an ace for every suit), so, given that you have one in your hand, three are left. You also know that there are fifty-two cards in the deck, which, minus the one in your hand, leaves fifty-one. So, the epistemic probability that the next card is an ace is three out of fifty-one, also represented as 3/51, or roughly 5.8 percent.

Let's try a more complicated example. Take, for example, a game of Texas Hold 'Em, where you have two cards in your hand, three cards face up on the table, and two cards face down:



The goal of Texas Hold 'Em is to make the best five card hand you can using the two cards in your hand (which can be used only by you) and three of the five cards on the table (which are shared by everyone playing the game).

To keep things simple, let's say that, in your hand you have two 9s:




In dealing the cards, the world (the order of the cards in the deck) has already determined the number and suit of the face-down cards. But, in order to survive the game without going broke, you need to figure out the likelihood that the cards on the table will give you the hand you need to beat the other players.

Now, one way to draw a really good hand given the cards on the table and that you were dealt these 9s is to draw another 9 for three-of-a-kind. What is the likelihood that there is another 9 lurking in the two cards that are face down? The probability that any one of those cards is a 9 is precisely two out of forty-seven, or around 4.2 percent. This is because you have two in your hand, so only two 9s remain in the deck, there are no 9s face up on the table, and there are forty-seven cards left in the deck (or in play).

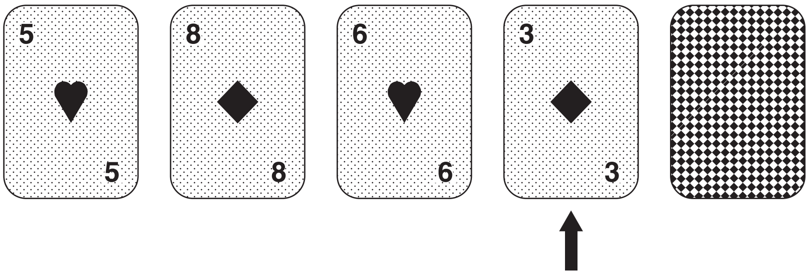
In fact, the epistemic probability is two out of forty-seven even if there are other players with cards in their hands. The world has determined the objective probability that one of the next two cards is a 9, whether those cards are on top, further down in the deck, or in someone else's hand. As far as your evidence goes, you only know the values of five cards.

To calculate probability that one or the other of those cards is a 9, you take the likelihood that any one card is a 9, given that there are two left (2/47 or 4.2 percent) and multiply that by two (since the two cards were drawn at random, this gives us the probability that any two cards drawn randomly from the deck contains a 9). So, if any one draw is 4.2 percent likely to be a 9, the likelihood that any two draws is a 9 increases your chances to 8.4 percent.

Remember, 8.4 percent is not the *objective* probability that one of those two cards is a 9. The objective probability has been settled by the world independently of what we know about it. Each of those cards is a 9 or it isn't. In this case, 8.4 percent expresses an *epistemic* probability. And how you bet depends on it.

So 8.4 percent is the probability that one of the two cards on the table is a 9. You should treat them just like random draws from the deck (since, if you're at a fair casino, that's what they were). So, given this probability, should you bet? Whether you should bet on an epistemic probability depends partially on our third type of probability: *credence*. We will discuss this in detail shortly. For the moment, imagine you do decide to bet and stay in the game.

As it turns out, the first round reveals a 3 of diamonds:




Now there are only forty-six possible cards in the deck that could be a 9. And since you know the remaining card came from the deck, the epistemic probability that any one of the three cards is a 9 drops to the probability of drawing a 9 randomly from a deck of forty-six cards with two 9s, that is, 2/46 or 4.3 percent.

Should you bet on *this* round? Again, whether you should depends on the third major type of probability: **credence** or, **subjective probability**, which corresponds to condition (iii). A subjective probability is a measure of how likely you *believe* or *feel* the event will happen—it is similar to a gut-level judgment. For instance, you can determine the objective probability of the cards on the table by looking at them (don't try this during a game). You can determine the epistemic probability of the cards on the table by drawing an inference from the number of cards on the table and those in your hand. But neither piece of information can tell you whether to bet. Your belief that the card you need is the one face down on the table is determined by epistemic probabilities plus a variety of other factors, including the likelihood that three 9s is a better hand than your opponents', the amount of money you will lose if you are wrong compared to the amount of money you will win if you are right, and your willingness to take risks. Subjective probability involves calculating the *personal costs to you* of betting.

For example, if after the 4 is turned over, one of your opponents at the table bets a very large sum of money, this might affect your judgment about the likelihood of winning, even though nothing about the objective or epistemic probabilities have changed. She may be bluffing, but she may have a good hand. For instance, she might have two jacks in her hand. Or she might have one of the other 9s and is hoping one of the two cards is a 7 for a straight. If one of them is a 7, then even if the other is a 9, you still lose (because a straight beats 3-of-a-kind). Obviously, weighing the subjective probabilities gets harder as the number of players increases.

There is little evidence on which to calculate subjective probabilities (unless your opponent has an obvious tell), but they are distinct from epistemic probabilities. Nonetheless, credences are still usually expressed as probabilities. If the weather person says there is a 70 percent chance of rain tomorrow, and you trust them, then your credence will be that there is a 70 percent chance of rain. Note that you might trust the weather person even if you have no other information about the weather—for example, what the radar looks like, the science of weather forecasting, the objective reliability of the weather person. This suggests that your belief that rain is 70 percent likely is, at best, a credence.

There are, to be sure, ways of forming rational probabilistic judgments under this sort of uncertainty. You may rely on your beliefs about the tendency of an opponent to bluff (which may involve some epistemic probabilities), or about your own desire not to lose the money you have put in (if you're betting with pennies, you may be much more willing to take risks than if you're playing with hundreds of dollars). Other examples of credences are less formal, and include beliefs like: "Based on my experience (or my trick knee), I believe it will be a cold winter," "Feels like rain is coming," and "You know those two, and it is *highly* likely that they'll get married."

It is worth noting that, with betting games, there is at least one widely accepted systematic method of calculating credences. Simply compare what are called the "pot odds" (the amount you might win versus the amount you have to bet) with the "card odds" (the likelihood that you will *not* get the card you need versus the likelihood that you will). If the pot odds are higher than the card odds, you have a reason to bet. The idea is this: If the payoff odds are better than the odds you will lose, it is better to play out the hand than to fold. (Some say that using this method "makes you more likely to win," but the "likely" here cannot refer to either objective or epistemic probabilities for reasons that will soon become clear.)

So, let's say the pot odds are 10 to 1, written: 10:1 (e.g., you have to pay $1 to win $10). In addition, let's say that your cards are the cards from above. In this case, the card odds are 22:1 (2/46 reduces to 1/23; there is one chance in 23 that you will get your card and 22 that you won't, thus 22 to 1 against). Since the pot odds (10:1) are lower than the card odds (22:1), you shouldn't bet.

On the other hand, there are other ways to get a winning hand from this set of cards. Since you have three hearts, then, instead of trying for three 9s, you might instead try for two more hearts to make a flush. What is the likelihood that the two face-down cards are hearts? With three hearts in your hand, ten are left in the deck. The likelihood of getting one heart is 10/47, or 21.2 percent (37:10 odds, roughly, 4:1, 37 chances you won't get a heart, 10 that you will). Things are different now than before with the 9s. With the 9s, you only needed to know the probability that *one* of two randomly drawn cards is a 9. In this case, you need to know the likelihood that *both* of two randomly drawn cards are hearts. Therefore, instead of multiplying 21.2 percent by 2 (for two chances at one card), we would need to multiply the likelihood of drawing one heart (10/47) by the likelihood of then drawing a second heart (9/46), which is 90/2162, which reduces to about 1/24. 1/24 translates to 23:1 odds against. Again, you should probably fold this hand. Of course, things are much more complicated at a real card table, since you must calculate (and pretty quickly) the odds of getting both the 9 and the two hearts (about 12:1, by the way), since either will increase your chances of winning.

You might ask why this method of calculating probability is categorized as a *credence* instead of an *epistemic probability*. The answer is simple: This calculation tells you nothing more about your chances of winning than the card odds alone. The likelihood that you will get a certain set of cards remains fixed given the organization of the deck regardless of how much money is at stake. Nevertheless, whether this method tells you to bet changes dramatically depending on how much money is at stake. With the card odds, you have already calculated the epistemic probability. To see this more clearly, imagine trying to roll one side of a twelve-sided die (11:1 against). Whether I give you 10:1 pots odds (you shouldn't bet) or 1000:1 pot odds (you should bet), your chance of rolling your number is still 1/12, or 8.3 percent. Comparing card odds with pot odds has proven useful to many gamblers, but it ultimately does not affect your likelihood of winning.

For the purposes of constructing and evaluating arguments, and unless you find yourself in a casino, it is helpful to focus only on epistemic probabilities. Credences, as important as they are, are difficult to assess rationally. You may bet me $1 that the next flip of this coin won't be tails. If I reason that, because the last five flips have been heads, I will take your bet, my reasoning would be fallacious, though it "seems" right "in my gut." To consider this a worthy bet, my credence in the coin's likelihood of being tails must be different from yours. In this case, my credence can be traced to poor reasoning (called the gambler's fallacy, see Chapter 8). But what accounts for *your* credence? Credences are notoriously difficult to evaluate and are often fallacious, so, where we can, our best *bet* (literally) is to reason as closely as possible with our epistemic probabilities while keeping acutely aware of how much we value certain outcomes. In other words, doing the math but keeping in mind what's at stake for us.

Similarly, when scientists evaluate the laws and events of nature, they are investigating what they hope are *objective* probabilities—they want to know what the world is like. Unfortunately, even scientists are limited to their evidence. Scientists depend on evidence to learn about nature, so that almost every probability they express depends wholly on the evidence they have for that claim. We would love to have objective probabilities, but we are stuck, most of the time, with epistemic probabilities and credences.

For more fun, mathematician Andrew Critch has a web page on how you can improve your credence judgments. Check it out at: https://acritch.com/credence/.

## Conditional Probabilities

In one sense, all probabilities are conditional; the truth of a probabilistic claim depends on its relationship to a set of conditions (we've described those conditions as objective, epistemic, or subjective). But the phrase **conditional probability** is reserved for probabilities that are conditional on *other probabilities*. Probabilities that depend on other probabilities are called, intuitively, **dependent probabilities**—a probability that depends on (is affected by) the probability of another event. These are distinct from **independent probabilities**, where a probability is not affected by the probability of another event. The latter are easier to understand than the former. If you roll a single die twice, the probability of rolling a 3 the second time are exactly the same as the first, no matter what you rolled first. The probability of drawing an ace from a deck of cards on the second draw (after you put the first back and reshuffle) is the same as the first. These are independent probabilities.

But imagine drawing a second card but not replacing the first before you do. The probability that you will draw an ace on the second draw, as we saw in some of the examples above, depends on what you drew the first time. If you are looking for aces and you drew an ace first, then the probability of drawing a second ace is 3 out of 51. If you drew something else first, then your probability of drawing an ace second is 4 out of 51.

Dependent or conditional probabilities need not depend on completely different events (drawing twice); they can depend on a variety of conditions, too. For instance, imagine if someone across the room rolled a die and told you the number is an even number. What is the probability that she rolled a 6 given that you know the roll is an even number? Now, these cases can be worked intuitively. There are three evens, only one of which is a 6; so, given that the number is even, the conditional probability that she rolled a 6 is 1/3, or P(0.333).

But what we really want to know is how to calculate such outcomes when the examples are more complicated. We need a formula. Consider three probabilistic events:

1. **The probability of drawing two consecutive aces without replacing the first.**
2. **The probability of drawing an ace given that you just drew an ace and didn't replace it.**
3. **The probability that the card you drew is an ace given that it is a heart.**

All of these are conditional probabilities.

In the first case, we simply multiply *the probability of drawing an ace* (P(A)) by the probability of drawing an ace given that we have drawn an ace (P(B|A)):

$$P(A\&B) = P(A) \times P(B|A)$$

The vertical line "|" stands for the English phrase "given that"—it is not a mathematical function like multiplication or division. The probability of drawing an ace is 4/52. The probability of drawing an ace after we've drawn an ace (subtract one ace from the deck and subtract one card from the whole deck) is 3/51. So, value of the claim in 1 is (4/52 × 3/51) or (1/221).

In the second case, things are more complicated. You've drawn one ace. Now you want to know the probability of drawing a second. Now, on one hand, we already know there are only three aces left and only fifty-one cards to choose from. So, we can just calculate 3/51 to get P(0.059). But what if we wanted to calculate it? We would need to take our answer to 1 and then show that we actually drew the first ace. To do that, we divide the probability we got in 1 by the probability that we drew the first ace. So, what we want is *not* P(A&B), but the probability of B given A: P(B|A). And the formula for that is:

$$P(B|A) = \frac{P(A\&B)}{P(A)} \qquad P(B|A) = \frac{(4/52\times (3/51)}{(4/52)} = 3/51(\text{or}1/17) = P(.059)$$

Our third conditional probability case is similar to the second. The difference is that there are not two events to calculate. There is only one, the drawing of a single card. But that card has two distinct but overlapping features: a number and a suit. Given that we drew a heart, what is the likelihood that we drew an ace? If you're card savvy, you know there is only one ace in the suit of thirteen hearts, so if you have a heart, you have a 1/13 chance of having the ace of hearts. But what if you weren't card savvy, and you wanted to calculate it? To do this, we use the same formula we did for probability number 2. We begin by finding the probability of drawing a heart and an ace (P(A&B)), which is equal to P(A) × P(B). The probability of drawing a heart is 13/52 and the probability of drawing an ace is 4/52, so we have a product of 1/52 (this, by the way, is the number of ace of hearts in the deck—just one). But now we need to show that we did, in fact, just draw a heart. Applying our formula, we need to divide our product by the probability of drawing a heart, 13/52.

$$P(B|A) = \frac{P(A\&B)}{P(A)} \qquad P(B|A) = \frac{(13/52) \times (4/52)}{(13/52)} = 1/13 = P(0.077)$$

Notice that all of these probabilities are very low, less than 10 percent. That's an important consideration to keep in mind before you decide to gamble on card games. There are strategies for overcoming these odds, such as comparing pot odds and card odds, but the raw epistemic probability of getting the cards you need at any given time is often pretty low.

The point here is to highlight the differences between independent and dependent probabilities, and to explain how that difference affects their calculation. You can actually use the same formula to calculate independent probabilities. For example, what is the probability of flipping two heads in a row with a fair coin? Coin flips are independent events because one flip does not affect the outcome of any other. Every flip has a ½ chance of heads and a ½ chance of tails. So, the probability of flipping two heads in a row (heads and heads) is P(½) × P(½), which is P(¼). But the probability of flipping heads given that you just flipped a heads is:

$$\frac{P(1/2) \times P(1/2)}{P(1/2)}$$

And this is just equal to P(0.5), the same as flipping any fair coin at any time. Actually, this is a good test for whether the events are dependent or independent. If P(B|A) = P(B), then the events are independent and so are the probabilities.

Reasoning about probabilities is not easy, especially as the numbers get larger. But we hope this primer will at least help you to avoid elementary mistakes when thinking about probabilities. In the next chapter we will take a look at some common fallacies that can occur when reasoning with probabilities.

## Using Probability to Guide Decisions: The Cost/Benefit Analysis

Many public calls for action appeal to the possibility of catastrophe: "If you don't *X*, the terrorists will win," "If you don't *Y*, the climate will change suddenly causing massive social collapse." Should we do *X* or *Y*? How might we tell? Notice that whether we should do *X* or *Y* has to do with more than the mere probability that *X* or *Y*; it also has to do with how much we value (in these cases, disvalue) the outcomes.

For example, imagine someone offers you a hamburger for \$1. If you like hamburgers, this is a pretty good deal. Now imagine someone offers you two hamburgers for \$1. Things are looking up. But if someone offered you twenty hamburgers for a \$1, the situation changes. You probably cannot (or wouldn't want to) eat twenty full-sized hamburgers in one sitting, and refrigerating them (let's say) diminishes their quality considerably. So, the value of twenty hamburgers for \$1 is not much greater than the value of two hamburgers for \$1. This effect is called **diminishing marginal value**; as the quantity of a valued thing increases, its value *to you* decreases. This happens when the Federal Reserve prints more money; the value of the dollar drops. It also happens among the very rich. Studies have shown that money increases happiness up to somewhere between \$75,000 and \$100,000/year salary.[1] This is an older study, and after inflation, the dollar amount might be higher. But the point remains no matter when you read this book: After you earn a certain amount of money, more money won't make you happier. So, any additional money is less valuable to you.

If probability is not the only factor relevant to making decisions, how do we incorporate value (also called *utility*) into our reasoning? One common strategy, used widely by economists and businesspeople, is to use a *cost/benefit analysis*, where the costs and benefits include the probabilities of different outcomes and any relevant types of value, whether money or happiness or preferences. The idea is to assign numbers that represent how much we value or disvalue an outcome and then subtract the costs (in disvalue or money) from the benefits (in value or money) of a set of actions, and if one of the outcomes has a positive value, that is the rational act. If more than

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[1]There is a large literature on this topic. Here are two examples: Daniel Kahneman and Angus Deaton, "High Income Improves Evaluation of Life but Not Emotional Well-Being," *Proceedings of the National Academy of Sciences of the United States of America*, Vol. 107, No. 138 (2010): pp. 16489–93, http://www.pnas.org/content/107/38/16489.full. S. Oshi, E. Diener, and R. E. Lucas, "The Optimum Level of Well-Being: Can People Be Too Happy?," *Perspectives on Psychological Science*, Vol. 2, No. 4 (2007): pp. 346–60.

one act has a positive value, the rational choice is the one with the highest positive outcome.

Calculations get more complicated when the values are more subjective, such as pleasure and comfort, so let's start with a simple case of monetary value. Imagine someone offers to pay you \$10 if you roll a 5 on one roll of a die. Should you take the offer? Intuitively, you lose nothing if you don't roll or if you roll something other than a 5, and you gain \$10 if you do roll a 5, so this is a pretty simple case. But we can calculate the **expected value** of the decision to explain precisely why it's a good deal.

The probability of rolling a 5 is $\frac{1}{6}$ (roughly 17 percent), and the payoff is \$10, so multiply P(0.17) by (10). The expected value of accepting the offer is 1.7. The expected value of not accepting the offer is 0: no probability of winning the \$10, P(0) × (10) = 0. The value of accepting the offer (1.7) is greater than not (0).

Here's a more complicated example. Imagine you can choose between the first offer (roll a 5, get \$10) and a second offer, pay \$2 and if you roll a 1, 3, or 5, you get \$10. Let's compare the expected values of each choice:

| | |
|---|---|
| Choice 1: P(0.17) × (10) = 1.7 | |
| Choice 2: P(0.5) × (8) = 4 | The probability here is 0.5 because 1, 3, and 5 are half the options on a die. The win is only \$8 because you paid \$2 to play. |

Even though the cost to play is higher, the probability of rolling the needed number is higher, so the expected value is higher. The second choice is the better option.

Now, let's look at a less precise example. Imagine you are trying to decide whether to get a puppy. You love dogs, and you know how to take care of them, and you're really excited to have a puppy in your life again. However, you also work long hours and you like to travel, both of which means you will need help getting the dog the exercise and support it needs. Do you cave and go to the shelter, or do you refrain?

To calculate the expected values of indulging and refraining, first identify the relevant values associated with those options. In this case, a puppy will be a long-term companion, and you will have a lot of fun going to the park and the lake and having it snuggle with you at night. But there's a downside to a puppy. They're a lot of work to house-train, you'll have to clean up after it, and it will likely shed. The first year's vet bills are expensive, and you'll have to pay a dog walker when you have to work late. You also want the freedom to go out with friends after work and travel at a moment's notice, and kennels can significantly increase the price of travel. The values are not strictly monetary, so you have to be a bit arbitrary with the numbers. Let's set the value of getting a puppy even given all the costs pretty high, let's say +10. Now, if you don't get a puppy, you'll likely have all the benefits of freedom and travel, so let's set that number pretty high, too: +9. We can represent the relationships like this:

Expected values:

| | Get a puppy | Don't get a puppy |
|---|---|---|
| **Freedom and travel** | | +9 |
| **Little freedom or travel** | +10 | |

Looking at this, you realize that if you could get a puppy and keep all the freedom and travel, that would be even better, so you set that value at +15. And if you couldn't do either—that is, you couldn't get a puppy and you lost out on freedom and travel, that would be pretty terrible. You set that at –10. Filling in our graph with these numbers, we get this:

Expected values:

| | Get a puppy | Don't get a puppy |
|---|---|---|
| **Freedom and travel** | +15 | +9 |
| **Little freedom or travel** | +10 | –10 |

To calculate the expected value of getting a puppy, we now assign probabilities to each quarter of our quadrant. Starting with our first two values, the probability of losing freedom and travel after getting a puppy is pretty high, let's say P(0.8). And the probability of having time for friends and travel if you don't get a puppy is also pretty high, P(0.8). These aren't P(1) because we can't be *certain* we'll get the benefits; life is sneaky and unfortunate that way. But the probability of getting both a puppy and the freedom to travel is pretty low, as is not getting a puppy and losing freedom and travel. So, let's set both at P(0.2). The probabilities don't have to complement one another (such that P(0.8) and P(0.2) add up to 1), because life is messy, and there are usually many different variables at play. But it's simpler when they do, so we'll keep our probabilities complementary.

Now all you have to do is some simple math:

The probability of the event, P($X$), multiplied by the value of the event, V($X$). Do this for both outcomes of getting a puppy (freedom and little freedom), and then add those numbers together.

**Expected value of getting a puppy: $(P(0.2) \times V(15)) + (P(0.8) \times V(10)) = 3 + 8 = +11$**

Now do the same for not getting a puppy:

**Expected value of not getting a puppy: $(P(0.8) \times V(9) + (P(0.2) \times V(-10)) = 7.2 + -2 = +5.2$**

On these probabilities, the expected value of getting a puppy is much higher than not. But remember, these numbers are subjective. You are the only one who knows how much you value getting or not getting a puppy. How much traveling means to you. Play around with the values and see how they change. Place much more value on travel and freedom. Also play around with the probabilities. Make the probability that you'll have more freedom with a puppy much lower. After you've practiced a little, try an example from your own life.

You probably wouldn't take the time to run a cost/benefit analysis in the case of getting a puppy (it's obvious that it's the best decision ever). But it is easy to imagine replacing these options with more complicated diet decisions, business decisions, or decisions about whether to move or change jobs. And cost/benefit analyses are not limited to decisions with only two options. You can calculate any number of outcomes with this formula:

$$((((P(O_1) \times V(O_1)) + (P(O_2) \times V(O_2))) + (P(O_3) \times V(O_3))) + \ldots (P(O_n) \times V(O_n)))$$

"O" represents the possible "outcome" of a decision. The ellipses […] indicate that you can evaluate as many different outcomes as you want, or as many as you find realistic.

## An Obstacle: The Problem of Induction

As we've said, probability is a form of inductive reasoning. And despite its usefulness in almost every area of our lives, all forms of inductive reasoning face a serious philosophical objection. The **problem of induction** is a classical philosophical problem that has, to this day, no widely accepted solution. The concern, very roughly, is that evidence about the past or a sample of a population does not count as sufficient evidence for claims about the future or about the whole population—precisely the opposite of what inductive reasoning presumes to help us do.

In his classic example, David Hume (1711–1776) asks us to consider the following question: What evidence do you have to believe that the sun will rise tomorrow? Any argument that it will rise tomorrow will be either deductive or inductive. Evidence about the past or a sample doesn't logically entail any particular thing about the future (by definition, it includes only information about the way the world *was*). Therefore, there is no deductive argument for claims about the future. Any probabilistic evidence simply restates the problem: What is the probability that the sun will rise tomorrow, *given that* it already has repeatedly risen in the past? If you answer, "high probability," you are assuming that *past states of affairs* are connected with or related in some important way to *future states of affairs*, so that the truth of claims about the past somehow imply or suggest the truth of some claims about the future. But what sort of connection could this be and how do we know there is one?

There is certainly nothing about a connection mentioned in the claim, "The sun has always risen in the past." So, we must be introducing (implicitly) some principle or connection that explains why the sun has always risen in the past is relevant to whether it will do so in the future. Many of us, for instance, assume that there is a set of natural laws that accounts for this uniformity of nature. In some sense, the sun cannot help but rise tomorrow because the laws of nature will make it so. But notice, we didn't mention those laws in our inductive argument. We only pointed out that the sun has always risen before.

Further, natural laws are not things that we can see or touch or hear; they are—according to Hume—only descriptions of past groupings of events. For instance, consider the series of events: I let go of the pen; the pen falls; I let go of the pen; the pen falls; I let go of the pen; and so on. This series *may* be explained by a set of laws, such as gravity and inertia. But this series—by itself—simply *describes* events that have happened in the past; it does not tell us *why* pens behave that way, and it does not tell us that pens will always behave that way. And even if those past events happened because of laws, why believe those laws *will* continue to govern events in the future? If we say laws existed in the past, we need some additional law that tells those laws will exist in the future. But, it seems we can only describe the way those laws behaved in the past. And, of course, descriptions of the way *laws* behaved in the past are no different than descriptions of how the *sun* behaved in the past; no connection is mentioned in these descriptions. Therefore, laws of nature cannot account for our beliefs about future states of affairs any better than the sun's past rising can account for our belief that it will rise tomorrow.

The problem seems to be that, in any argument from past states of affairs (e.g., the sun has always risen; the pen has always fallen) to future states of affairs (e.g., the sun will rise tomorrow; the pen will fall), we will need, at some point, a premise stating that the future will look like the past. But since the argument is an attempt to prove that the future will look like the past, including a premise that the future will look like the past makes our argument *circular*; we are assuming the very conclusion we need to prove.

Consider the argument in standard form:

**1.**

1. Every morning humans have observed, the sun has risen.

2. Therefore, the sun will rise tomorrow morning.

The conclusion of argument 1 follows from the premise only if we assume that something connects these past states of affairs with the future. We can introduce this premise as follows:

**2.**

1. Every morning humans have observed, the sun has risen.

3. The laws of nature guarantee that the future will look like the past.

2. Therefore, the sun will rise tomorrow morning.

The conclusion of 2 follows validly from the premises, but we need some reason to think premise 3 is true. We might do this with the following argument:

**3.**

4. The laws of nature have always governed past events.

3. Therefore, the laws of nature guarantee that the future will look like the past.

Like 1, the conclusion of argument 3 does not follow from the premises without assuming there is some reason to think there is a connection between the way the laws have behaved and the way they will behave. We might make this assumption explicit with another premise:

**4.**

4. The laws of nature have always governed past events.

5. The future will look like the past.

3. Therefore, the laws of nature guarantee that the future will look like the past.

But now, as with argument 2, though the conclusion of argument 4 follows from the premises, we need some reason to believe that premise 5 is true. How might we justify 5? Unfortunately, only by assuming that something like 5 is true:

**5.**

<u>5. The future will look like the past.</u>

5. Therefore, the future will look like the past.

And of course, an argument like this leaves us no better off than where we began.

Taking stock, here is the problem: You seem clearly justified in believing the sun will rise tomorrow. You should be as sure of this as almost anything (really!). Yet, we do not directly experience that the sun will rise tomorrow (we are not yet there), and any deductive argument for the claim that the sun will rise tomorrow is circular (the past does not entail anything about the future; and adding any premise to that effect assumes what we are trying to prove). So, where do we go from here?

The type of circularity involved in the above deductive arguments is called **premise-circularity**, which means that there will always be a premise that explicitly restates the conclusion. A simpler example of a premise-circular argument would be a child attempting to justify the claim, "I need candy," by simply stating "Because I need it."

But what if we could construct an argument that does not require an explicit premise about the past's connection to the future? Philosopher of science Wesley Salmon (1925–2001) offers an insightful example of this sort of argument:

> A crystal gazer claims that his method is the appropriate method for making predictions. When we question his claim he says, "Wait a moment; I will find out whether the method of crystal gazing is the best method for making predictions." He looks into the crystal ball and announces that future cases of crystal ball gazing will yield predictive success. If we protest [arguing from induction] that his method has not been especially successful in the past, he might well make certain remarks about parity of reasoning. "Since you have used your method to justify your method, why shouldn't I use my method to justify my method? … By the way, I note by gazing into my crystal ball that the scientific method is now in for a very bad run of luck."[2]

In this case, the crystal-ball-gazer does not explicitly identify any connection between crystal ball gazing and the truth of claims derived from crystal-ball-gazing. He simply uses the crystal ball to justify a claim about crystal-ball-gazing. Instead of attempting to validly derive the reliability of crystal-ball-gazing, the gazer appeals to crystal-ball-gazing to justify the future reliability of crystal-ball-gazing. The rule here is not induction,

[2]Wesley Salmon, *Foundations of Scientific Inference* (Pittsburgh: University of Pittsburgh Press, 1967), pp. 12–13.

but crystal-ball-gazing. Nevertheless, there is a worry that, if I assume the reasoning principle, or rule, that I am trying to prove (crystal-ball-gazing is reliable because crystal-ball-gazing tells me so), my conclusion is no more justified for me than before I constructed the argument. This type of circularity is called **rule-circularity** because, though the rule is not explicitly stated in the argument, it is assumed in order to prove it.

Is rule-circularity any less worrisome than premise-circularity? It would seem not. This is because any rule-circular argument can be made premise-circular by adding a premise about the reliability of the method being used; and it seems that this sort of premise is already implicitly assumed in rule-circular arguments. Therefore, the same worry seems to attach to induction:

**6.**

1. Crystal-ball-gazing tells me crystal-ball-gazing is reliable.

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2. Therefore, crystal-ball-gazing is reliable.

**7.**

1. Induction tells me induction is reliable.

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2. Therefore, induction is reliable.

Taking stock once again, we find that, direct experience does not justify induction, deductive arguments for induction are premise-circular, and inductive arguments for induction are rule-circular. Therefore, induction is an unjustified form of reasoning. If this argument is sound, science and all other inductive reasoning processes aimed at justifying the truth of claims (as opposed to, say, their usefulness) are in serious trouble.

Philosophers have offered a variety of solutions to the problem of induction, but none are widely accepted. For example, American philosopher Laurence BonJour (1943–) argues that there is a way of justifying induction that is not considered by Hume, namely, **inference to the best explanation**. We will take a closer look at inference to the best explanation in Chapter 9, but for now it is enough to note that BonJour argues that, among competing explanations, the best explanation for induction's past success is that nature is uniform. Inference to the best explanation is a complicated form of reasoning, and BonJour argues that it is justified a priori, that is, independently of experiential evidence. We need no experience, either directly of the future, or of the past, or of any connection between the past and the future to justify induction. We may rely on our a priori evidence that inferences to the best explanation are justified. And from this, we may justify our belief in induction. To motivate this conclusion, we would need to explain BonJour's account of a priori justification, and how inference to the best explanation is justified on non-experiential evidence. Do not quickly dismiss it on account of our brief discussion. Many philosophers (including one of the authors—Jamie) argue that our beliefs about the rules of mathematics and logic are similarly justified.

American philosopher John Hospers (1918–2011) offers a defense of induction very different from BonJour's. Hospers concedes that arguments for induction are circular, but argues that, in this case, circularity does not constitute sufficient reason to reject induction. In fact, he argues, most of our deductive rules suffer the same fate:

**8.**[3]

1. If snow is white, *modus ponens* is valid.
2. Snow is white.
3. Therefore, *modus ponens* is valid.

**9.**

1. Either *modus ponens* is valid or $2 + 2 = 5$.
2. It is not the case that $2 + 2 = 5$
3. Therefore, *modus ponens* is valid.

There is no way to prove that a rule is valid without appealing to a valid rule. But we certainly do not think we should reject *modus ponens* or disjunctive syllogism as unjustified. We could not perform logical or mathematical calculations without them; they are *indispensable* to our reasoning process. Induction is similarly indispensable. John Hospers explains:

> It would seem … that to demand a logical basis for the principle [of induction] is as unreasonable as to demand it in the case of the principles of logic themselves. … In the case of the principles of logic it was the impossibility of any coherent discourse without the use of them; in the present case the situation is not quite so radical: it is the fruitlessness of any scientific procedure without the adoption of the Principle of the Uniformity of Nature, which alone enables us to make inferences from the past to the future. … the laws of nature are the only sound basis for such prediction. It is these or nothing.[4]

Hospers admits that indispensability arguments are pragmatic rather than epistemic, that is, they do not guarantee or necessarily track the truth of claims they justify. Nevertheless, we are stuck with them for many of our most fundamental reasoning processes. If we are not willing to give up valid arguments despite their circularity, then we should not be willing to give up induction.

As we discuss inductive argument forms in the next chapter, it is important to keep worries about induction in the back of our minds. BonJour's and

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[3]Ibid., p. 14.

[4]John Hospers, *An Introduction to Philosophical Analysis* (Upper Saddle River, NJ: Prentice-Hall, 1996), p. 102.

Hospers's responses to the problem are merely two among dozens, none of which are widely accepted. Therefore, unless you find one of these responses convincing, every inductive conclusion should probably be qualified with, "if there were a satisfactory solution to the problem of induction."

## Exercises

**A. For each of the following, explain whether the claim expresses a statistic or whether it expresses a probability (note: some probabilistic claims will contain statistical data and some statistical data will be represented as percentages).**

1. 74 percent of men interviewed say they would prefer not to have men tend to them in a hospital.
   (*Men's Health Magazine*, April 2010, Kyle Western.)
2. Men who smoke had more than a 30 percent increase in risk of dying from [colon cancer] compared to men who never had smoked. ("Cigarette Smoking and Colorectal Cancer Mortality in the Cancer Prevention Study II," *Journal of the National Cancer Institute*, Vol. 92, No. 23, 1888–96, December 6, 2000, Oxford University Press.)
3. Men who smoke have more than a 30 percent increase in risk of dying from colon cancer compared to men who never have smoked.
4. In 2003 about 45,000 Americans died in motor accidents out of population of 291,000,000. So, according to the National Safety Council this means your one-year odds of dying in a car accident is about 1 out of 6,500. Therefore your lifetime probability (6,500 ÷ 78 years life expectancy) of dying in a motor accident are about 1 in 83. (www.reason.com)
5. Scientists find that ten out of ten people have mothers.
6. Most people do not die on an airplane. Therefore, you will probably not die on your upcoming flight.
7. The probability of rolling two 6s with two dice is (1/6) x (1/6).
8. The odds of a mother having twins are 90:1.
9. Out of 100 coin flips, 57 percent were heads and 43 percent were tails.
10. The Cubs have a 10:1 shot this season.

**B. For each of the following claim, identify which type of probability is being expressed: objective probability (chance), epistemic probability, or subjective probability (credence).**

1. "They've only been on three dates. I bet they'll break up before next week."

2. "The card in your hand is either a 2 of hearts or it isn't."
3. "It feels like rain."
4. "He's giving you 4:1 odds on a ten-dollar bet? You should definitely take it."
5. "Given what we know about the chimp, showing him a red cloth will likely make him angry."
6. "The data indicate that trans fats are bad for your health."
7. "The radioactive isotope thorium-234 decays at a rate of half every 24 days."
8. "The likelihood of drawing the ace of spades is 1 in 52."
9. "I just don't think our economy is in that bad of shape."
10. "Given that a pen has fallen every time I have dropped it in the past, it is likely that it will fall the next time I drop it."

**C. For each of the following arguments, explain whether the probability claims in the premises make it inductively strong, inductively weak, or valid. If it is strong, weaken it; if it is weak, strengthen it.**

**1.**

1. Many Muslims are Sunni.

<u>2. Janet is a Muslim.</u>

3. Therefore, Janet is Sunni.

**2.**

1. Most violent criminals are recidivists.

<u>2. Joe is a violent criminal.</u>

3. Therefore, Joe is likely a recidivist.

**3.**

1. At least a few lawyers are honest.

<u>2. Nayan is a lawyer.</u>

3. So, Nayan might be honest.

**4.**

1. Aces can be played high or low in blackjack.

<u>2. In this game of blackjack, you were just dealt the ace of spades.</u>

3. Therefore, you can play it high or low.

**5.**

<u>1. In most cases, weddings are nauseating affairs.</u>

2. This wedding we're invited to, will likely be a nauseating affair.

**6.**

1. Some politicians are trustworthy.

<u>2. Ayush is trustworthy.</u>

3. Hence, he might be a politician.

**7.**

1. The islands are nice this time of year.

<u>2. You're going to Fiji?</u>

3. It should be great!

**8.**

<u>1. This restaurant has a reputation for bad service.</u>

2. I don't suspect this visit will be any different.

**9.**

<u>1. All the watches I've worn break easily.</u>

2. I can't imagine this one will be different.

**10.**

1. Every swan scientists have studied have been white.

<u>2. Scientists are on their way to study swans in Australia.</u>

3. They will probably find only white swans there, too.

**D. Calculate the probabilities of each of the following events.**

1. The probability of drawing a 6 and 2 from a normal deck of cards.
2. The probability of drawing two aces from a normal deck of cards.
3. The probability of drawing an ace given that you just drew a 2.
4. The probability of drawing a 2 given that you just drew a 2.
5. The probability of drawing a 2 given that you just drew a black suit.
6. The probability of rolling 3s twice in a row on a single six-sided die.
7. The probability of rolling a 3 given that you rolled an odd.
8. The probability of rolling a 3 given that you rolled an odd on your last roll.
9. The probability of rolling three 5s in a row.
10. The probability of drawing an ace given that you are holding two aces.

**E. For each of the following decisions, construct a cost/benefit analysis to justify one of the options.**

1. After you graduate, do you go to college or go to work?
2. After college, do you settle down immediately (get a family) or spend time traveling and building your career?
3. Your boss offers you a promotion that comes with a hefty raise. The catch is that it is a job you despite. Do you take it?

4. You've just been dumped by your significant other. Tonight, your ex's roommate comes knocking at your door asking to go out on a date. Do you accept?
5. You recently found out that your boss is lying to clients and cheating them out of small amounts of money, though they are not aware of it. She has recently put you in a position where you have to corroborate the lie. If anyone finds out, you will both be fired. Do you stay on?

**F. To the best of your ability, explain the problem of induction and one potential solution in your own words.**

## Real-Life Examples

## 1. The Fine-Tuning Design Argument

**Consider the following excerpt of an argument from philosopher Robin Collins. Collins uses probability measures from physics to argue that the probability that a being like God exists is greater than the probability that a being like God doesn't. Write a short essay explaining Collins's argument. Using the concepts we've discussed in this chapter, explain what type of probabilities he is using (objective, epistemic, or subjective), and explain how these probabilities are supposed to lend strength to the conclusion that something like God exists (e.g., do they make the conclusion highly probable?).**

**The entire article, as well as a more technical version of it, can be found at Professor Collins's website:** http://home.messiah.edu/~rcollins/.

* * * * *

(Excerpted from, Robin Collins, "The Fine-Tuning Design Argument," http://home.messiah.edu/~rcollins/Fine-tuning/FINETLAY.HTM, all italics are his, footnotes have been removed.)

### General Principle of Reasoning Used

### The Principle Explained

We will formulate the fine-tuning argument against the atheistic single-universe hypothesis is in terms of what I will call the *prime principle of* *confirmation*. The prime principle of confirmation is a general principle of reasoning which tells us when some observation counts as evidence in favor of one hypothesis over another. *Simply put, the principle says that whenever we are considering two competing hypotheses, an observation counts as evidence in favor of the hypothesis under which the observation has the highest probability (or is the least improbable)*. (Or, put slightly differently, the principle says that whenever we are considering two competing hypotheses, $H_1$ and $H_2$, an observation, O, counts as evidence in favor of $H_1$ over $H_2$ if O is more probable under $H_1$ than it is under $H_2$.) Moreover, the degree to which the evidence counts in favor of one hypothesis over another is proportional to the degree to which the observation is more probable under the one hypothesis than the other. For example, the fine-tuning is much, much more probable under the theism than under the atheistic single-universe hypothesis, so it counts as strong evidence for theism over this atheistic hypothesis. In the next major subsection, we will present a more formal and elaborated rendition of the fine-tuning argument in terms of the prime principle. First, however, let's look at a couple of illustrations of the principle and then present some support for it.

## Additional Illustrations of the Principle

For our first illustration, suppose that I went hiking in the mountains, and found underneath a certain cliff a group of rocks arranged in a formation that clearly formed the pattern "Welcome to the mountains Robin Collins." One hypothesis is that, by chance, the rocks just happened to be arranged in that pattern—ultimately, perhaps, because of certain initial conditions of the universe. Suppose the only viable alternative hypothesis is that my brother, who was in the mountains before me, arranged the rocks in this way. Most of us would immediately take the arrangements of rocks to be strong evidence in favor of the "brother" hypothesis over the "chance" hypothesis. Why? Because it strikes us as extremely *improbable* that the rocks would be arranged that way by chance, but *not improbable* at all that my brother would place them in that configuration. Thus, by the prime principle of confirmation we would conclude that the arrangement of rocks strongly supports the "brother" hypothesis over the chance hypothesis.

Or consider another case, that of finding the defendant's fingerprints on the murder weapon. Normally, we would take such a finding as strong evidence that the defendant was guilty. Why? Because we judge that it would be *unlikely* for these fingerprints to be on the murder weapon if the defendant was innocent, but *not unlikely* if the defendant was guilty. That is, we would go through the same sort of reasoning as in the above case.

## Support for the Principle

Several things can be said in favor of the prime principle of confirmation. First, many philosophers think that this principle can be derived from what is known as the *probability calculus*, the set of mathematical rules that are typically assumed to govern probability. Second, there does not appear to be any case of recognizably good reasoning that violates this principle. Finally, the principle appears to have a wide range of applicability, undergirding much of our reasoning in science and everyday life, as the examples above illustrate. Indeed, some have even claimed that a slightly more general version of this principle undergirds all scientific reasoning. Because of all these reasons in favor of the principle, we can be very confident in it.

## Further Development of Argument

To further develop the core version of the fine-tuning argument, we will summarize the argument by explicitly listing its two premises and its conclusion:

*Premise 1*. The existence of the fine-tuning is not improbable under theism.

*Premise 2*. The existence of the fine-tuning is very improbable under the atheistic single-universe hypothesis.

*Conclusion*: From premises (1) and (2) and the prime principle of confirmation, it follows that the fine-tuning data provides strong evidence in favor of the design hypothesis over the atheistic single-universe hypothesis.

At this point, we should pause to note two features of this argument. First, the argument does not say that the fine-tuning evidence proves that the universe was designed, or even that it is likely that the universe was designed. In order to justify these sorts of claims, we would have to look at the full range of evidence both for and against the design hypothesis, something we are not doing in this chapter. Rather, the argument merely concludes that the fine-tuning strongly *supports* theism *over* the atheistic single-universe hypothesis.

In this way, the evidence of fine-tuning argument is much like fingerprints found on the gun: although they can provide strong evidence that the defendant committed the murder, one could not conclude merely from them alone that the defendant is guilty; one would also have to look at all the other evidence offered. Perhaps, for instance, ten reliable witnesses claimed to see the defendant at a party at the time of the shooting. In this case, the fingerprints would still count as significant evidence of guilt, but this evidence would be counterbalanced by the testimony of the witnesses. Similarly the evidence of fine-tuning strongly supports theism over the atheistic single-universe hypothesis, though it does not itself show that everything considered theism is the most plausible explanation of the world. Nonetheless, as I argue in the conclusion of this chapter, the evidence of fine-tuning provides a much stronger and more objective argument for theism (over the atheistic single-universe hypothesis) than the strongest atheistic argument does against theism.

The second feature of the argument we should note is that, given the truth of *the prime principle of confirmation,* the conclusion of the argument follows from the premises. Specifically, if the premises of the argument are true, then we are guaranteed that the conclusion is true—that is, the argument is what philosophers call *valid*. Thus, insofar as we can show that the premises of the argument are true, we will have shown that the conclusion is true. Our next task, therefore, is to attempt to show that the premises are true, or at least that we have strong reasons to believe them.

## 2. Predicting the Weather

**Read the following passage from the National Weather Service on how meteorologists use probability to express the probability of precipitation. Answer the questions that follow.**

* * * * *

Forecasts issued by the National Weather Service routinely include a "PoP" (probability of precipitation) statement, which is often expressed as the "chance of rain" or "chance of precipitation."

EXAMPLE

ZONE FORECASTS FOR NORTH AND CENTRAL GEORGIA

NATIONAL WEATHER SERVICE PEACHTREE CITY GA

119 PM EDT THU MAY 8 2008

…

THIS AFTERNOON … MOSTLY CLOUDY WITH A 40 PERCENT CHANCE OF

SHOWERS AND THUNDERSTORMS. WINDY. HIGHS IN THE LOWER 80S. NEAR

STEADY TEMPERATURE IN THE LOWER 80S. SOUTH WINDS 15 TO 25 MPH.

.TONIGHT … MOSTLY CLOUDY WITH A CHANCE OF SHOWERS AND

THUNDERSTORMS IN THE EVENING … THEN A SLIGHT CHANCE OF SHOWERS

AND THUNDERSTORMS AFTER MIDNIGHT. LOWS IN THE MID 60S. SOUTHWEST

WINDS 5 TO 15 MPH. CHANCE OF RAIN 40 PERCENT.

What does this "40 percent" mean? … will it rain 40 percent of the time? … will it rain over 40 percent of the area?

The "Probability of Precipitation" (PoP) describes the chance of precipitation occurring at ***any*** point you select in the area. How do forecasters arrive at this value? Mathematically, PoP is defined as follows:

PoP = C × A, where "C" = the confidence that precipitation will occur ***somewhere*** in the forecast area and "A" = the percent of the area that will receive measureable precipitation, ***if it occurs at all.***

So … in the case of the forecast above, if the forecaster knows precipitation is sure to occur (confidence is 100 percent), he/she is expressing how much of the area will receive measurable rain. (PoP = "C" × "A" or "1" times "0.4" which equals 0.4 or 40 percent.)

*But*, most of the time, the forecaster is expressing a combination of degree of confidence *and* areal coverage. If the forecaster is only 50 percent sure that precipitation will occur, and expects that, *if it does occur,* it will produce measurable rain over about 80 percent of the area, the PoP (chance of rain) is 40 percent. (PoP = 0.5 × 0.8 which equals 0.4 or 40 percent.)

In either event, the correct way to interpret the forecast is: there is a 40 percent chance that rain will occur at any given point in the area.

1. **If a meteorologist is 80 percent confident that precipitation will occur and predicts that, if any precipitation occurs, it will occur over about 30 percent of the area, what is the PoP?**
2. **Does knowing how this probability is calculated change how you understand weather prediction? Does it change how you plan your day using the weather forecast? Explain why or why not?**
3. **Do a bit of your own research on how meteorologists form their confidence of precipitation somewhere in the forecast area (C in the PoP formula). Write a short paragraph explaining it in your own words. Is this confidence based on epistemic probabilities? Credences? A combination of both? Explain your answer.**

Excerpted from The National Weather Service Forecast Office, Peachtree, GA, "Explaining the 'Probability of Precipitation,'" http://www.srh.noaa.gov/ffc/?n=pop.

# Generalization, analogy, and causation

8

**In this chapter, we introduce three types of inductive argument. You will see how reasoners generalize from samples to populations and from past events to future ones. You will see how comparisons between objects and events can be used to draw inferences about new objects and events, and how causal relationships are either appealed to or inferred inductively. In addition, we will explain some common mistakes, or fallacies, committed when reasoning inductively.**

Inductive arguments come in a variety of forms. In this chapter, we will explain three popular forms: *inductive generalization*, *argument from analogy*, and *causal argument*. For each argument form, we will discuss the form itself, some strengths and weaknesses of that form, give some examples, and then give you the opportunity to practice using each form. At the end of this chapter, we provide further exercises to help you distinguish each inductive form, as well as a real-life example.

## Inductive Generalization

We often hear reports of new experiments about medical treatments, or behaviors that will make our lives better:

> **"CRESTOR can lower LDL cholesterol up to 52% (at the 10-mg dose versus 7% with placebo)" (**www.crestor.com**).**
>
> **"Research has shown that regular aspirin use is associated with a marked reduction from death due to all causes, particularly among the elderly, people with heart disease, and people who are physically unfit" ("Heart Disease and Aspirin Therapy,"** www.webmd.com**).**
>
> **"A U.S. Department of Transportation study released today estimates that 1,652 lives could be saved and 22,372 serious injuries avoided each year on America's roadways if seat belt use rates rose to 90 percent in every state" (**www.nhtsa.gov**).**

How do researchers draw these sorts of conclusions? How do they know what their drug might do for *you*? We assume you weren't one of their test subjects. We also assume they don't have access to your medical records or lifestyle. Nevertheless, something connects their research to your body—a member of the population that *wasn't* part of the study. Every conclusion like this is drawn from incomplete information.

You also generalize from incomplete information in your own life. For instance, you probably have no fear of your next airplane flight because most airplanes make their destinations safely. Similarly, you probably have no fear that the next soft drink you drink will be poisonous because most soft drinks aren't poisonous. And recall our discussion from the last chapter about whether the sun will rise tomorrow morning. Your past experiences inform your beliefs about the future even though you haven't been to the future. Nothing in your pool of evidence *guarantees* that future instances of an event will display the same features as past instances. Nevertheless, past evidence seems to provide *strong guidance* for beliefs that go beyond the data.

The most common way to use our past experience to support beliefs about the future is to use an **inductive generalization**. An inductive generalization is an inference from *a sample of some population* or *a set of past events* to *every member of that population* or *future events*. For example, from a sample of 486 registered voters, 2,500 citizens of the UK, or 30 known felons, we might infer something about *all* registered voters, *all* citizens of the UK, or *all* known felons. These are examples of reasoning from a sample to a population. Similarly, we might reason from past experiments on sugar, past sightings of swans, or past experiences of happiness to the nature of sugar generally, future sightings of swans, or future causes of happiness. These are examples of reasoning from the past to the future. If the sample or past events we have selected meet the right conditions, then inferences about the population or future instances will be strong.

Inductive generalizations tend to have the following form:

**1. Most (or almost all, or more than 50 percent) of a sample of X is Y.**

**2. Probably, all Xs are Ys.**

Here are some examples:

**1.**

1. Most of our 35-year-old male test subjects reacted positively to drug X.

2. Therefore, most 35-year-old men will probably react positively to it.

**2.**

1. Almost all the sixth-graders we interviewed love Harry Potter.

2. Therefore, Harry Potter probably appeals to most sixth-graders.

**3.**

1. 75% of 300 Labour Party members we interviewed said they approve of Bill X.

2. Therefore, probably most Labour Party members approve of Bill X.

Notice that, in each of these examples, a sample of a population is identified in the premises (*some/most* 35-year-old men, sixth-graders, etc.), and from this sample a generalization is drawn to the whole population (*all* 35-year-old men, all sixth-graders, etc.).

Inductive generalization is sometimes called **enumerative induction**, because we are enumerating a set of events or instances and drawing an inductive inference from them. But, to be precise, enumerative induction reasons from a past sample to *the next* instance of an event. For example, if every swan we've ever seen is white, then the next swan we see will probably be white. The principle is the same because there is an implicit assumption about most or all swans. We might just as easily have said, "All of the swans I will see will probably be white." But when reasoning to a next instance rather than the whole population, this is called enumerative induction.

What conditions constitute a good sample for an inductive generalization? There are four widely agreed-upon criteria:

1. **The sample must be random (i.e., unbiased).**
2. **The sample must be proportionate.**
3. **The sample must be obtained using a valid instrument.**
4. **The sample must be obtained using a reliable instrument.**

## A Sample Must Be *Random* (i.e., Unbiased)

If we are concerned with public perception of a liberal politician's job performance, we do not want our sample taken only from the conservative population, or only from the liberal population, or only from the rich population, or only from the religious population. These niche groups do not necessarily represent the whole population, and because they are not representative, they **bias** the sample. A **random** sampling takes information from all relevant portions of the population. If a sample is not random, it is biased.

Whether a sample is biased depends on the information we are looking for. For instance, if instead of the public perception of a politician's job performance, we are interested in *men's* perspective on that performance, we want to be sure *not* to include any women's perspectives. But we also do not want to restrict our sampling to the teenage boy population or the elderly man population. Of the population we are concerned with, even if narrow—in this case, men—our sample must still be random within our range of interest.

The methods used by surveyors are a primary source of bias. For instance, if surveyors call participants on the telephone between 7:00 and 9:00 p.m. on weekdays, they will miss significant portions of the population, including many younger people who no longer have land-line phones, college students who work retail jobs in the evenings, people who work swing shift, and people who are unwilling to answer interviewers during prime time.

Similarly, surveys such as radio call-ins, questionnaires found in newspapers or magazines that must be sent in or submitted online, and online opinion polls tend to be biased toward a certain type of participant, namely, those whose interests overlap with those of the media in which the poll is offered. In these surveys, researchers do not seek out or select participants, but participants choose to participate; the sample selects itself, and we call such samples *self-selected*. Inferences about whole populations drawn from self-selected samples are often biased (**self-selection bias**). We *might* be interested in only the sorts of people who would self-select to respond—for example, a magazine's advertisers may only be interested in the opinions of those who are interested in the magazine. But in many cases—politics, education, medical treatments—self-selection is a bad thing. One way to mitigate self-selection bias is to include a demographic questionnaire: age, race, occupation, sex, gender, and the like. This way, if your primary participant pool turns out to be, say, women in their late 60s, then at least your conclusion can reflect that. You know not to draw an inference about the whole population of people from a sample biased in favor of women in their late sixties.

When you evaluate survey data, check the method used to obtain the data. Ask: Does this method leave out significant portions of the population? Does the conclusion reflect the population likely to have participated in the survey? If a survey method is likely to lead to bias, a conclusion will not follow strongly from the data.

## A Sample Must Be *Proportionate*

Samples that are too small are not a good indication of the whole population. In the United States, there are roughly 100,000,000 registered voters. Therefore, if we want to know the public's perception of the president's job performance, a survey of 200 people will not be proportionate to the population of registered voters. Similarly, in a college of 2,000 students, a survey of one student will not be representative of the student body.

If a sample is too small or indeterminate, a strong inductive inference cannot be drawn. Consider example 2 above. Although "all the sixth-graders we interviewed" love Harry Potter, it is not clear how many we interviewed. Was it ten or a thousand? To draw an inference about most sixth-graders, we need more information about our sample.

A generalization that draws a conclusion about a population from a disproportionate sample size commits the fallacy of **hasty generalization**. (For more on the fallacy of hasty generalization, see Chapter 10.) The problem is that such an inference includes too little information in the premises to grant a high degree of probability to the conclusion.

There is some difficulty in determining when a sample is proportionate. Is 1 percent enough? Is 10 percent? Clearly, the larger the percentage, the better the sample will be. But in cases like the president's job performance in the United States, we are not likely to have the money or the time to survey even 1 percent of the population.

For very large populations, we (the authors' preference here) like to use the 1 percent rule. If a survey or experiment sampled 1 percent of the population (1 out of every 100 people in that particular population), the results are likely representative. Of course, it is much easier to get a 1 percent sample in very small, well-known populations, for example, eighth-graders in your county, women in the state of Georgia between the ages of eighteen and twenty-two, CEOs in Atlanta. It is much more difficult when the actual population size is unknown, for example, dolphins in the Atlantic, undocumented immigrants in the United States, pine trees in Virginia.

There are some ways to mitigate the weakening effects of small sample sizes. If more than one research group is studying the same feature of a population (and are asking the relevant questions in the right way; see "validity" and "reliability" below), the results can be combined for a much larger sample size. For instance, if the question is "Is the governor doing a good job?" and if three research groups ask this exact question to different samples of the population, you can average the results for a new generalization that is stronger than any one of the three. Imagine that each group randomly samples 900 voters in the state of Georgia and get the result: *Yes*, 55 percent, 57 percent, 51 percent of the time, respectively. Now your sample size is 2,700 and your percentage of *Yes* answers is 54.3 percent. Of course, since the population of Georgia is just over 9 million, you are nowhere close to the 1 percent rule, but the conclusion that more than 50 percent of Georgians are happy with the governor is strong*er* than before.

Is it objectively strong? Probably not, especially since just 300 additional *No*s would drop the approval rating below 50 percent. On the other hand, if you surveyed 1 percent of Georgians, roughly 90,000, and the results were 54.3 percent, it would take over 7,000 *No*s to drop the approval rating below 50 percent. This is a much more stable statistic. The conclusion (that the job approval is over 50 percent) is still derived inductively, and may be false given the variability in survey techniques. But in this case, at least, the conclusion would follow strongly (or strongly enough) from the premises.

When evaluating survey data, check the sample size. Use your best judgment to determine whether the sample size is large enough to represent the population. If the sample size is considerably small (many national political surveys in the United States include only 900 participants), the conclusion will not follow strongly (enough) from the premises.

## A Sample Must Be Obtained Using *a Valid Instrument*

Here we must be careful, because the word "valid" has a different meaning from the term we use to describe the relationship between premises and a conclusion. A *valid deductive argument* is an argument in which the conclusion follows from the premises with certainty. A **valid scientific instrument** (survey or experiment) is an instrument that *yields the relevant information we are looking for*, that is, it measures what it claims to measure.

For instance, we might survey college students voting for their student government president whether they like Bud Buffman for the position. But if our survey simply asked, "Do you like Bud?" our results might be overwhelmingly, "Yes," but only because the students thought we were asking about Budweiser beer (commonly abbreviated "Bud," as in their "This Bud's for you" ad). Or they might not realize we are asking about the student election. While we want to know how students feel about Bud Buffman as student government president, we may be getting their opinion on irrelevant matters. In this case, the survey does not yield the relevant information, and is therefore, invalid.

Similarly, in the 1930s, psychologist Lewis Terman discovered that intelligence test scores differed in unexpected ways between children who were raised in the country and those raised in urban areas. The IQs of country children dropped over time after entering school, while the IQs of urban children rose over time after entering school. More recently, researchers have shown that Terman's intelligence tests were not calibrated for **cultural bias** (wording questions so that only native speakers or members of a certain economic class can respond accurately). This means that the tests were tracking cultural factors, traits that were not indicative of intelligence, thus rendering the tests invalid. Similar studies were conducted with Wechsler intelligence scales given to groups of American Indian children, some of whom were more "acculturated" than others. The less acculturated groups performed worse than the more acculturated groups. Researchers explained that this discrepancy reflected a bias in the test.

Other threats to validity include the *framing bias* (asking questions too narrowly or in a closed-ended or question-begging way, e.g., "Have you stopped beating your wife?"), and *gender* and *race bias* (to present information using language or phrasing that lead different genders or races to interpret the same questions differently). To avoid invalidity, try to be sure the instrument you use has been tested for validity. Otherwise, you will not know whether your results really express what you want to know.

## A Sample Must Be Obtained Using *a Reliable Instrument*

In addition to validity, a scientific instrument must be structured so that it measures the relevant information *accurately*. Imagine a tire gauge that gives you dramatically different readings despite no changes to your tire. The gauge is measuring what it claims to measure (air pressure), so it is valid. But it is not measuring it accurately, so the gauge is unreliable.

Many factors affect the reliability of an instrument. For instance, psychologists have learned that, in some cases, the order in which certain questions are asked on surveys affects responses—a phenomenon known as *ordering bias*. Imagine you were given a survey with the following two questions:

1. **Is abortion always wrong?**
2. **Is it permissible to abort if not doing so will result in the deaths of both the mother and fetus?**

To be consistent, someone who genuinely opposes *all* abortions should answer "yes" to 1 and "no" to 2. But we can easily imagine such a person answering "yes" to 1 and also "yes" to 2. This doesn't mean they are inconsistent; they just might have not considered certain relevant circumstances. Question 2 primes respondents to consider a real-life scenario where someone has to make a decision as to whether one person dies or two. The respondent might still say that abortion is "bad" in that case but concede that it's the "right" thing to do.

If that same person were given the questions in a different order, their answer to whether abortion is "always" wrong might change:

1. **Is it permissible to abort if not doing so will result in the deaths of both the mother and fetus?**
2. **Is abortion always wrong?**

In this case, when the survey participant gets to question 2, they have just considered the case in question 1. Because of this, they might answer question 2 differently than if they had not considered the case. They might not reject abortion in *every conceivable case*. The point is that, while the questions really are testing for opinions about abortion, and so the survey is valid, the method of gathering the information yields different results based on an irrelevant factor, namely, the order of the questions. This means the survey is unreliable.

To overcome ordering bias, researchers construct a series of different surveys, where the questions are presented in different orders. If the sample is large enough, the ordering bias will cancel out.

Other threats to reliability include *confirmation bias* (unintentionally choosing data that favors the result you prefer) and the availability heuristic (using terms that prompt particular types of responses, such as "Is the Gulf War just another Vietnam?" and "Is the economy better or worse than when we only paid $1.50 per gallon for gasoline?"). Try to construct testing instruments that mitigate these biases. Otherwise, you will not know whether your results are reliable.

One last word of caution: Notice in examples 1–3 above that the conclusions do not claim more for their populations than the premises do for their samples. For example, the premise "most 35-year-old test subjects" implies something about "*most* 35-year-old men," not about "*all* 35-year-old men." Similarly, the premise "75 percent of 300 Labour Party members" implies something about "*75 percent* of all Labour Party members," not about "*all* Labour Party members." Inferences drawn from incomplete information are still beholden to the limits of the quantifiers in the premises. A conclusion that generalizes beyond what is permitted in the premises also commits the fallacy of hasty generalization (see Chapter 10 for more on hasty generalization).

## Getting familiar with … inductive generalization

**A. Complete each of the following inductive generalizations by supplying the conclusion.**

**1.**

1. Almost all politicians lie.
2. Blake is a politician.
3. Hence, …

**2.**

1. We surveyed 80% of the school, and all of them agreed with the class president.
2. John goes to our school.
3. Therefore, …

**3.**

1. You haven't liked anything you've tried at that restaurant.
2. Therefore, this time…

**4.**

1. Most of the philosophers we met at the conference were arrogant.
2. And those two we met at the bar weren't any better.
3. Oh no, here comes another. I bet…

**5.**

1. In the first experiment, sugar turned black when heated.
2. In experiments two through fifty, sugar turned black when heated.
3. Therefore, probably…

**6.**

1. We surveyed 90% of the city, and only 35% approve of the mayor's proposal.
2. Thus, most people probably…

**7.**

1. Every time you have pulled the lever on the slot machine, you've lost.
2. So, …

**8.**

1. 65% of 10% of citizens get married.
2. Terri is a citizen.
3. Hence, …

**9.**

1. Every girl I met at the bar last night snubbed me.

<u>2. Every girl I met at the bar so far tonight has snubbed me.</u>

3. Therefore, …

**10.**

1. All the politicians at the convention last year were jerks.

<u>2. All the politicians we've met at the convention this year were jerks.</u>

3. Hence, probably, …

**B. For each of the following examples, explain a way the method of data collecting could undermine the strength of an inductive generalization. There is more than one problem with some examples.**

1. Marvin County schools offered any child who is interested the opportunity to change schools to a school with a new curriculum in order to test the effectiveness of the new curriculum.
2. Interested in the eighth-grade pop culture, surveyors interviewed eighth graders from twelve girls' schools and three co-ed schools.
3. To find out what typical Americans think of the current political client, 785 college students were polled from a variety of campuses all over the UnitedStates.
4. To determine how many students at University of California were engaged in unsafe sex, researchers interviewed every student in Professor Grant's economics class.
5. To find out how well Georgians think the Georgia governor is doing in office, researchers polled 90 percent of the population of the largely Republican Rabun County.
6. Interviewers set up a booth outside the local Walmart to ask anyone who approached them whether they thought Walmart's hiring policies are discriminatory.
7. Tameeka says, "I've known two people who have visited Europe, and they both say that Europeans hate Americans. It seems that people outside the U.S. do not like us."
8. In order to determine the attitudes of college students to the government's foreign policy on terrorism, researchers asked college students the following question: "Are you in favor of the imperialist policy of treating all foreigners as terror suspects?"
9. A survey question asks, "Given the numerous gun-related accidents and homicides, and the recent horrifying school shootings, are you in favor of more gun regulation?"

10. Veronica says, "I've had three employees who claim to be Christian work for me, and none was a team player. I just won't hire someone if they claim to be Christian because I need team players."

## Errors in Statistics and Probability

Often, you will see a statistic followed by "±3%" or "±1.5%" or the words "plus or minus *x* percentage points. Here's an example: "The percentage of Americans who approve of Congress's decision on the latest bill is 52%, ±3.2."

Here's another:

> Interviews with 1,030 adult Americans, including 953 registered voters, conducted by telephone by Opinion Research Corporation on March 19–21, 2010. The margin of sampling error for results based on the total sample is plus or minus 3 percentage points and for registered voters is plus or minus 3 percentage points. (CNN Opinion Research Poll)

This percentage is called the *margin of error*, or *random sampling error*, in the sample data. It is important to understand what this percentage represents so we are not misled when evaluating arguments.

A margin of error is a mathematical function of the size of a sample. It is an estimate of the possible variation within the population, *given that* the sample is representative. Margins of error measure sampling error, that is, the possibility of error in the statistical calculation, which is based on something called the confidence interval. It does not measure possible errors in representativeness, such as randomness, validity, or reliability, and it is only indirectly related to proportionateness. If your sample is too small, the likelihood of statistical error is relatively high. But you already know that if your sample is too small it is not representative. If you already know that your sample is proportionate, random, obtained validly and reliably, the margin of error will inform you of the possibility of a statistical error, but not of a representativeness error. And if you know these things, you already know that your inference is strong. So, margins of error do not inform your evaluation of an inductive generalization.

To see why, consider that, all we need to know to calculate the margin of error is a sample size. Here are some standard margins of error:

| Sample Size | Margin of Error |
|---|---|
| 2,401 | 2% |
| 1,067 | 3% |

| | |
|---|---|
| 600 | 4% |
| 384 | 5% |
| 96 | 10% |

Beyond 2,000 test subjects, margins of error do not change dramatically. A sample of 10,000 has a margin of error of 1 percent. We need not know anything about the nature of the questions (reliability and validity), potentially biasing features (self-selection bias, ordering bias, confirmation bias, etc.).

Some researchers are fairly up-front about the limitations of their studies. A recent Gallup Poll (www.gallup.com) included this block of info:

> **Survey Methods**
>
> Results are based on telephone interviews with 1,033 national adults, aged 18 and older, conducted March 26–28, 2010. For results based on the total sample of national adults, one can say with 95% confidence that the maximum margin of sampling error is ±4 percentage points.
>
> Interviews are conducted with respondents on landline telephones (for respondents with a landline telephone) and cellular phones (for respondents who are cell phone only).
>
> In addition to sampling error, question wording and practical difficulties in conducting surveys can introduce error or bias into the findings of public opinion polls.

In this Gallup poll, researchers remind readers that some biasing factors are always possible. "Question wording" may refer to the possibility of cultural, framing, or ordering bias, and "practical difficulties" may refer to time constraints, self-selection (the sort of people who would answer an interviewer's questions), difficulties guaranteeing randomness, and idiosyncrasies among members of the population. This reminder is helpful to us all; even those of us who teach this material, since it is easy to take statistics at face value.

How does all this help critical thinkers? In order to effectively evaluate statistical data, we should first determine the degree to which they meet the conditions of a good sample (random, proportionate, valid, reliable). We should believe inferences drawn from this data only to the degree they meet these conditions.

## Statistical Fallacies

In addition to all the factors that can undermine representativeness, there are a number of ways that we misuse statistics. Three very common mistakes made when reasoning about stats are *the regression fallacy*, *base rate neglect*, and *the gambler's fallacy*.

## The Regression Fallacy

Were your siblings always getting praised when their grades improved, while you were criticized as yours dropped? If so, you may have been the victim of the regression fallacy. Consider the case of spanking. Some people argue that spanking improves children's behavior, while others argue that it has no effect compared to other parenting techniques, such as praising good behavior. Those who argue that it works claim to have experiential proof that it works: after a child is spanked, he or she is less likely to act poorly. In contrast, when praised, a child is just as likely as before to act poorly. Yet, psychologists who study these things say these parents are just wrong. Why would they say this?

It turns out that we're all pretty average; sometimes we act well, sometimes we act poorly. After we do really bad things, we usually have a streak of fairly neutral behavior with some good thrown in. Similarly, after we do something praiseworthy, we usually have a streak of fairly neutral behavior with some bad thrown in. That's what "average" means: mostly neutral, a little good and a little bad.

Now, consider what parents are looking for when they spank or praise. After acting badly, what typically follows is for a child to act neutrally or well, regardless of whether they are spanked. But parents are *watching* for *bad behavior*, and because the kids are not doing something bad after they're spanked, it looks like spanking works. In reality, kids are just returning their average baseline—their *mean* (remember from math class that "mean" means "average"). Though it looks like spanking led to fewer instances of bad behavior, kids were just regressing to their mean.

What's interesting is that the same is true for especially good behavior, too. But in reverse. Kids usually do not get praised for just doing what they're supposed to do. They typically only get praised for the extra good stuff. Yet, because we're mostly average, after a child does something praiseworthy, their subsequent behavior is pretty neutral. And they still do some bad stuff here and there. Good kids regress back to their average, too. So, even though parents are praising the good behavior, behavior doesn't stay good! But when they spank, behavior improves! Voila! A fallacy is born. The regression fallacy occurs when we attribute especially good or bad effects to an intervention when the more likely explanation is just that effects are simply regressing to their average.

Most of our parents cannot see this trend over time because they aren't documenting every behavior of their children. And even some social scientists forget that people and events regress to a mean. After a child does really well on one standardized test, he or she is likely to do poorly on the next. It's not because he or she isn't smart or has stopped learning. The fact is, no matter how smart the child, some of that good score depended on luck, some of it on the precise questions that were asked, and some of it on genuine knowledge. Since that last element is all that a child can control, statistics tell us that a really good score will likely be followed by a worse one, and a really bad score will be followed by a better one. The scores regress to the mean because most of us (by definition) are average. This means that making educational decisions based on a handful of test scores is not representative of the child's abilities. To avoid the regression fallacy, make sure there are enough trials to get a statistically significant result. Allow for the possibility of luck—and be sure the results couldn't be explained by statistics alone.

## Base Rate Neglect

Another way we make errors when reasoning about probability is to ignore the rate at which events occur (their base rate) relative to the rate at which we perceive them. In this fallacy, a reasoner draws a conclusion about the cause of an event while ignoring (intentionally or unintentionally) the rate at which that event normally occurs. For example, someone might say: "Every time I start running regularly, my joints hurt. But if I drink water immediately after running for a few days in a row, my joint pain goes away. So, if you're afraid you'll have joint pain, you should try drinking water after each run." The arguer here is inferring a causal relationship between *drinking water immediately after running out* and *the waning of joint pain*. The problem with this argument is that, whether or not you drink water, joint pain will subside in a few days, once your body is conditioned to running again. Even if every time you drink water, joint pain subsides, since joint pain subsides 100 percent of the time *regardless of whether you drink water*, the fact that the pain subsides *after* drinking water does not indicate that drinking water *caused* the pain to subside. The base rate of subsiding joint pain is 100 percent (unless you are injured or have other joint problems). Therefore, it is fallacious to identify water as the cause; it is fallacious because it is neglecting to include the base rate at which the event occurs normally in the reasoning.

Other examples are more interesting. Consider someone who takes a medical test that is 99 percent reliable and she is told that she has tested positive. What is the likelihood that she actually has the disease? It is tempting to think 99 percent, but this is misleading. The probability that you actually have the disease depends on *both* how reliable the test is *and* on how likely it is that anyone ever gets the disease. Let's say you also learn that only 1 person in 100,000,000 ever gets this disease (that's about 3 people in the entire United States). Even if your *test* is really good (99 percent reliable), the likelihood that you actually have the disease is low (just over 1 percent).[1] Ignoring the base rate of the disease can lead to gross miscalculations, and therefore, to unjustified beliefs.

This mistake is common when people try new treatments for ailments like cuts and colds. It may seem like the ointment or cold remedy is working,

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[1]The formula for calculating this is complicated. It requires applying a formula known as Bayes's Theorem to the probabilities noted. For those interested, it looks like this:

$$P(A|B) = \frac{P(B|A)}{P(B)} \times P(A)$$

Substituting, we get:

$$P(\text{Disease}|\text{Positive test result}) = \frac{P\,(\text{Positive test result}|\text{Disease})}{P\,(\text{Positive test result})} \times P(\text{Disease})$$

The probability of a positive result if you have the disease is 99 percent and the probability of having the disease is 1 in 100,000,000 or 0.000000001. What's the probability of a positive test result, period? We can treat it as the frequency with which a positive result will come up in a population of 300,000,000, which includes those who have the disease and those who don't. The test will catch 99 percent of disease instances in the three with the disease or 2.97 cases. In the remaining 299,999,997 people, it will produce false positives 1 percent of the time, or 2,999,999.97. Add those together and you get 3,000,002.94 out of 300,000,000, which is a shade over 1 percent (0.0100000098).

$$P(\text{Disease}|\text{Positive test result}) = \frac{0.99 \times 0.00000001}{0.0100000098}$$

$$P(\text{Disease}|\text{Positive test result}) = \frac{0.0000000099}{0.0100000098}$$

$$P(\text{Disease}|\text{Positive test result}) \cong 9.89999 \times 10^{-7}$$

$$P(\text{Disease}|\text{Positive test result}) \cong 1 \text{ chance in } 1{,}010{,}102$$

Bottom line: If the test says you have the disease, it is very likely that you don't. Unless you calibrate your risk-taking to a finer grain than about one chance in a million, the test provides no useful information. (Thanks to Robert Bass for this example.)

reducing the time it takes to heal. But how might you know? Most people don't have enough cuts or colds to know how long it takes from them to heal without any treatment. The company that makes Airborne herbal health formula was once forced to pay reparations for falsely claiming that the formula "prevents colds."[2] People accepted the advertising because we generally have no idea the base rate at which we get colds in the first place. The fact that we cannot, based on our own anecdotal experience, distinguish causes effectively suggests that we need additional evidence for testing such claims. As we will see in Chapter 9, this is why controlled experiments are so helpful.

## The Gambler's Fallacy

Have you ever had a losing streak and thought, "Okay, I'm due for a win now"? If so, you may have committed the gambler's fallacy. The gambler's fallacy occurs when we use evidence of past, independent events to draw probabilistic conclusions about future events. Imagine flipping a fair coin seven times, each of which came up heads. What is the probability that the eighth flip will also come up heads? It is 50 percent. Every flip is independent of every other, so with a fair coin with two options, one option is just as likely as the other every time. The same goes for roulette wheels and playing cards. No spin or hand (once shuffled) causally affects the probabilities of subsequent spins or hands.

What misleads us here is the law of large numbers. The law of large numbers says that, given enough flips, the coin will land tails half the time. So, if it has already landed heads seven times, the odds will even out … eventually. It's the *eventually* bit that trips us up. It's true that the longer you flip the coin, the more likely you will get an even number of heads and tails. But how long will that take? If you're betting, do you have enough money to hold out? Do you have enough money so you can bet enough to cover your previous losses *and* make money when you do win? And what if this streak is evening out the numerous tails flipped the thousand times before you showed up to gamble? Which large numbers are you counting on? Unless you are playing a game that involves skill (and you have that skill, and you're not playing against someone better skilled), the house always wins.

The point is that the law of large numbers does not tell you anything about the distribution of outcomes or the causal relationship among the flips *in the immediate future*. It only tells you that the whole set of outcomes (past and

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[2]Steven Novella, "Airborne Settles Case on False Advertising," March 26, 2008, *Science-Based Medicine.org*, http://www.sciencebasedmedicine.org/airborne-admits-false-advertising/.

future) will look more and more like the outcomes of any single flip or spin or hand.

## Getting familiar with … errors in statistics and probability

**For each of the following, explain which probability error has been committed.**

1. "Every time I take this new VitaMix cold medicine, my cold goes away. Therefore, I know it works."
2. Jim has played and lost at craps seven times in a row. He concludes that he must win soon, so he increases his next bet to cover his former losses.
3. "Every time I leave the house without an umbrella, it rains. Why me!?" (This is also an example of something called a "hedonic asymmetry." We pay more attention to events that cause emotional responses—positive or negative—than to events that don't. So, even though the number of times it rains when you don't take an umbrella may be roughly equal to the times it rains when you do, you tend to remember the times you don't more vividly because they cause a strong emotional response.)
4. John just found out that most car accidents happen within two miles of where a person lives. Because of this, he has decided to move at least two miles away from his current apartment.
5. After watching Kareem win three tennis sets in a row, the recruiter is sure that Kareem will be a good fit for his all-star team.
6. "I touch my front door ten times every morning, and nothing too bad ever happens to me. Therefore, if you want your life to go well, you should start touching your front door ten times before you leave."
7. After acing her first exam, Simone was shocked to discover that she only got an 85 on the second. She concludes that she must be getting dumber.
8. "I am bracing for bad luck. My life has been going much too well lately to keep this up. Something bad will have to even it out at some point."
9. "Ever since I bought this mosquito repellent, I haven't been bitten by one mosquito. It must really work."
10. Almost every athlete who has appeared on the cover of *Sports Illustrated* experienced a significant decline in performance just after the issue is released. Fariq decides to turn down an offer to appear on the magazine's cover, fearing that his stats will fall. (Example adapted from Thomas Gilovich, *How We Know What Isn't So* (New York: The Free Press, 1991), pp. 26–7.)

## Argument from Analogy

There are some claims for which statistical data are either irrelevant or difficult or impossible to gather. This sort of claim would answer questions like these:

- **How do doctors distinguish your illness from the patient's down the hall?**
- **How does an archaeologist determine that a piece of stone is a *tool* and not simply a *rock*?**
- **How does a historian determine that two texts were written by the same author?**

Past quantities of these things will not help us answer these questions, only information about their qualities, or "properties," can help us.

For each question, an investigator typically relies on **argument from analogy**. In an argument from analogy, a comparison is made between two states of affairs (usually an object or event), one of which is better understood than the other. Then, on the basis of their similarities and differences, new information is inferred about the lesser known object. For example, imagine you have a Dell laptop computer. Your Dell laptop has a 16" screen, 3 terabytes of memory, and 5 gigs of RAM. In addition, your Dell has the Microsoft Office Suite software. Now imagine you are looking to buy another laptop and, on EBay, you discover a Dell like yours, with a 16" screen, 3 terabytes of memory, and 5 gigs of RAM. Simply given these similarities with your laptop, it seems that you may infer that the EBay laptop also has the Microsoft Office Suite. *You don't even have to understand what these features mean*. From the similarities between the laptops, you may infer something about a new laptop from something you already know about your old laptop.

Doctors often do the same thing when diagnosing an illness. Imagine you are a doctor and a patient comes to you with the following symptoms:

- **A sudden, severe sore throat.**
- **Pain when swallowing.**
- **Body temperature over 101$^{o}$ F.**
- **Swollen tonsils or lymph nodes.**
- **White or yellow spots on the back of the throat.**

Imagine, also, that you have had five other patients with the same symptoms this week and each of these other patients had strep throat. What can you conclude? Given the similarities in the symptoms, it seems safe to conclude this patient also has strep throat.

How do doctors distinguish one disease from another? Imagine that you just diagnosed this patient with strep throat, when another patient comes in with all these symptoms, minus the white or yellow spots on the back of the throat? Do you conclude that the patient *does not* have strep throat based on this one dissimilarity? It can be difficult to tell because the symptom that really sets strep throat apart from a cold or the flu is the spots on the throat. In this case, you may want to perform a strep test, which is another indicator of the disease.

Arguments from analogy typically have the following form:

1. Object A has features v, w, x, y, and z.
2. Object B has features v, w, x, and y.

**3. Therefore, object B probably also has feature z.**

Here are three more examples:

**1.**

1. Watches are highly organized machines with many interrelated parts that all work together for a specific purpose, and they were designed by an intelligent person.
2. The mammalian eye is an organized machine with many interrelated parts that all work together for a specific purpose.

3. Therefore, it is likely that the mammalian eye was also designed by an intelligent person.

**2.**

1. This instrument fits well in a human hand, has a sharp blade, a hilt to protect the hand, and was designed by humans to cut things.
2. This rock fits well in a human hand, has what appears to be a blade, and what appears to be a hilt to protect the hand.

3. Therefore, this rock was probably designed by humans to cut things.

**3.**

1. My old Ford had a 4.6 liter, V8 engine, four-wheel drive, a towing package, and ran well for many years.
2. This new Ford has a 4.6 liter, V8 engine, four-wheel drive, and a towing package.

3. Hence, it will probably also run well for many years.

It is not always easy to use this method to diagnose illnesses. Some diseases are too similar. For instance, colds, the flu, swine flu, and allergic rhinitis all exhibit the same symptoms, but to greater or lesser degrees. And there is no test to distinguish them until they get much worse. In many cases, physicians use the base rate of the illness to diagnose. For example, the swine flu is rare, so it's rarely considered. And if colds are currently prominent in the immediate area, this is the most likely diagnosis. But, this is why it is important to monitor a cold carefully, even if it starts mildly, to know whether further testing and treatment are necessary. So, how do we know when an analogy is a *strong* analogy?

## Strengths and Weaknesses of Analogies

Unfortunately, arguments from analogy, without proper qualification, are *notoriously weak*. There are often more dissimilarities than similarities. Even if you can identify 185 similarities between two objects, if there are 250 dissimilarities, it is not clear whether there is any strong inference you can draw. For instance, bears are like humans in many ways. Both are mammals (which means both are warm-blooded, give birth to live young, have hair, and have milk-producing mammary glands), both are omnivores, both play important roles in their environments, both are protective of their young, and both are unpredictable when they encounter strangers. Nevertheless, there are hundreds of differences between bears and humans, so it is not clear what sort of inference we could draw about one from the other given these similarities. We might be tempted to conclude that bears are moral or rational creatures, or we might be tempted to conclude that humans *aren't* moral or rational creatures. But both seem wrong. This means that a good analogy must be about more than similarities alone.

The other necessary feature of a good analogy is that the similarities are *relevant* to the conclusion we are interested in. Despite enormous similarities, two objects may be different in critical ways. Chimpanzees are humans' closest genetic ancestor. Our DNA is 98 percent similar. Nevertheless, we should not conclude from this similarity that humans are chimpanzees, or that chimpanzees are humans. Genetic similarity is not enough to strictly delineate species. Consider our laptop case again, Dell computers do not often come with software, so despite enormous similarities, we are not justified in inferring that the EBay laptop comes with Microsoft Office Suite. The features of the computer's hardware are irrelevant to whether it has a certain software. We can see this more clearly if, instead of considering that your computer has a certain software, you consider the fact that it was once owned by your brother. Surely, despite enormous similarities, you should not conclude that the Dell on EBay was probably owned by your brother.

So, in order for an argument from analogy to be strong, there must be a set of *relevant similarities* between the objects or events compared. And the examples just given show that such arguments face serious threats that may not be obvious. Two widely acknowledged weaknesses are that (1) there are often more dissimilarities than similarities between the compared objects or events, and (2) the similarities noted are often irrelevant to the feature inferred in the argument.

## There Are Often More Dissimilarities Than Similarities

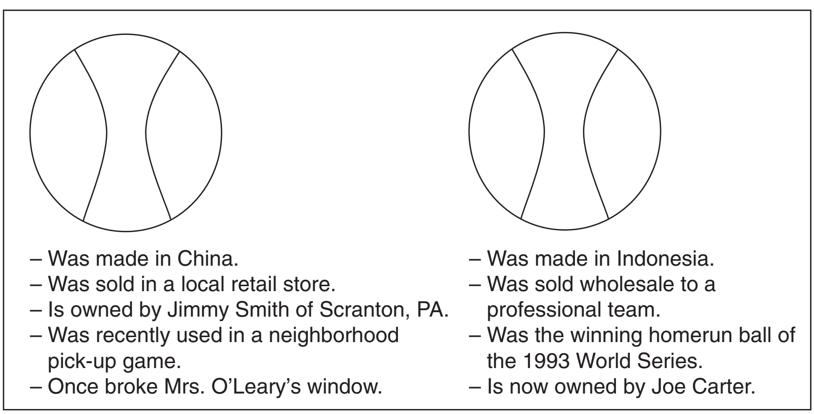
Consider example 1 above, comparing watches and cells. There are many more dissimilarities between watches and cells than similarities. For example, watches are made of metal and glass, are designed to tell time, have hands or digital displays, have buttons or winding stems, have bands, are synthetic. Cells have none of these features. In fact, many things are often different in as many ways as they are similar. Consider two baseballs (Figure 8.1). Even though they share all the same physical properties (shape, size, weight, color, brand, thread, etc.), they may be dissimilar in dozens of other ways:

Therefore, the key to constructing a good argument from analogy is not simply to amass a large number of similarities, but to identify a number of *relevant* similarities. But determining just which similarities are relevant is a challenge.

## Often, the Most Obvious Similarities Are Irrelevant to the Feature Inferred in the Conclusion

Consider, again, the analogy between watches and cells, perhaps having a "purpose" or a "goal" more strongly implies an intelligent designer than

**Figure 8.1** Baseball Analogy



having interrelated parts. If this is right, then noting that both watches and cells have a goal makes the argument for design stronger than noting that it has interrelated parts. In fact, having interrelated parts may be irrelevant to design.

How can we determine whether a feature of an object or event is relevant to the feature we are interested in? There is no widely accepted answer to this question. One approach is to ask whether the feature in question is "what you would expect" even if you weren't trying to build an argument from analogy. For example, you wouldn't expect for any particular computer, that it was owned by your brother. So that's clearly an irrelevant feature. But you would expect complicated, interrelated parts to exhibit purpose. So, complicated, interrelated parts are not irrelevant to the purpose of a watch.

Of course, this is a pretty weak strategy. If you find a rock in the wilderness with a handle-shaped end, it's hard to know what to say. While you wouldn't necessarily expect to find a handle-shaped end, it is certainly not unusual to find rocks with funny-shaped protuberances. And one such protuberance is a handle-shaped end. Does this mean that the rock is more or less likely to have been carved into a tool? We can't say. Thus, this approach isn't very strong.

A more promising strategy is to gather independent evidence that there is a *causal relationship* between certain features of an object or event and the feature being inferred.

Consider example 3 from above:

**3.**

1. My old Ford had a 4.6 liter, V8 engine, four-wheel drive, a towing package, and ran well for many years.
2. This new Ford has a 4.6 liter, V8 engine, four-wheel drive, and a towing package.

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3. Hence, it will probably also run will for many years.

That a vehicle has a 4.6 liter, V8 engine may be irrelevant to whether that vehicle will run for many years. We can imagine a wide variety of 4.6 liter, V8s of very poor quality. It doesn't seem plausible to find independent evidence linking the features "4.6 liter, V8" with "will run for many years." But it does seem plausible to think that *certain* 4.6 liter, V8s, for instance those made by Ford, could run longer than others. We can imagine gathering evidence that the 4.6 liter, V8s made by Ford during the years 1980–1996 have an excellent track record of running for many years. From this evidence we could draw an analogy between the old Ford and the new Ford based on their relevant similarities, reformulating 3 as 3*:

**3*.**

1. My old Ford had a 4.6 liter, V8 engine, was made in 1986, and ran well for many years.
2. Ford produced excellent motors between 1980 and 1996.
3. This new Ford has a 4.6 liter, V8 engine, and was made in 1996.
4. Hence, it will probably also run well for many years.

If an arguer attempts to draw an analogy in which there are more dissimilarities than similarities *or* the similarities are irrelevant to the conclusion, she has committed a fallacy known as **false analogy**. Strong arguments from analogy avoid one or both weaknesses. One important way of avoiding these weaknesses is to include a well-supported *causal claim* in the premises or conclusion. In example 3*, premise 2 is a causal claim; Ford produced (caused) excellent motors.

Notably, if you can point to a causal connection between features, your argument from analogy starts to look less like an analogy and more like an argument from causation. And that is the subject of the next section.

## Getting familiar with … arguments from analogy

**Complete each of the following arguments from analogy by supplying the conclusion.**

**1.**

1. Bear paw prints have five toe marks, five claw marks, and an oblong-shaped pad mark.
2. This paw print has five toe marks, five claw marks, and an oblong-shaped pad mark.
3. Thus, …

**2.**

1. *My* mug is red with "Starbucks" written on it, and a chip on the handle.
2. This mug is red with "Starbucks" written on it, and has a chip on the handle.
3. So, this is…

**3.**

1. The jeans I'm wearing are Gap brand, they are "classic fit," they were made in Indonesia, and they fit great.

2. This pair of jeans are Gap brand, "classic fit," and were made in Indonesia.

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3. Therefore, …

**4.**

1. Alright, we have the same team and coach we won with last year against the same team.
2. We're even wearing the same uniforms.

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3. It is likely that…

**5.**

1. At the first crime scene, the door was kicked in and a playing card was left on the victim.
2. At this crime scene, the door was kicked in and there is a playing card on the victim.

---

3. Therefore, …

**6.** There are several stones here. Each stone has a broad head, sharp on one side. These stones are similar to tools used by a tribe in another region of this area. Therefore, these stones….

**7.** Everything I have read about this pickup truck tells me it is reliable and comfortable. There is a red one at the dealer. I want it because….

**8.** This bottle of wine is the same brand, grape, and vintage as the one we had for New Year's Eve. And that bottle was great, so, ….

**9.** This plant looks just like the edible plant in this guidebook. Therefore, ….

**10.** All the desserts I have love have ice cream, chocolate syrup, and sprinkles. This dessert has ice cream, chocolate syrup, and sprinkles. Therefore, ….

## Causal Arguments

A **causal argument** is an inductive argument whose premises are intended to support a causal claim. A **causal claim** is a claim that expresses a cause-and-effect relationship between two events. Some examples include:

1. **The sun caused my car seats to fade.**
2. **Pressing a button caused the television to turn on.**

**3. Texans elected the new governor.**

**4. Penicillin cured my infection.**

Notice that not all causal claims include the word "cause" in them. As long as a claim implies that one object or event brings about another, it is a causal claim. In examples 3 and 4, the words "elected" and "cured" imply that the subjects of the claims (respectively: Texans, penicillin) did something to bring about the objects of the claims (the governor's appointment, the elimination of the infection).

The concepts of *cause* and *effect* are the source of much philosophical strife. Because of this, reasoning about causes is one of the most difficult things philosophers and scientists do. For our purposes, we will use a fairly common-sense notion of a cause.

It is important to note that just because a claim has the word "because" in it does not make it a causal claim. For example, none of the following *because* claims are causal claims:

**5. I'm going to the game because you asked me.**

**6. The reason he is pitching is because the score is so low.**

**7. She failed because she is lazy.**

**8. You're only crying because you're losing.**

The word "because" can be used to express a *cause* or an *explanation*. In examples 5–8, because expresses explanations. In 5, your asking me explains why I'm going to the game. In 8, your losing explains why you're crying.

## Explanations versus Arguments

Explanations are not arguments. Whereas arguments are intended to support the truth of a claim, explanations attempt to account for that truth. Arguments try to answer the question: Is that true? Explanations try to answer the question: Why is that true?

For instance, imagine that you say you like a certain movie. If someone asks you why you like it, you give an explanation not an argument. "I think the film has great cinematography. I like the plot. I think the actor is convincing in any role she plays." These are very simple explanations, but notice: They are not reasons for anyone else to like the film. They are reasons, but they are not reasons attempting to support the truth of a claim. You are not trying to prove that it's true that you like the film—that is taken for granted by your audience. You are simply pointing to the things about the film that constitute your liking it.

To be sure, your explanation might prompt your audience to go see the film themselves if they haven't already. They might take it as a certain kind of reason: "Oh, if that person liked the film, then I might, too." But additional premises would be needed to make this a strong inference: You and that person have similar tastes in film, your reasons for liking the film are the sorts of reason that person tends to like films, they already agree that the actor in question is convincing, and so on.

So, we can describe the difference between arguments and explanations in terms of their distinct purposes. An argument is a reason to believe a claim is true. An explanation is a reason why a claim is true or how it came to be true. An explanation might be *causal* (Y happened because X made it happen) or *constitutive* (X is Y because features A, B, and C are what it means to be Y). Arguments are made up of premises that support a conclusion. Explanations are made up of *explanans* (claims that explain) and an *explanandum* (a claim that needs explaining).

## Evaluating Causal Arguments

Once you have identified that an argument has a causal claim in the conclusion, you can begin to evaluate the argument. Causal arguments can take the form of any of the three types of inductive arguments we have discussed already: enumeration, generalization, or analogy. In fact, some of the arguments we considered earlier in this chapter can be re-formulated as causal arguments.

Consider the patient with the symptoms of strep throat. Because five other patients had those symptoms and strep throat, we concluded that this patient must also have strep throat. If we think about it, we probably also think that the streptococcus bacteria (which causes strep throat) *causes* the patient to have the symptoms we noted. We could have formulated it as: Streptococcus caused these symptoms in the other patients; therefore, it is probably causing these symptoms in this patient. Nevertheless, our conclusion did not express this, implicitly or explicitly, so it is not, strictly speaking, a causal argument.

That causal arguments take the form of other inductive arguments raises an interesting question: Why single them out as a unique type of inductive argument? The primary reason is that causal relationships are special. Without noting the causal relationship between the symptoms and the bacteria, we could have easily inferred from the fact that five people had those symptoms plus strep throat, that someone who has strep throat must also have those symptoms. This would be a perfectly good argument from analogy. But we would not, in this case, want to say that *the symptoms caused the strep throat*. This confuses the cause with the effect, but without more information, there is no way to determine which event is the cause and which is the effect. The information needed for that usually comes from scientific experiments, which we'll say more about in Chapter 9.

Causal relationships are special because they relate two events in one specific direction, from cause to effect. We call a one-directional relationship, "asymmetric." An **asymmetric relationship** is a relationship that holds only in one direction (in other words, there's an asymmetry between two events). For example, if I am a parent to someone, that person is not a parent to me. Parenting relationships are asymmetric. Asymmetric relationships stand in contrast to **symmetric relationships**, which are relationships that hold in both directions. For example, if I am a sibling to someone, that person is a sibling to me. Sibling relationships are symmetric.

Since causal relationships are asymmetric, to evaluate them we must determine (1) whether they meet the conditions of a good inductive argument (of whatever form—enumeration, generalization, analogy, etc.), and (2) whether they are testable. Consider two cases.

First, imagine discovering strong evidence that people who write songs live longer than people who do not. Would you conclude that (1) writing more and more songs causes you to live longer, (2) living longer causes you to write more and more songs, (3) some independent factor leads to both long life and songwriting, or (4) the connection is merely coincidental? How would you decide?

Second, imagine discovering strong evidence that as coffee sales increase, allergy attacks decrease. Would you conclude that (1) coffee reduces allergy attacks, (2) allergy attacks prevent coffee sales, (3) some independent factor leads both to increased coffee sales and low allergy attacks, or (4) the connection is merely coincidental? How would you decide?

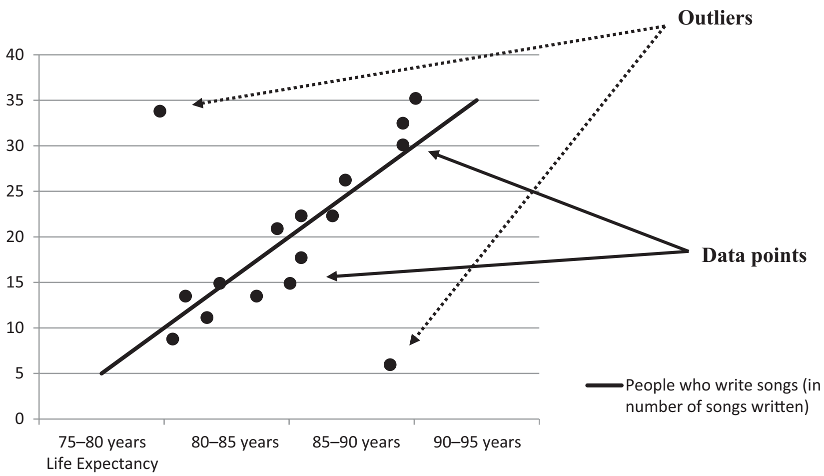
Choosing appropriately involves avoiding three common mistakes that attend causal arguments. These mistakes can affect your conclusions even if all the other conditions for a good inductive argument are met. In this section, we will discuss these mistakes so you will be aware of them, and in the next section, we will discuss some reasoning strategies that will help you avoid them. The three common mistakes are:

1. **Mistaking Correlation for Causation**
2. **Mistaking Temporal Order for Causal Order**
3. **Mistaking Coincidence for Causation**

## Mistaking Correlation for Causation

In both examples above, you discovered "strong evidence" connecting two events: writing songs and life expectancy in one case, and coffee sales and allergy attacks in the other. Statisticians call this relationship a **correlation**.

**Figure 8.2** Example of a Positive Correlation




Data can be positively or negatively correlated. In a **positive correlation** (Figure 8.2), the frequency of one event increases as the frequency of another event increases, as in the songwriting/life expectancy example:

## Positive Correlation

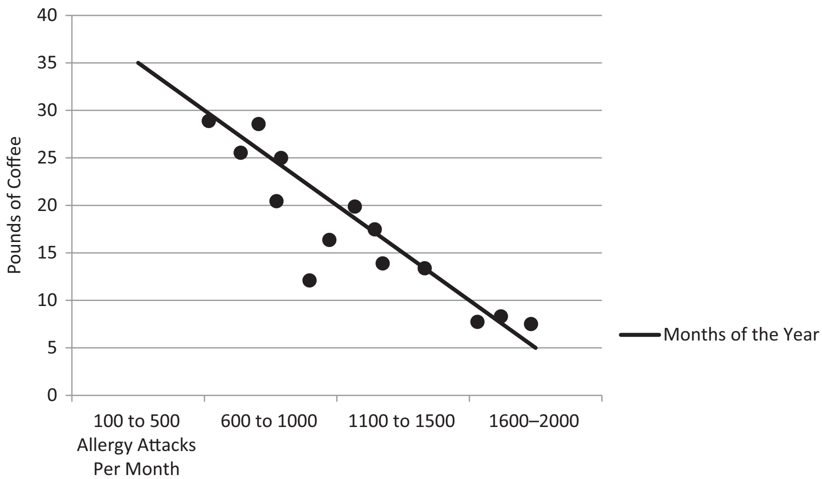
In this example, the data points represent people who write songs. They are placed on the graph according to the number of songs they wrote (vertical axis) and the number of years they lived (horizontal axis). If the data points fall roughly along a diagonal line that extends from the bottom left of the graph to the top right, there is a strong positive correlation between the events—as instances of one increase, so do instances of the other. The more tightly the points fall along this line, the stronger the correlation. Of course, even when you discover a strong correlation, there may be outliers. **Outliers** are data points that do not conform to the correlation line. If there are too many outliers, the correlation is not strong.

In a **negative correlation** (Figure 8.3), the frequency of one event decreases as the frequency of another event increases. Consider the case of increased coffee sales and reduced allergy attacks. If we compare how much coffee is sold each month with how many allergy attacks are reported during those months, we might get the following graph:

## Negative Correlation

In this example, the data points represent months of the year. They are placed on the graph according to how many pounds of coffee are sold (vertical axis)

**Figure 8.3** Example of a Negative Correlation




and how many allergy attacks are reported (horizontal axis). If the data points fall roughly along a diagonal line slanting from the top left of the graph to the bottom right, there is a strong negative correlation between how much coffee was sold and how many allergy attacks happened. Just as with positive correlations, the more tightly the points fall along this line, the stronger the correlation.

Now, the question is: Does correlation indicate anything with respect to causation, that is, does it help us answer the question about whether one of these events caused the other? Without further evidence, it would seem not. There is no obvious causal relationship between writing songs and long life or drinking coffee and allergic reactions. It certainly seems strange to think that allergic reactions might reduce coffee drinking. Nevertheless, it is possible and can be useful for suggesting that a causal relationship exists somewhere to explain the correlation. For example, maybe it has an indirect effect: During bad allergy seasons, people go out for coffee less frequently. Or, perhaps causation runs the other way, and coffee has some antihistamine effects we were unaware of. Perhaps writing songs greatly reduces stress, and therefore, the chances of heart disease. We would need to do more work (namely, scientific work) to find out if any of these hypotheses is plausible.

The most that a *strong* correlation implies (absent any additional experimental conditions) is that the events are not coincidentally related. If a correlation is strong, it is unlikely that it is a function of *mere* chance (though possible). When we reason about causal events, we rely on a certain regularity in nature, attributed most often to natural laws (gravity, inertia, etc.). That regularity helps us predict and manipulate our reality: we avoid running near cliffs, walking in front of buses, we press the brake pedal when we want to stop, we turn the steering wheel when we want to avoid a deer in the road, and so on. The fact that these relationships between our behavior and the world seem to hold regularly often leads us to believe that two events paired in increasing or decreasing intervals under similar conditions are related causally. But even these strong correlations do not tell us where the causal relationship is located.

The cautionary point here is to resist believing that two events that regularly occur together stand in any particular causal relationship to one another. This is because two events may occur regularly together, yet not imply any sort of causal relationship. The rising of the sun is paired regularly with my heart's beating at that time, waking up is often paired with eating, certain lights turning green is often followed by moving cars, and so on. But none of these events (that we know of) are causally related. My heart could stop without the slightest change in the sun's schedule; I could wake without eating and sit still at a green light. Thus, causal relationships are more likely in cases of strong positive or negative correlations than simple regularities, but they aren't guaranteed.

It is also true that the problem of induction (see Chapter 7) raises an important problem for assuming the regularity of nature. But the assumption that nature is consistently regular is so fundamental to the way we reason, it is difficult to ignore. For this reason, when we discover a strong correlation, like that stipulated in our two examples above, we tend to believe that chance or coincidence (option (4) in each example above) is less plausible than a causal relationship of some sort. Therefore, a strong correlation simply indicates that we should investigate further the apparent causal relationship between *A* and *B*.

## Mistaking Temporal Order for Causal Order

Temporal order is the order events occur in time. An event at two o'clock precedes an event at three o'clock. It is true that a cause cannot occur after its effect in time. Rain today doesn't help crops last month, and a homerun next Saturday won't win last week's game. It is also true that not all causes precede their effects; some are simultaneous with their effects. For instance, a baseball's hitting a window causes it to break, but the hitting and the breaking are simultaneous. However, it is sometimes tempting to think that because one event precedes another, the first event causes the second, especially if those events are paired often enough.

Consider classic superstitions: walking under a ladder or letting a black cat cross your path gives you bad luck; wearing your lucky socks will help your team win; not forwarding those emails about love or friendship will give you bad luck. These superstitions often arise out of our desire to control reality. If you win a game, you might begin looking for some cause that you can use to help you win the next game. "It just so happens that I wore my red socks today; that might be the reason we won!" If you win the next game wearing the same socks, you might be tempted to think the superstition is confirmed and that wearing your red socks causes you to play better.

But it should be clear that just because one event regularly precedes another doesn't mean the first event causes the second. This is a fallacious inference known as *post hoc, ergo propter hoc* (after the fact, therefore because of the fact). For example, in typing this book, we regularly place consonants just before vowels. We do it quite often; perhaps more often than not. But even if we do, that is no indication that typing consonants is causally related to typing vowels. Similarly, traffic signals turning red are often followed by stopping cars. But surely no one would believe that red lights cause cars to stop. At best, the reason people stop at red lights is that there are laws requiring them to, and people do not want to be fined for refusing to stop. Therefore, that event *A* occurs before event *B* does not imply that *A* caused *B*. To determine whether *A* caused *B*, we need more information, which we will talk about in the next chapter.

## Mistaking Coincidence for Causation

We just noted that we should not think that simply because one event precedes another that the first causes the second. But what about events that seem to occur together in clusters? Many of us have learned a new word or have begun thinking about a vacation only to suddenly begin hearing the word or the destination very frequently. It seems an amazing coincidence that, after learning the word, "kibosh," Jamie began hearing it practically everywhere: on television, in a book, in a conversation at the next table in a restaurant. Surely, learning the word doesn't cause all these instances. And there's no reason to think the "universe" (or some other mysterious force) is talking to us. In fact, there are some good explanations for why these coincidences happen that are not mysterious at all.

Of course, surely, there is *some* causal force at work. And as it turns out, there is. The phenomenon of encountering something repeatedly after learning it or recognizing it for the first time is known in psychology as the *Baader-Meinhof Phenomenon* or the *frequency illusion*. These are versions of a tendency to ascribe meaning to an otherwise coincidental set of events, a tendency called *synchronicity*. For example, if you are planning a big life-changing move across country, you will likely start to notice references to that place on billboards or on television or in songs. The explanation is that, because the move is significant for you, your mind is *primed* to recognize anything associated with that place in a way that it wouldn't normally be.

Synchronicity is a causal process, but this is not the sort of cause we typically attribute in cases like these. We are often tempted to think there is something *intentional* behind them, that fate or God is trying to tell us something, or that someone is speaking from beyond the grave.

But coincidences are a regular part of all our lives, and there is little reason to believe that any particular causal force is at work to bring them about. The mistake is in thinking that because some events are improbable, then some independent causal force must be at work to bring them about. But it is not obvious that this is the case. Consider this: Probabilities are calculated either by counting past occurrences of events (on average, boys have performed better in college than in high school) or by identifying the disposition of an object to act a certain way (a fair, two-sided coin will land heads about 50 percent of the time). These probabilities help us reason about objects, but they do not dictate precisely how an object will act.

For example, imagine flipping a quarter fifty times and writing down the result each time. You might discover that one segment of your results looks like this:

H T H H T T H T H T H H H T T T T T T T T T T T T T T T T T H H T

Notice the long string of tails in the middle. Since the probability of a coin landing heads is around 50 percent every time you flip it, this result is unexpected and the probability that it would happen if we flipped another fifty times is very low. Nevertheless, there is no reason to believe there are any causal forces at work beyond the act of flipping the coin. For any string of flips, any particular pattern could occur, each fairly improbable when compared with the tendency of a coin to land heads about 50 percent of the time. The same goes for drawing letters out of a bag of Scrabble letters. Drawing any *particular* long string, like this one

a o e k p e n l d z e n r b d w p d i u t h e q n

is very improbable, though no causal forces need be introduced to explain them. If a highly improbable event can be explained without appealing to extra mechanisms, it is reasonable to do so. This is a reasoning principle known as "simplicity," or "Ockham's Razor," which we will discuss in more detail in Chapter 9. The basic idea is this: Do not introduce more explanations than are absolutely necessary.

How might we know when a highly improbable event needs an additional explanation? Causal factors become more plausible when low probability is combined with some other feature, say "specificity," that is, something that appears to serve a unique purpose. Notice in the string of letters above, you can find two English words: *pen* and *the*.

a o e k **p e n** l d z a n r b d w p d i u **t h e** q n

Are these special? Not likely, the chances of two, short words with no particular significance is not very interesting.

Consider, on the other hand, a different string of letters drawn from a Scrabble bag:

f o u r s c o r e a n d s e v e n y e a r s a g o

This particular string is no more or less probable than the above string (it has the same number of letters), but there is something unique about this string. It appears to have a purpose that the former string does not, namely to communicate in English the first six words of the Gettysburg Address. If we drew these letters in this order from the Scrabble bag, we should probably suspect that something fishy has happened. Why? It is not simply because the probability is low, but because there is something peculiar about this low probability order—it means something in a way that few other low probability orders could. This sort of special meaning is called *specificity*. So, coincidence or low probability alone is not enough to make a causal judgment. When *low probability* is combined with *specificity*, you have at least a *stronger* reason to believe there is a particular causal force at work.

Mistaking coincidence for causation has been motivated a host of new age religious ideas that seek to explain coincidence in terms of supernatural causal forces. We found the following paragraph from www.crystalinks.com using a random online search for "synchronicity":

> We have all heard the expression, "There are no accidents." This is true. All that we experience is by design, and what we attract to our physical world. There are no accidents just synchronicity wheels, the wheels of time or karma, wheels within wheels, sacred geometry, the evolution of consciousness in the alchemy of time.

Unfortunately, this set of claims is not supported by any philosophical argument or scientific evidence. The idea seems to be that, simply noticing the "coincidences" in nature will help you achieve a higher spiritual consciousness. How could we test the claim that there are no accidents? If, in fact, there are no accidents, how might we know what an "accident" is in the first place? How could we identify any particular event that is not an accident? Further, it is unfortunate that the writer of this paragraph say that everything is "synchronicity," which is the *error* of ascribing meaning to the sorts of accidental correlations that happen all the time. If our arguments above are correct, and there is good evidence that coincidence does *not* imply causation, this paragraph is nonsense.

## Getting familiar with … causal arguments

**A. Complete each of the following arguments by supplying a causal claim for the conclusion.**

**1.**

1. I have let go of this pen 750 times.
2. Every time, it has fallen to the floor.
3. Thus, …

**2.**

1. As I press the gas pedal on my truck, it accelerates.
2. As I release the gas pedal, the truck decelerates.
3. Therefore, …

**3.**

1. In the past, when I thought about raising my arm, it raised.
2. So, …

**4.**

1. On the mornings I drink coffee, I am more awake than on the mornings I drink nothing.
2. Similarly, on the mornings I drink black tea, I am more awake than on the morning I drink nothing.
3. But on the mornings I drink milk, I am not more awake than drinking nothing.
4. Therefore, …

**5.**

1. The label says gingko biloba increases energy.
2. I have taken gingko biloba every day for two months.
3. I notice no increase in energy.
4. Thus, …

**B. Explain whether each of the following is a *causal argument* or an *explanation*.**

1. The window is broken, and there is a baseball in the pile of glass. Therefore, the baseball probably broke the window.

2. The window broke because the baseball was traveling at a velocity high enough to break the chemical bond holding the molecules of glass together.
3. The sun rises every morning because the Earth rotates on its axis once every twenty-four hours. As it turns toward the sun, we experience what we colloquially call "the sun's rising."
4. He got sick for three reasons: he was constantly around sick people; he never washed his hands; and he was always touching his face.
5. He ran off the road because the cold medicine made him drowsy. Running off the road caused him to hit the lamppost. The lamppost caused the head trauma. Thus, driving while on cold medicine can lead to serious injuries.

**C. Explain the mistaken identification of causation in each of the following examples. Give an explanation of what might really be happening.**

1. "I flipped five tails in a row. That's highly improbable! The universe must be telling me I need to go to Vegas."
2. "After each Alcoholics Anonymous meeting, I crave hamburgers. Those meetings are going to make me fat."
3. "There is a strong positive correlation between being poor and being obese. This tells us that poverty causes obesity."
4. "Every night, just after I sit down to eat, I get a phone call. I don't understand why the universe is treating me this way."
5. "I see the same woman in the elevator every morning. And we take the same bus into town. Fate must be trying to put us together."

## Exercises

**A. Construct either an *inductive generalization* or an *argument from analogy* for each of the following claims (i.e., regard each of the following claims as the conclusion of an argument; come up with premises to support these claims).**

1. "The next mallard we see will have a white stripe on its neck."
2. "I bet the next car we see will be blue."
3. "That cop will probably hassle us."
4. "That shirt is not likely to fit you."
5. "This car won't be better than any of the others."
6. "All politicians are the same."
7. "Probably all rock musicians use drugs."
8. "I think all professors grade too hard."
9. "You know as well as I do that frat boys cheat on their girlfriends."
10. "Everyone lies."

**B. For each of the following generalizations, explain whether it is biased or disproportionate.**

**1.**

1. We interviewed 1% of Londoners, and the vast majority approve of the prime minister's job performance.
2. Therefore, probably all England approves.

**2.**

1. Both students I asked said they would rather have a different lunch menu.
2. I agree with them.
3. Therefore, probably the whole school would agree.

**3.**

1. Almost everyone I know believes smoking cigarettes is unhealthy.
2. Also, the editors of this magazine say it is unhealthy.
3. Thus, almost everyone nowadays believes smoking is unhealthy.

**4.**

1. We gave our product to members of 150 fraternity houses across the nation.
2. 85% of fraternity men said they like it and would use it again.
3. Therefore, probably 85% of people would like our product.

**5.**

1. This whole grove of ponderosa pine trees has developed disease X.
2. Probably, all ponderosas are susceptible.

**C. Construct an argument from analogy for each of the following claims.**

1. "You have a cold, just like everyone else in the dorm."
2. "I bet you'll have as many problems with this car as you did with your last."
3. "The new mp3 player from Mac will be better than the one that came out last year."
4. "You will look great in that dress, just like she does."
5. "You are going to have a terrible hangover."

**D. Explain why each of the following arguments from analogy is weak, by explaining whether there are more dissimilarities than similarities between the compared objects or events, or whether**

**the similarities are not relevant to the feature in the conclusion, or both.**

**1.**

1. Our college has a basketball team, a sports arena, and two head coaches, and we're number 1 in the nation.
2. Your college has a basketball team, a sports arena, and two head coaches.
3. Therefore, your college is probably also number 1 in the nation.

**2.**

1. That guy is 6'1" tall, has brown hair, was born in Tennessee, and has cancer.
2. I am 6'1" tall, have brown hair, and was born in Tennessee.
3. So, I probably have cancer.

**3.**

1. That object is round, inflatable, white, and used for volleyball.
2. This object is round, inflatable, and striped. (weather balloon)
3. It follows that it is probably used for volleyball.

**4.**

1. Last semester I took a philosophy course with Dr. Arp in room 208 and it was super easy.
2. The philosophy class Dr. Arp is offering next semester is also in room 208.
3. This implies that that class will be super easy, as well.

**5.**

1. The last book I read by that author had a male protagonist.
2. That book was over 600 pages and terribly boring.
3. Her new work also has a male protagonist and is at least as long.
4. Therefore, it will probably be terribly boring.

**E. Construct a causal argument for each of the following claims. Come up with imaginary evidence if you need to, but make sure it is relevant to the conclusion. You may construct it as an enumerative induction, generalization, or analogy, but be sure Mothere is a causal claim in the conclusion.**

1. Turning the ignition on my car causes the engine to start.
2. Taking aspirin cures my headache.
3. Just seeing me causes my dog to get happy.

4. Drinking coffee makes my heart race.
5. As a bee moves from flower to flower, it pollinates the flowers.

**F. Explain the mistake made in each of the following arguments, by explaining whether the argument mistakes correlation for causation, mistakes temporal order for causal order, or mistakes coincidence for causation.**

**1.**

1. Every time I have worn this ring, my choir performances are excellent.
2. Therefore, this ring is responsible for my excellent performances.

(So, I'm definitely wearing this ring during the next performance.)

**2.**

1. I always get nervous just before I go on stage.
2. So, nervousness causes me to perform publicly.

(In that case, I should definitely stop getting nervous, so I won't have to perform.)

**3.**

1. That girl is here at the library every time I come in.
2. She must be interested in me.

**4.**

1. The last three times I played golf, my knee hurt.
2. And today, while playing golf, my knee is hurting.
3. Golf must cause knee problems.

**5.**

1. As it turns out, people who write a will tend to live longer.
2. Hence, writing a will leads to long life.

(So, if you want to live longer, you should probably write a will.)

**6.**

1. Acne increases significantly from age 10 to age 15.
2. So, aging must cause acne.

**7.**

1. Every time Dr. Watson teaches a class, someone fails.
2. Therefore, Dr. Watson's teaching leads to failures.

**8.**

1. I see the same woman at the traffic light on my way to work every morning.
2. Therefore, fate has determined that we should be together.

**9.**

1. Every time I let the dog out, he uses the bathroom.
2. So, maybe if I stop letting him out, he'll stop using the bathroom.

**10.**

1. Interestingly, religious belief seems to decline with the number of academic degrees a person has.
2. Thus, education causes atheism and agnosticism.

## Real-Life Examples

# 1. The Ouija Board

**a. Consider the following case:** Two girls, Brittny and Chloe, are playing with a Ouija board. Chloe asks whether she will get into a good college. The girls place their hands on the planchette and concentrate. Surprisingly, the planchette seems to move on its own, directing the girls' hands to "Yes" on the board. Chloe sighs with relief, concluding that she will, in fact, get into a good college.

- Give reasons for thinking this may not be a case of supernatural causation.

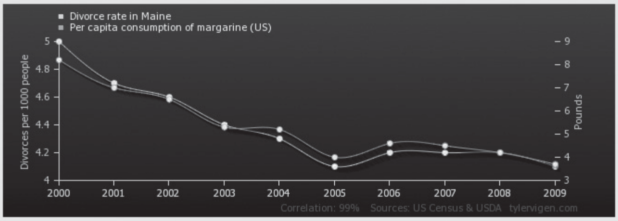
**b. Consider this modification of the previous case:** Instead of asking about colleges, Chloe asks the name of the boy she will marry. Again, they place their hands on the planchette and concentrate. The planchette begins moving over the letters on the board, spelling out B-R-A-D. Chloe blushes. As it turns out, there happens to be a boy in her school she likes named Brad. On this evidence, she begins thinking about how to ask him to take her to the prom.

- Give reasons for thinking this may not be a case of supernatural causation. What else might explain these eerie results?

# 2. Correlation and Causation

**Consider the following negative statistical correlation from the website Spurious Correlations, tylervigen.com (reproduced under a CC BY 4.0 license):**

Divorce rate in Maine
correlates with
Per capita consumption of margarine (US)




| | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 |
|---|---|---|---|---|---|---|---|---|---|---|
| *Divorce rate in Maine* *Divorces per 1000 people (US Census)* | 5 | 4.7 | 4.6 | 4.4 | 4.3 | 4.1 | 4.2 | 4.2 | 4.2 | 4.1 |
| *Per capita consumption of margarine (US)* *Pounds (USDA)* | 8.2 | 7 | 6.5 | 5.3 | 5.2 | 4 | 4.6 | 4.5 | 4.2 | 3.7 |
| **Correlation: 0.992558** | | | | | | | | | | |

Permalink - Mark as interesting (1,565) - Not interesting (367)

1. **What can we conclude, if anything, from the multi-year correlation between divorce and margarine consumption in Maine?**
2. **Imagine that reducing margarine intake doesn't save marriages (or vice versa … whatever that might mean). What else might explain this strange correlation?**
3. **If we do not trust this correlation (or any others on the Spurious Correlations site), why might we trust any statistical correlations? What features might make a correlation reliable evidence for identifying a cause?**

# Scientific experiments and inference to the best explanation

9

**We explain the basic structure of scientific reasoning and how explanatory arguments work. We introduce the concepts of *observation*, *hypothesis*, and *test implication*, explain how to distinguish *control* and *experimental* groups, and discuss standard types of formal and informal experiments along with their strengths and weaknesses. We also discuss an argument strategy known as *inference to the best explanation* that can help us identify the most plausible explanation among competing explanations.**

## Testing Causal Claims

Causal claims are often used to identify the event or object that brought about another event. Why did that bush move? What makes chameleons to change colors? How did the victim die?. Causal claims answer these questions differently than explanations. Whereas explanations attempt to account for the truth of the claims, causal claims attempt to pinpoint the cause behind the explanation: a bird landed in that bush, *causing* it to move; chemicals in chameleons' blood *cause* cells called "chromatophores" to activate various pigment cells; cyanide poisoning *caused* the victim to die.

In the previous chapter, we explained how inductive arguments can be structured in different ways: generalization, analogy, and causal arguments. We discovered that many of the weaknesses of generalizations and analogies can be overcome if we add a causal component to the argument. But then we discovered a set of problems for causal arguments. Even if an inductive argument for a causal claim is strong, we may still mistake irrelevant factors (e.g., correlation, temporal order, or coincidence) for causal factors. Even good inductive arguments with strong correlations cannot always help us identify the relevant cause of an event.

To remedy this problem, philosophers and scientists have devised a number of clever methods for identifying causes, distinguishing them from irrelevant events. The foremost strategy among these is the *experiment*. An **experiment** is a method of testing causal claims by holding certain features of an event fixed (the controls), observing any changes in the object or event of interest (the variable), and then reasoning inductively from the results to a conclusion about why the variable changed (the cause). Experiments help philosophers and scientists rule out events that are irrelevant to the event they are trying to understand.

Experiments may be scientific, conducted in labs, using a variety of physical instruments. They may also be philosophical, or "thought experiments," conducted using hypothetical examples and case studies. The results of scientific experiments are evaluated using our sense faculties, while the results of thought experiments are evaluated using the rules of logic and mathematics or our rational intuitions to evaluate the possibility/impossibility or plausibility/implausibility of a particular claim. These results are then formulated into claims that are used as evidence in an argument.

Both scientific and thought experiments can be "formal," in which extensive care is taken to control for and reduce bias. Formal scientific methods often use complicated equipment and strict methodologies. Formal philosophical methods often rely heavily on deductive reasoning forms, including complex logic or mathematics.

Scientific and thought experiments can also be "informal." This means philosophers and scientists use a series of heuristics, or rules of thumb, to eliminate less plausible causal claims and to increase our confidence in either one causal claim or a small pool of causal claims. Informal methods are often used when less evidence is available or because gathering evidence would be impractical. In this chapter, we will discuss formal and informal scientific experiments.

## The Structure of a Scientific Experiment

Imagine coming across some event you want to understand better. It may be the changes in ocean tides, the phases of the moon, the changing colors of a chameleon, your little sister's choice in boyfriends, whatever. Let's label whatever it is "O," for "observation." In order to understand *what causes* O, you will need to devise some claim that, *if true*, would account for O's happening (i.e., something that would tell us why or how O happened). That claim is your **hypothesis**, which we'll label "H."

A hypothesis, perhaps contrary to what you have heard, is not simply an "educated guess." It *can* be an educated guess, but it can also be something more helpful. *A hypothesis is a claim that counts as a reason to expect some observation.* For our purposes in this chapter, our hypothesis will be *causal claims*. If H is true, we would expect to find O. H is *at least* a causal indicator of O, and, if we've chosen H carefully and tested it well, we might learn that it is *the* cause.

What's the difference between a "causal indicator" and a "cause"? Think about it this way: Some events happen together even when one doesn't cause the other. People who drive sports cars are more likely to get speeding tickets than people who don't. Now, driving a sports car doesn't (directly) cause people to get more tickets. And there may be a lot of reasons why it happens. Maybe cops are more likely to watch sportier cars, or maybe sports car enthusiasts have a certain "need for speed." Whatever the reason, one explanation for why some people get more speeding tickets than others (observation) is that they drive sports cars (causal indicator). Causal indicators are very common in medicine. For example, Black patients are at higher risk of hypertension, and white men are at higher risk of heart disease. There's nothing inherent about being Black or white that causes these risks, rather, they are the result of a long history of social circumstances.

The only restriction on formulating a hypothesis is that it must be *testable*. A hypothesis can be about Santa Claus or protons or hobbits, as long as there is something that could serve as evidence for its truth. Is Santa real? If so, then we would likely expect to hear a sleigh land on our roof at some point during the night or to find sooty footprints on the carpet. Maybe he would show up on a motion-sensor video camera we secretly set up. These are tests we can run—*experiments*—even if Santa isn't real. If we do not hear hoofs or see sooty footprints, we have some reason to believe Santa didn't come, and therefore (since we already know we have been especially good this year), Santa is not real.

Of course, this experiment may not be a good one: Santa may have magic dust that allows reindeer to land silently and prevents his boots from getting sooty. But the point is, for a claim to be scientific, there must be some observable indicator we could expect if Santa were real. If that observable event happens, we have some reason to believe he exists. If that observable indicator does not happen, we have some evidence that he doesn't. This is true for real things, too. There must be something that the flu virus does such

**Figure 9.1** Simple Experimental Models

| The Simple Model of Confirmation | The Simple Model of Disconfirmation |
|---|---|
| 1. If H, then I. | 1. If H, then I. |
| 2. I. | 2. It's not the case that I. |
| 3. Therefore, probably H. | 3. Therefore, probably not H. |

that, if we never found it, we could conclude that the flu virus doesn't exist. Perhaps there is some other disease that we have been mistakenly calling "influenza" all these years.

## Simple Models of Confirmation and Disconfirmation

Let's keep thinking about Santa. Imagine waking up on Christmas morning and finding a glittering array of toys. Let O be, there are toys under the tree. Now imagine asking yourself, "Did Santa bring these toys?" How might we test the hypothesis: *Santa brought these toys* (H)? There is a classic set of experimental models for testing hypotheses that serve as a useful introduction to experiments. These are called the **simple models of confirmation** and **disconfirmation**.

To set up the models, it would not do to reason this way: If H is true, then O occurs (If Santa brought these toys, then there are toys under the tree). H presupposes O, but not vice versa, so O doesn't tell us anything about whether H is true. We already know O occurs; we want to know whether H causes O. For that we need an *independent* test, something else that is true if H is true. We call this independent even a **test implication**, and represent it as "I." With these terms in place, our models look like this (Figure 9.1).

As we mentioned above, if Santa brought these gifts, then one implication is that we heard hoofs on the roof last night (I). Filling in the variables, our experiment looks like this:

**Santa Test**

1. If Santa brought these gifts, then we would have heard hoofs on the roof last night.

| | |
|---|---|
| $2_1$. We heard hoofs on the roof last night. | $2_2$. We did not hear hoofs on the roof last night. |
| $3_1$. Therefore, Santa brought these gifts. | $3_2$. Therefore, Santa did not bring these gifts. |

If H is true, I is what we would expect to find. So, if we discover that I is true, H is confirmed, and if we discover that I is false, H is disconfirmed.

What does it mean to say that a hypothesis is *confirmed* or *disconfirmed*? Does it mean it is definitely true or definitely false? Unfortunately, no. It is important to treat both models as *probabilistic*, and therefore, *inductive*. This is straightforward for the simple model of confirmation, since it is invalid. It commits the formal fallacy of "affirming the consequent" (see Chapter 6 for more on formal fallacies). However, this argument form is useful as an inductive form because it *increases the probability* that H is true, even if H doesn't follow with necessity.

Recall the following claim from an earlier chapter: If it rains, then the sidewalk is wet. If we learn that the sidewalk is wet, we cannot draw any *valid* conclusion as to whether it is raining. Someone could have turned the sprinkler on or have washed the sidewalk with a pressure washer. Nevertheless, learning that the sidewalk is wet increases (albeit very slightly) the probability that it is raining. This is because it is evidence that *some wet-making event* occurred. Since rain is a wet-making event, it is more likely that it rained than if the sidewalk weren't wet.

Treating the simple model of disconfirmation as inductive is less straightforward. This model *seems* to express the deductive argument form *modus tollens* (see Chapter 6). If this is right, the argument is valid; if the premises are true, the conclusion must be, and we know for sure that the hypothesis is disconfirmed. In deductive logic, we have the privilege of assuming the premises are true. The problem is that, with causal arguments, we do not know H's relationship to I; that is the very relationship we are interested in. We're posing a sort of guess based on what we already understand about the situation. Further, H may not imply I in every case or under every condition even if H is true most of the time. Consider the case of the pain-relieving drug Tylenol.

Most of us are comfortable with the belief that Tylenol relieves pain, that is, we believe that the primary medicine in Tylenol, acetaminophen, *causes* a reduction in pain. Nevertheless, there are times when Tylenol just doesn't seem to work. In these cases, we would have model of disconfirmation that looks like this:

1. If (H) Tylenol relieves pain, then (I) taking Tylenol will relieve my headache.
2. <u>(Not I) Taking Tylenol did not relieve my headache.</u>
3. Therefore, (not H) Tylenol does not relieve pain.

Both premises seem true and the argument is valid, and yet the conclusion seems false. What has happened?

The problem is that reality is more complicated than our original hypothesis (or even our seventh or fifteenth). In any experiment, there are sometimes *hidden variables*, or features of reality we weren't originally aware of, that are relevant to our hypothesis. For instance, there may be conditions under which Tylenol just doesn't work, whether for a specific kind of pain (there are many) or because of person's body chemistry. This, however, doesn't mean that it doesn't relieve pain in most instances. There are just a limited number of times that it doesn't, for instance, neurologic pain. Sometimes we can identify these cases and make our hypothesis more precise (e.g., If H under conditions $C_1$, $C_2$, and $C_3$, then I). We can also make I more specific: "Tylenol will relieve the pain from a small cut." Other times we must rest content with the probability that it will relieve pain given the vast number of times it has in the past. The problem of hidden variables explains why even disconfirmation must be treated inductively and why many experiments must be conducted before we are justified in claiming that a hypothesis is confirmed or disconfirmed with high probability.

A further problem is that we might simply have chosen the wrong test implication. It may not be that H is false, but that H doesn't imply I. Consider our Santa case. If Santa has magic dust that dampens the noise from reindeer hoofs, then Santa could have brought the gifts even though we didn't hear hoofs during the night.

Because of these problems, we cannot evaluate models of confirmation and disconfirmation in deductive terms. We must treat them probabilistically. We call those cases where Tylenol does not relieve pain *disconfirming evidence*—a reason to believe it doesn't relieve pain. But one test is not the final word on the matter. Once we've run several dozen tests, if the number of times it relieves pain significantly outnumbers the times it doesn't, then our total evidence is *confirming*: we have a reason to believe it is highly likely that Tylenol relieves pain.

We can now state our definitions of confirmation and disconfirmation clearly:

**Confirmation:** evidence that a causal claim is true
**Disconfirmation:** evidence that a causal claim is false

Neither confirmation nor disconfirmation is conclusive. A hypothesis can be confirmed by all available evidence for a long time, and then, upon discovering new contrary evidence, it can be disconfirmed. Or a previously disconfirmed hypothesis can, upon discovering new evidence, be confirmed. This is why multiple trials are so important for testing new drugs, as we will see in the next section.

# Complex Models of Confirmation and Disconfirmation

Since we know a number of ways experiments can go wrong, philosophers and scientists have found it helpful to state explicitly as many assumption as possible in the models of confirmation and disconfirmation. Consider the case of testing a new headache medicine. Our hypothesis is that drug X relieves headaches. There are two big ways an experiment on drug X can go wrong even if drug X works.

First, when we conduct an experiment, we make a number of assumptions about the way the world works—other scientific claims that have to be true in order for this particular experiment to work. For example, that the coating on drug X is inert (has no affect on headaches) and that drugs can enter a person's system through ingestion. Call these assumptions about science **auxiliary hypotheses**. Second, our experiment can go wrong because of the conditions under which the experiment takes place. For instance, the temperature could affect the results, the sample could be biased, and the measuring instruments could malfunction. Call these experimental conditions **initial conditions**.

If something goes wrong with our auxiliary hypotheses or initial conditions, the results of our experiment may not tell us anything about how good our hypothesis is. In order to make these explicit and mitigate their damage, we need to update our experimental models. Instead of the simple models of confirmation and disconfirmation, we will switch to the complex models, in which we list the auxiliary hypotheses and initial conditions alongside our hypothesis (see Figure 9.2).

Of course, including these complicating features has an important effect on the probability of H. We cannot be sure whether our test has revealed results about H as opposed to AH or IC. In order to rule them out and increase the likelihood that we have really tested H, we need to devise some experimental models that include certain types of *controls*. An experimental control is a way of holding our assumptions (AH and IC) fixed while we test

**Figure 9.2** Complex Experimental Models

| The Complex Model of Confirmation | The Complex Model of Disconfirmation |
|---|---|
| 1. If (H & AH & IC), then I. | 1. If H, then I. |
| 2. I. | 2. It's not the case that I. |
| 3. Therefore, probably (H & AH & I). | 3. Therefore, probably not (H & AH & IC). |

H. They are not foolproof, and we often cannot control for very many of them. But science's powerful track record suggests that we do a fairly good job of testing the relevant hypothesis. To see how these work, we will look at a set of *formal* and *informal* experiments.

## Getting familiar with … confirmation and disconfirmation

**A. For each of the following observations and causal claims, construct a simple experimental model.**

1. "I have allergic reactions. Shellfish probably causes them."
2. "I often have headaches. I think they are from too much stress."
3. "Many people have allergic reactions. I bet they are all caused by eating shellfish."
4. "I'm a pretty happy person. But I dance a lot. I bet that's what does it."
5. "I cannot sleep at night. I probably drink too much tea."

**B. State two *initial conditions* and at least one *auxiliary hypothesis* that might affect the results of experiments on these hypotheses.**

1. Ethanol makes gasoline less efficient.
2. Drinking milk twice per day increases cancer risk over a lifetime.
3. Eating a lot of cheese and beer raises bad cholesterol levels.
4. Texting and driving causes car accidents.
5. Changing time zones causes jet lag.

**C. Short answer.**

1. Explain the limitations of simple models of confirmation and disconfirmation.
2. Explain some reasons why models confirmation and disconfirmation cannot be treated deductively.
3. Come up with two examples of an observation and a hypothesis. Construct a simple experimental model for each.
4. Explain the concept of a "hidden (or confounding) variable" and give some examples. Do some online research if you need to.
5. Based on your understanding of this chapter and the last, why are experiments so important for causal arguments? (We will ask this question again in the exercises at the end of this chapter. So, even if you don't feel competent to answer it well here, keep it in mind as you read through the remainder of this chapter.)

## Formal Experiments

Because of their subject matter (and because they often receive more research money than philosophers!), scientists have the luxury of conducting formal experiments. Formal experiments are highly structured experimental procedures that help us control for as many assumptions as possible. When you think of a laboratory experiment, you are thinking of a formal experiment. But formal experiments can include careful observation in the field, surveys and polls, and comparing data from a set of experiments. They are typically constructed on one of three models:

1. **Randomized Experimental Study**
2. **Prospective Study**
3. **Retrospective Study**

### Randomized Experimental Study

A randomized experimental study is widely considered the best experiment for testing causal claims. This type of test gives researchers an enormous amount of control over the experimental process, and, with enough time and money, these experiments yield a lot of useful data.

Consider the following example. Imagine we want to discover the effects of taking Emaci-Great, a new experimental diet pill, over a twelve-month period. Researchers decide that, if the pill works, participants should lose around twenty pounds over a twelve-month period. In a randomized experimental study, researchers choose subjects that meet certain conditions to comprise the test population. In this case, they need participants who need to lose weight. Let's say they choose people twenty-five to thirty-five years old who are at least 20 lbs overweight.

To conduct the study, researchers divide the test population into an "experimental group" and a "control group." This is the first step in a *double-blind experiment*. The first blind is that the participants do not know which group gets the drug and which gets an innocuous substance called a "placebo," which is typically a water pill. This helps to mitigate one potentially confounding problem with our initial conditions called the *placebo effect*, a psychological phenomenon that affects some people who believe they are getting the real drug and will get results. In some cases, patients who are given a pill, regardless of what the pill is, experience (to a small degree) the effects they assume the experimental drug has. Administering a placebo to the control group cancels out this effect in the experimental group.

The second blind is that the researchers evaluating the data do not know which participants received the drug and which the placebo. This helps to cancel *confirmation bias*, which is a psychological phenomenon in which researchers will conclude that some dataset confirms their desired hypothesis, even though the data is quite ambiguous or inconclusive.

The hypothesis is: Emaci-Great causes weight loss. The test implication should be something specific and restricted to the practical constraints on gathering a population. So, researchers might formulate the test implication: subjects between the ages of twenty-five and thirty-five, and who are at least 20 lbs overweight, will lose at least 10 lbs over a two-month period. Plugging these into our simple models, we can see clearly how to confirm or disconfirm our hypothesis:

1. If (H) Emaci-Great causes weight loss, then (I) subjects between the ages of twenty-five and thirty-five, and who are at least 20 lbs overweight, will lost at least 10 lbs over a two-month period.

| **Either I…** | **or not I…** |
|---|---|
| 2. subjects between the ages of twenty-five and thirty-five, and who are at least 20 lbs overweight, lose at least 10 lbs over a two-month period | 2. subjects between the ages of twenty-five and Thirty-five, do not lose at least 10 lbs over a two-month period. |
| **Therefore, either H is confirmed and…** | **or H is disconfirmed and…** |
| 3. Emaci-Great causes weight loss. | 3. Emaci-Great does not cause weight loss. |

The results of the double-blind experiment are then evaluated. If the experimental group lost significantly more weight than the control group, we have confirming evidence that Emaci-Great is an effective diet drug. If the experimental group did not lose much weight, or the results are inconclusive, researchers either start over with a new test population, or move on to a different drug.

In addition to the conditions of a double-blind experiment, researchers *control* for other factors that may affect weight loss by choosing participants from a range of demographics, such as varying lifestyles, diets, drug use (prescription and non-prescription), a range of ages, and genders. In a more complicated experimental model, we would include these explicitly as part of our initial conditions. Whatever inferences we draw from the research must be restricted by these factors. For instance, if we could not control for diet, then we cannot conclude the drug works no matter what people eat.

So, in a **randomized experimental study**, researchers (1) begin with a relevant population (in this case, obese adults); (2) randomly choose a control and experimental group; (3) introduce *X* (the alleged cause, in this case, Emaci-Great) to the experimental group, and introduce a placebo to the control group; (4) observe the groups over a specified time; and (5) compare the results with the relevant effect, *Y*.

## Strengths and Limitations of Randomized Studies

Unfortunately, this type of study requires a lot of resources, such as lab space, expensive technology, the drug, placebos, researchers' time, lab assistants' time, and participants' time. And since formal experiments depend heavily on how much money a corporation is willing to contribute or how much grant money is available, some experiments are simply impractical.

In addition, it is illegal to conduct some experiments, irrespective of whether there are moral implications. For instance, experimental studies on the effects of marijuana (in most states), firing a gun in public, and running stop signs would violate civil laws even if they were conducted under morally permissible circumstances.

And finally, randomized experiments can raise controversial moral issues. If, instead of a diet pill, researchers wanted to investigate the effects of heroin, a randomized experiment would require that they inject participants with heroin. But there is independent evidence that heroin has damaging effects that can be permanent or life-threatening, and it seems immoral (not to mention illegal) to place participants at that much risk. The same goes for testing the effects of smoking, fast food, post-traumatic stress syndrome, and biological weapons. As with heroin, there are also many legal restrictions motivated by moral considerations, such as experiments that cause pain or trauma. For examples of experiments the moral implications of which led to legal restrictions on animal testing, Google "Seligman learned helplessness"; on children, Google "little Albert experiment"; on adults, Google "Milgram experiment." If practical, legal, or moral limitations apply, researchers typically choose a different type of experimental study.

# Prospective Study

Let's say that Emaci-Great includes an ingredient that is controversial in the researchers' country, so the government agency in charge of such things would not approve tests on Emaci-Great. There is another country where the drug is legal and used regularly, but it would cost far too much to conduct a randomized study in that country. So, for practical reasons, researchers choose a prospective study.

Researchers begin by gathering a group of people that meet the control conditions for weight, diet, age, and so on, and who also already use the main ingredient in Emaci-Great. This is the experimental group. They then match the experimental group with a group that is similar in control conditions (weight, diet, age, etc.), but that *does not* use the main ingredient in Emaci-Great. This is the control group. Researchers then watch the participants over a specified period of time and evaluate whether there is greater weight loss in the experimental group than in the control group.

In this type of experiment, participants obviously know whether they are taking the ingredient, so the placebo effect cannot be controlled for. However, researchers can let their assistants choose the groups and record the data so that the researchers can evaluate the results without knowing which participant was in which group. This is known as a *single-blind experiment.* The researchers are blind, even though the participants are not. In some cases, even single-blind experiments are impractical. For instance, some psychologists use prospective studies to track the effects of abortion on anxiety. In cases, it may be difficult to identify relevant control groups under single-blind conditions.

The hypothesis is the same as in the randomized study: Emaci-Great causes weight loss. The test implication is also the same: subjects between the ages of twenty-five and thirty-five, and who are at least 20 lbs overweight, will lose at least 10 lbs over a two-month period. If the experimental group loses significantly more weight than the control group, we have strong evidence that Emaci-Great is an effective diet drug. If the experimental group does not lose much weight, or the results are inconclusive, researchers either start over with a new test population, or move on to another drug.

So, in a **prospective experimental study**, researchers (1) choose an experimental group with a relevant set of control factors (A, B, C, and D) plus the hypothesized cause, *X*; (2) match this group with a control group that has the relevant set of control factors (A, B, C, and D), but *not X*; (3) observe the groups over a specified time; and (4) compare the results with respect to the relevant effect, *Y*.

## Strengths and Limitations of Prospective Studies

Prospective studies avoid worries about the morality of an experiment, since they do not require researchers to administer a hypothesized cause that might potentially harm participants. They also tend to require fewer resources than randomized experiments. Nevertheless, there are a handful of limitations of these studies.

Researchers have far less control over the test population (both control and experimental groups). Participants are not administered the hypothesized cause, so if they forget or take a different dosage or change one of their control conditions (e.g., start drinking heavily or taking other drugs), the results may be affected. In addition, we have hypothesized that *X* is the relevant causal factor, but there may always be others that researchers unintentionally ignore or just aren't clever enough to recognize that may affect the results of the test. Any conditions, causes, or events that researchers cannot control, but that might affect an experiment's results, are called *confounding factors*. The possibility of confounding factors limit the strength of conclusions drawn from prospective studies.

## Retrospective Study

Imagine, now, that there are significant moral concerns about diet pills in general. Dozens of people taking a variety of diet pills, including participants in Emaci-Great studies, have developed severe stomach ulcers. Developers of Emaci-Great, concerned that the main ingredient of their product might be harming people, commission a study to determine the extent to which Emaci-Great is linked to the ulcers.

Researchers are commissioned to look back (hence "retrospective") over the lifestyles of people who developed ulcers and try to identify something they all have in common. In this type of experiment, the idea is to start from an *effect* instead of a cause, and, by controlling for a variety of factors, accurately identify the cause.

In this case, researchers choose an experimental group of subjects who both used to take diet pills and developed ulcers, controlling for various other factors, especially type of diet pill (along with weight, diet, age, etc.). They then match this group with a control group with similar control factors (type of diet pill, weight, diet, age, etc.) but *without* the ulcers. They then attempt to identify something present in the ulcer group not present in the non-ulcer group.

In this case, researchers begin with a test implication: many people who take diet pills develop ulcers. And instead of using their imaginations to develop a hypothesis, researchers begin looking for differences between the experimental group and the control group. If they discover an additional, non-diet-pill-related feature in the ulcer group (for instance, the experimental group also took large doses of ibuprofen), then diet pills, including Emaci-Great, would no longer be a moral concern. On the other hand, if researchers discovered a higher ulcer rate in participants who took diet pills with the main ingredient in Emaci-Great, then developers of Emaci-Great may need to pursue a different product line.

So, in a **retrospective experimental study**, researchers (1) choose an experimental group with a relevant set of control factors (A, B, C, and D) plus an *effect*, *Y*, that needs an explanation; (2) match this group with a control group that has the relevant control factors (A, B, C, and D), but *not Y*; and (3) look for something, *X*, that appears in the experimental group but not the control group that might explain *Y*.

## Strengths and Limitations of Retrospective Studies

Like prospective studies, retrospective studies avoid the morality problem associated with randomized studies. In addition, retrospective studies are useful when there is no known cause or clear hypothesis, or when a disease or cause is rare. For instance, a person may exhibit symptoms similar to the flu, but also develop fainting spells. Researchers can then gather data from patients with these symptoms and compare them with patients who simply had flu-like symptoms, then investigate the difference in diagnosis or genetic makeup of the disease. In this way, researchers can begin to narrow the possible causes of these symptoms.

But also like prospective studies, retrospective studies suffer from the problem of confounding factors. Not only may there be additional causes that researchers do not consider, for whatever reason, with no clear hypothesis, it is easier to misidentify causes. So, the problem of confounding factors may be even more worrisome for retrospective studies.

### Getting familiar … with formal experiments

**A. For each of the following causal claims, explain how you would set up a randomized experimental study. (i) Identify some relevant controls for your test group; (ii) explain a specific test implication; (iii) explain how you would conduct the experiment.**

1. Eating a bag of potato chips every day leads to weight gain.
2. Regular exercise lowers blood pressure.
3. Taking large doses of vitamin C reduces the duration of a cold.
4. Yoga increases your overall sense of well-being.
5. Drinking protein shakes after weight lifting increases strength.

**B. For each of the following causal claims, explain how you would set up a prospective study. (1) Identify some relevant controls for your test group. (2) Explain a specific test implication. (3) Explain how you would conduct the experiment.**

1. Smoking marijuana causes short-term memory loss.
2. Drinking soda raises cholesterol.

3. Chevy trucks are safer in accidents than other models.
4. Going to church makes you a better person.
5. Cigars are much less harmful than cigarettes.

**C. For each of the following observations, explain how you would set up a retrospective study to discover a relevant cause. (1) Identify some relevant controls for your test group; (2) explain how you would conduct the experiment.**

1. My allergy attacks have increased.
2. Chronic headaches.
3. An overall sense of well-being.
4. Students at school *A* score, on average, higher on their SATs than students at school *B*.
5. More white people are employed at company X than Black people.

## Informal Experiments

When formal experiments are not practical for identifying causes and evaluating causal arguments (because non-scientists rarely receive funding for experiments), there are a handful of informal experiments at our disposal. Philosopher John Stuart Mill (1806–1873) discovered five simple informal tests for causes. Because of their widespread influence, they have become known as **Mill's Methods:**

1. **The Method of Agreement**
2. **The Method of Difference**
3. **The Joint Method of Agreement and Difference**
4. **The Method of Concomitant Variation**
5. **The Method of Residues**

## 1. The Method of Agreement

One way to explain why some event, *E*, occurs is to identify a set of conditions or events that preceded *E* in a variety of cases, and then to identify one event that is common to each set. If there are a number of events that occur before *E* in each case, but only one common to all cases, the one they have in common is probably the cause. This is an informal variation on the retrospective study;

we begin with a test implication and look back over previous cases in order to identify a cause.

For example, imagine there are ten friends that regularly hang out at one another's apartments. One of the friends, Jan, begins sneezing violently at four of the friends' apartments. To investigate the cause, one of the friends, Brad, sets up the following argument:

1. Brad's house: Jan ate hot dogs, sat on shag carpet, pet Brad's cat, then began sneezing.
2. Dean's house: Jan ate hamburgers, sat on mohair couch, pet Dean's cat, then began sneezing.
3. Rachel's house: Jan pet Rachel's cat, ate quiche, sat on a wooden chair, then began sneezing.
4. Brit's house: Jan ate a soufflé, pet Brit's cat, then began sneezing.
5. <u>All cases of sneezing were preceded by Jan's petting a cat.</u>
6. Therefore, Jan is probably allergic to cats.

In this case, there is only one feature common to all the cases, that is, there is only one event on which all cases *agree* (hence, the method of "agreement"), and that is Jan's petting the cat.

The method of agreement has the following general form, though the number of cases may vary:

1. Case 1: Features A, B, C, and D preceded event E.
2. Case 2: Features B and C preceded event E.
3. Case 3: Features A and C preceded event E.
4. Case 4: Features C and D preceded event E.
5. <u>All cases of event E have feature C in common.</u>
6. Therefore, it is likely that C is the cause of E.

The method of agreement is limited to cases where there is only one feature that agrees among all the cases. If more than one feature agrees, you will need to use method number 3, The Joint Method of Agreement and Difference, to identify the cause.

## 2. The Method of Difference

Another way to explain some event, *E*, is to identify a set of conditions or events that preceded *E* and a similar set of events that did not precede *E*, and if there is only one feature present in the case where *E* occurs that is not present in the case where it doesn't, that feature is likely to be the cause. The Method of Difference is also similar to the retrospective study; we begin with an implication and look back over cases to identify a cause.

Consider Jan's sneezing, again. Imagine Brad had set up the experiment in the following way:

1. Brad's house on Monday: Jan ate hot dogs, sat on the shag carpet, pet Brad's cat, then began sneezing.
2. Brad's house on Friday: Jan ate hot dogs, sat on the shag carpet, but did not begin sneezing.
3. <u>Jan began sneezing only after she pet the cat.</u>
4. Therefore, it is likely that Jan is allergic to cats.

In the case, there is only one feature different between the days Jan visited Brad, that is, there is only one feature on which the cases differ (hence, the method of "difference"), and that is her petting his cat. Therefore, petting the cat is probably the cause.

The method of difference has the following general form, though, again, the number of cases may vary:

1. Case 1: Features A, B, and C preceded event E.
2. Case 2: Features A and B did not precede event E.
3. <u>Event E occurred only when C was present.</u>
4. Therefore, it is likely that C is the cause of E.

Like the Method of Agreement, the Method of Difference is limited to arguments where, when *E* is absent, there is only one feature that differs from cases where *E* is present. If more than one feature differs, you will need to use method number 3, to which we now turn.

## 3. The Joint Method of Agreement and Difference

When more than one feature of a case agrees or differs prior to some event *E*, it is helpful to combine the methods of agreement and difference. In order to explain some event, *E*, identify a set of cases in which multiple conditions or events precede *E*. If one event is present in cases where *E* occurs and absent in cases where E does not occur, that event is probably the cause of *E*.

Imagine things had happened slightly differently with Jan's sneezing. Let's say she began sneezing at the first two apartments, but not at the second two, and that the meals were similar. Brad could have set up the following informal experiment:

1. Brad's house: Jan ate hot dogs, sat on shag carpet, pet Brad's cat, then began sneezing.
2. Dean's house: Jan ate hot dogs, sat on mohair couch, pet Dean's cat, then began sneezing.
3. Rachel's house: Jan ate quiche, sat on a wooden chair, and didn't sneeze.
4. Brit's house: Jan ate hot dogs, sat on shag carpet, and didn't sneeze.
5. All cases of sneezing were preceded by Jan's petting a cat.
6. <u>In cases where Jan didn't pet a cat, Jan didn't sneeze.</u>
7. Therefore, Jan is probably allergic to cats.

This example is slightly trickier. Notice that we need both premises 5 and 6 in order to conclude that petting the cat caused the sneezing. This is because eating hot dogs was also present in both cases of sneezing. So, to conclude the relevant feature is the cat and not the hot dog, we need a premise that eliminates hot dogs. Premise 6 does this because it was also present in premise 4, but did not precede sneezing. Similarly, sitting on shag carpet preceded sneezing in one case, but not in another. The only event that occurred when sneezing was present and did not occur when sneezing was absent was Jan's petting the cat.

The Joint Method of Agreement and Difference has the following general form, though the number of cases may vary:

1. Case 1: Features A, B, and C preceded event E.
2. Case 2: Features A, C, and D preceded event E.
3. Case 3: Features A and B did not precede event E.
4. Case 4: Features B and D did not precede event E.
5. All cases of E were preceded by C.
6. <u>In cases where C was not present, E was not present.</u>
7. Therefore, it is likely that C is the cause of E.

## 4. The Method of Concomitant Variation

In some cases, causes come in greater or lesser frequencies, so it is not easy to identify a specific cause from a set of events. For instance, a drink with a small amount of caffeine may increase alertness only a small degree, while the same drink with a large amount of caffeine may increase alertness to the point of jitteriness. In this case, all the same features are present in all cases, only the amount of caffeine varies. In order to overcome this problem and identify the relevant cause of *E*, hold all but one of the conditions or events fixed, vary the frequency of the remaining condition or event, then evaluate the corresponding frequency of *E*. This is an informal variation on the randomized experimental study. We control for as many features as possible, and treat one of the events as a hypothesis, varying its frequency in order to evaluate its effects on the test implication, *E*.

Imagine that every time Jan visits Brad's house she eats hot dogs, sits on his shag carpet, pets the cat, and sneezes. But sometimes she sneezes much more often than others. What explains the difference in frequency of the sneezes? Brad could set up the following experiment to identify the cause:

1. Brad's house on Monday: Jan eats one hot dog, sits on the shag carpet for fifteen minutes, pets the cat twice, and sneezes four times.
2. Brad's house on Tuesday: Jan eats four hot dogs, sits on the shag carpet for thirty minutes, pets the cat twice, and sneezes four times.
3. Brad's house on Wednesday: Jan eats one hot dog, sits on the shag carpet for twenty minutes, pets the cat four times, and sneezes ten times.
4. Brad's house on Thursday: Jan eats four hot dogs, sits on the shag carpet for thirty minutes, doesn't pet the cat, and doesn't sneeze.
5. As the frequency of eating hot dogs or sitting on the carpet changes, the frequency of E remains constant.
6. As the frequency of petting the cat increases, the frequency of the sneezes increases.
7. As the frequency of petting the cat decreases, the frequency of the sneezes decreases.

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8. Therefore, the frequency changes in sneezing is caused by the frequency changes in petting the cat.

This example is more complicated, but if you read through it closely, you will see that, even though the frequency of eating hot dogs or sitting on the carpet goes down, the sneezing either remains the same or increases. However, the frequency of the sneezing goes up or down as the frequency of petting the cat goes up or down. This allows us to identify the cat as the cause, even though both of the other events were present in all cases.

The Method of Concomitant Variation has the following general form:

1. Features A, B, and C precede event E.
2. As the frequency of B and C are increased or decreased, the frequency of E remains constant.

3. As the frequency of A increases, the frequency of E increases.
4. As the frequency of A decreases, the frequency of E decreases.
5. Therefore, variations in E are probably caused by variations in A.

It is important that both premises 3 and 4 are present. This is because *E* may increase or decrease independently of *A*, *B*, or *C*, in which case, the increase in frequency of both *A* and *E* may be a mere coincidence. But if an increase or decrease in the frequency of *E* corresponds to an increase or decrease in the frequency of *A* (they vary "concomitantly"), then it is more likely that *A* causes *E* than that the correspondence is merely coincidental.

Though this is a more complicated argument form to explain, examples of concomitant variation abound. If a funny noise that your car is making gets louder as you press the gas and quieter as you release the gas, it is likely that there is a problem with the engine (or other component of the powertrain system), as opposed to a problem with a wheel or the battery or the fan, all of which operate independently of the gas pedal. Similarly, if an allergic reaction becomes more severe the more shellfish you eat, you are probably allergic to shellfish. And finally, if the academic quality of a school decreases as the population increases, it is likely that overcrowding is affecting the school's educational mission.

## 5. The Method of Residues

Sometimes an event is complex, and various features of that event have different causes. For example, the words on the page you are reading are a product of at least three groups: the authors, the editors, and the person who types the manuscript for print. Therefore, if there is a mistake in the content, it could be caused by any one of the three (though we poor authors always take the blame). If you discover a mistake and learn that it was not in the original manuscript given to the editor (which it probably would be in our case), and that it was not in the copy given to the person who types the manuscript for print, then the mistake was most likely caused by the last person in that chain. This is an example of the *method of residues*—identify all possible causes, eliminate those that didn't play a role in this case, and conclude that the cause or causes remaining are most likely responsible for the observation.

There is also another way to use the method of residues. Sometimes an event can be explained by multiple causes. If this is the case, it is important to have a test that will help us identify the right cause in a given case. For example, lung cancer can be caused by a number of events, including smoking, being around smokers, breathing coal dust, and genetics. If someone has lung cancer, we can attempt to identify which causes are present and which are absent. If we learn that lung cancer does not run in the family (so it is not likely genetic), the person doesn't smoke, and the person doesn't work in a coal mine, we might conclude that she probably works a job where she is constantly around smokers. In this case, like the one before, we identify all the possible causes, eliminate those that were not involved in this case, and conclude that the remaining cause or causes must be responsible for the observation.

For a more detailed example, consider, again, our allergy-prone friend, Jan. Let's say that her allergy attacks sometimes include more than just sneezing; in some cases, her eyes also water, and her skin itches terribly. Today, at Brad's house, Jan develops itchy skin, but no other allergy symptoms. Brad knows that her sneezing is caused by her petting his cat, and her eyes typically water when it is spring and there is lots of pollen in the air. To explain her itchy skin, Brad could set up the following informal experiment:

1. Jan's bad allergy attacks consist of sneezing, watery eyes, and itchy skin.
2. Itchy skin can be the caused by a pet allergy, a food allergy, or grass pollen allergy.
3. Exposure to cats causes sneezing, but not itching, so a pet allergy is not the cause.
4. Jan just ate hot dogs and has had no reaction to hot dogs in the past, so it is not a food allergy.
5. <u>Jan was sitting in the grass earlier.</u>
6. Therefore, the itching is likely the result of a grass pollen.

The method of residues has the following general form:

1. Event E is known to be caused by feature A, B, or C (or a combination of them).
2. <u>The relevant feature of E (or this instance of E) was not caused by A or B.</u>
3. Therefore, C probably caused the relevant feature of E (or this instance of E).

## Getting familiar with … informal experiments

**A. For each of the following informal experiments, explain which of Mill's Methods is being used.**

1. You get sick after eating lobster for the first time and conclude that it probably was the lobster.
2. "Why in the heck are there dead worms on the front porch for the past three weeks I have taken out the trash for trash collection on

Monday mornings," you think to yourself as you step over a dead worm to place the trash in the bin located in your driveway. Then, you remember that it had rained heavily for the past three Sunday nights, which you figure brought out many worms, that subsequently died on the porch because they could not get back to the soil.

3. Susan has to weigh her cat at the vet, but the cat won't sit still on the scale by herself. So, the nurse records Susan's weight first, which is 120 pounds. Then she has Susan and her cat step on the scale, notes that the scale now reads 130 pounds, and records the cat's weight as 10 pounds. Which of Mill's methods did the nurse utilize?
4. Al, Ben, and Courtney go out to eat for dinner and have the following:
   a. Al: chicken soup, spinach salad, soufflé, ice cream sundae
   b. Ben: chicken soup, mushroom soup, ice cream sundae, coffee
   c. Courtney: Soufflé, pie, tea

   Al and Courtney both get sick and vomit all night long. Why do you think so? And which of Mill's methods did you use to arrive at the conclusion?
5. Zoe sneezed every time she went into the basement. Her parents tried to figure out what was causing it by vacuuming, dusting, and scrubbing the floors, in various combinations, and having her go in the basement afterward. Zoe still sneezed, no matter if the basement was: vacuumed, but not dusted or scrubbed; dusted, but not vacuumed or scrubbed; scrubbed but not vacuumed or dusted; vacuumed and dusted, but not scrubbed; vacuumed and scrubbed, but not dusted; dusted and scrubbed, but not vacuumed; vacuumed, dusted, *and* scrubbed. One thing that stayed the same throughout the vacuuming, dusting, and scrubbing events, however, was that the fabric softener sheets (which gave off a strong lilac smell) were present every time Zoe went into the basement. Zoe's parents then removed the fabric softener sheets and sent Zoe into the basement. Finally, she stopped sneezing! They put the fabric softener sheets back, and guess what happened? She sneezed again. They have since stopped using the fabric softener sheets and Zoe no longer sneezes when she goes into the basement. So, from this whole ordeal, Zoe and her parents reasoned that the fabric softener sheets were what caused the sneezing.

**B. Set up one of Mill's Methods to identify the cause of each of the following observations.**

1. "I suddenly feel sick after eating at that restaurant. How could I tell if it was something I ate?"
2. "I think one of my medications is making me dizzy. How can I tell which one?"

3. "There are at least four reasons for my headaches: stress, allergies, head injury, and brain tumors. How can I tell which one?"
4. "The longer I listen to Dr. Arp, the more tired I become. How can I tell whether it is his lecture-style that's making me sleepy?"
5. "When I visit some people, I get really hungry, when I visit others I don't. What might cause that?"

## A Problem for Causal Tests: Underdetermination

A causal claim expressing the results of an experiment (formal or informal) *explains why* we observe what we observe. Why do we observe that group *A* lost more weight than group *B*? Because group *A* was taking Emaci-Great and Emaci-Great causes weight loss. Sometimes, however, the results of an experiment are ambiguous between two explanations. For instance, we might discover two hypotheses, both of which cannot be true, but which are both sufficient to explain the same test implication:

| | |
|---|---|
| 1. If $H_1$, then I. | 1. If $H_2$, then I. |
| 2. I. | 2. I. |
| 3. Therefore, $H_1$. | 3. Therefore, $H_2$. |

A classic case from the history of science illustrates this problem well. In the 1700s, experiments on the nature of heat led to a wide array of explanations. One powerful explanation was the Caloric Theory of Heat, which states that heat is an invisible, liquid-like substance that moves in and out of objects much like water, moving from areas of high density to low density, following a path of least resistance. The Caloric Theory was incredibly useful, allowing scientists to explain why air expands when heated, why warm drinks cool when left on a cool table in cool air, the radiation of heat, and from the theory we can deduce almost all of our contemporary gas laws.

A competing powerful explanation was the Kinetic Theory of Heat (or "Kinetic-Molecular Theory"), according to which solids and gases are composed of tiny molecules or atoms in motion colliding with one another. The faster the molecules collide with one another, the more energy that is expended. Heat is simply the expended energy of molecular motion. This theory was also incredibly useful in explaining the phenomena the Caloric Theory explains.

So, which is the better explanation? For years, researchers didn't know. Eventually, the debate was settled in the Kinetic Theory's favor, but until then, researchers were stuck evaluating the virtues of the theories themselves.

Many were skeptical of the Kinetic Theory because it involved introducing atoms or molecules as scientific objects. Since we cannot see molecules and they do not intuitively act the way we experience heat acting (flowing from one object into another, radiating from objects, etc.), the Kinetic Theory requires a big change in our previous beliefs about the nature of reality.

On the other side, the material "caloric" was no more directly observable than molecules. And the view must be combined with a few extra physical laws in order to explain the motion of some gases and the speed of sound. Nevertheless, these additions made the theory quite precise and was used to make predictions even after the Kinetic Theory made it obsolete.

Now we find ourselves with an interesting philosophical puzzle. We have two inductive arguments, both apparently strong and both consistent with all available evidence. In cases like this, we say that the theories are *underdetermined* by the data, that is, the data we have is not sufficient for choosing one theory over the other. To resolve this problem of **underdetermination**, rather than looking for additional evidence, we can turn to some of the features of the explanations themselves.

## A New Type of Argument: Inference to the Best Explanation

The features of an explanation that help us determine which is more plausible are called **theoretical virtues**. Theoretical virtues serve as practical reasons for choosing one explanation over another. They serve as *practical* (or *prudential*), and not *epistemic,* reasons because there are no arguments to show that they constitute evidence for the *truth* of the explanations under consideration. They have, however, led to important advancements in science and philosophy, and therefore have become important to the process of reasoning about causal explanations. Therefore, an explanation with more theoretical virtues is considered a *better explanation* than an explanation with fewer virtues. An argument that concludes one explanation is better than another by contrasting their theoretical virtues is called an *inference to the best explanation*, or an **abductive** argument. An inference to the best explanation is a **prudential argument**. Prudential arguments tell you what is practical or useful to believe when there is too little evidence to draw strong conclusions about what is true or false.

The American philosopher C. S. Peirce (1839–1914) is thought to be the first to name this method of reasoning, but it was used at least as far back Isaac Newton (1642–1726) and philosopher John Locke (1632–1704) in the seventeenth century.

## Explanatory Virtues

The actual number of explanatory virtues is unsettled, but there are six that philosophers widely agree on:

1. **Independent Testability**
2. **Simplicity**
3. **Conservatism**
4. **Fecundity** (Fruitfulness)
5. **Explanatory Scope**
6. **Explanatory Depth**

## Independent Testability

As we have seen, a hypothesis formulated to explain an observation does not become plausible simply because we were able to think of it. There must be some implication of the hypothesis that will allow us to confirm or disconfirm that hypothesis. But we can't choose something that's already built into the hypothesis. Imagine trying to test the hypothesis that seatbelts save lives. One way to test this would be to see how many people die in crashes who were wearing seatbelts. But this number alone wouldn't do it. It is dependent on the hypothesis you're trying to prove. From the fact that, say, very few people who wear seatbelts die in car crashes, you cannot conclude anything about the effectiveness of seatbelts. It could be that cars are just really, really safe and seatbelts don't really play a causal role. To know whether seatbelts save lives, you would need an *independent* test. For example, you would need to compare the number of people who wear seatbelts and die in car crashes with the number of people who don't wear seatbelts and die in crashes. This hypothesis can be independently tested. Hypotheses that famously cannot be independently tested are things like "only empirical claims are trustworthy" and "some cancers are cured by miracle." A dependent test tells you what you should expect if your hypothesis is true (e.g., crash deaths with seatbelts are X percent of non-deaths with seatbelts), but it doesn't tell you whether your hypothesis is true. An independent test tells you whether your hypothesis is true.

## Simplicity

**Simplicity** is a very old theoretical virtue that was expressed famously by William of Ockham (1288–1348) in the phrase, "Plurality must never be posited without necessity" (from *Sentences of Peter Lombard*). Ockham took certain arguments as conclusive that something supernatural was responsible for the creation of the universe, namely, the Christian God. He offered this phrase in response to those who asked how he knew there was only one supernatural being and not two or dozens. The idea is that, if one is good enough, it is more likely to be true than two or a dozen; the others are superfluous. It is a principle of economy, and it is as widely accepted and used today as it was in the Middle Ages. The fewer mechanisms or laws a hypothesis needs in order to explain some observation, the *simpler* that hypothesis is.

The idea is that, if two hypotheses explain the same observation, but one invokes two laws while the other only invokes one, the hypothesis with fewer laws is more likely to be true. Simplicity motivated much of the Newtonian revolution in physics. Newton's theory could explain most observed motion with only three laws compared to the dozens of laws and conditions required in earlier theories.

## Conservatism

A theoretical virtue that keeps investigation stable is **conservatism**. An explanation is conservative if accepting it requires that we change very little about our previous beliefs. Often, new and exciting theories will challenge some of our previous beliefs. This virtue tells us that the fewer beliefs we have to change the better. In their famous, *The Web of Belief* (1978), philosophers W. V. Quine and J. S. Ullian give an excellent example of how conservatism works:

> There could be … a case when our friend the amateur magician tells us what card we have drawn. How did he do it? Perhaps by luck, one chance in fifty-two; but this conflicts with our reasonable belief, if all unstated, that he would not have volunteered a performance that depended on that kind of luck. Perhaps the cards were marked; but this conflicts with our belief that he had no access to them, they being ours. Perhaps he peeked or pushed, with help of a sleight-of-hand; but this conflicts with our belief in our perceptiveness. Perhaps he resorted to telepathy or clairvoyance; but this would wreak havoc with our whole web of belief.[1]

Notice that, in this case, we are forced to change at least one of our previous beliefs. But which one? The least significant is the most plausible weak spot. Quine and Ullian conclude, "The counsel of conservatism is the sleight-of-hand."

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[1]W. V. Quine and J. S. Ullian, *The Web of Belief* (New York: McGraw-Hill, 1978), p. 67.

## 4. Fecundity (Fruitfulness)

An explanation is **fecund**, or fruitful, if it provides opportunities for new research. Science and philosophy make progress by taking newly successful explanations and testing them against new implications and applying them in new circumstances. If an explanation limits how much we can investigate the hypothesis, it should be preferred less than an explanation that does not limit investigation. A classic example of a hypothesis thought to limit our research capabilities comes from the field of Philosophy of Mind.

"Substance dualism" is the view that mental states (beliefs, desires, reasoning) are products of a non-physical substance called a "mind" or "soul." "Materialism" is the view that mental states are simply products of physical human brains. Many have argued that materialism is much more fecund than substance dualism. Since brains are subject to neurological research and souls, for example, are not subject to any further research, many researchers conclude that dualism's explanation of mental states is "impotent" compared with materialism's. If this is correct, materialism is a better explanation than dualism because it has the virtue of fecundity, whereas dualism does not.

## Explanatory Scope

An explanation's **explanatory scope**, also called its *generality*, is the number of observations it can explain. The more observations a hypothesis can explain, the broader its explanatory scope. The hypothesis that metal conducts electricity to explain our observation that a small bulb lights when connected to a battery by a metal wire, also explains why lightning is attracted to lightning rods, why electricity travels through natural water that is laden with metallic minerals (but not purified water), and why the temperature of wire rises when connected to a power source. The explanatory scope of this hypothesis is limited, however. It cannot explain why smaller wires become warmer than larger wires when attached to the same current. It also cannot explain why some materials do not conduct electricity, like glass and purified water. Nevertheless, if one hypothesis has more explanatory scope than another, the one with the broader scope is a better explanation.

## Explanatory Depth

An explanation's explanatory depth is the amount of detail it can offer about the observations it explains. The more detailed the explanation, the richer its **explanatory depth**. For example, pre-Darwinian evolutionary biologist

Jean-Baptist Lamarck hypothesized that variation among biological species (a giraffe's long neck, a zebra's stripes) could be explained in terms of two mechanisms operating on organisms through events that happened to a particular generation of organisms while they were alive. This generation then passed this new feature on to the next generation. So, a giraffe's long neck can be explained by the fact that each generation of giraffe had to reach higher and higher to eat leaves off certain trees. Each generation stretched its neck slightly and then passed on this stretched feature to the next generation. Unfortunately, except for suggesting some principles of alchemy, Lamarck offered few details of how this could occur.

Charles Darwin, on the other hand, argued that each generation passed on some variation to its offspring, but these traits were not a result of any particular events that happened to that generation. Instead, he suggested that the variations were random and offered a single mechanism, natural selection, to explain how these variations were preserved or eliminated from generation to generation. The introduction of a single, detailed explanatory mechanism gave Darwin's theory much more explanatory depth than Lamarck's.

## Applying the Virtues

There is no systematic formula for applying the virtues. It could happen that hypothesis 1 has three of the virtues and hypothesis 2 has the other three. In that case, it would be difficult to tell which is the better explanation. Which virtues are most important depends on the particular nature and circumstances of the observation in need of explanation. In some cases, we might be willing to sacrifice a great deal of simplicity, if the alternative is a hypothesis with great explanatory scope and depth. Similarly, we might be willing to forego broad explanatory scope, if the alternative is a hypothesis with great explanatory power and fecundity. Therefore, applying the virtues takes a bit of creativity and insight. Here are three examples to help you get the feel for it.

## Three Examples

### 1. Gremlins versus Animals

**$O_1$: There is a noise in the attic.**
$H_1$: Gremlins are bowling in the attic.
$H_2$: A wild animal crawled in.

Which of the hypotheses is a *better* explanation of why we hear a noise in the attic? Most of us would not hesitate in choosing $H_2$, but why? Surely, a noise in the attic is exactly what we would expect if gremlins were bowling in the attic. And the same goes for the wild animal. But $H_2$ has several more explanatory virtues than $H_1$. $H_1$ is not clearly independently testable, since if we checked the attic, it is unlikely that we would actually see gremlins (they are sneaky devils). $H_1$ is also more complex than $H_2$ because it introduces beings that aren't normally found in attics to explain the noise. If there is a more common cause, we should choose that. Similarly, $H_1$ is less conservative than $H_2$; it requires that we accept the existence of gremlins—something we may not be prepared to do without a great deal more evidence. And it should be easy to see, now, that we could go on to show that $H_2$ is more fecund, broader in scope, and richer in depth than $H_1$.

## 2. Gravel versus Carelessness

**$O_2$: A rock broke the window on the house.**
$H_3$: A piece of gravel from the road was thrown into the window by a passing car's tire.
$H_4$: A young boy hit a rock with a stick into the window (accidentally or intentionally).

This is a more commonplace example and slightly more difficult. Both hypotheses seem independently testable, both have sufficient scope and depth for events like $O_2$, and neither reduce our ability to investigate further. In addition, neither introduces any complex mechanisms or additional laws to explain $O_2$. Nevertheless, $H_3$ seems to challenge our belief about the direction car tires typically throw rocks and the force with which they throw them. It seems clear that a tire can throw a rock to the rear of a car with enough force to crack a window. But it is less likely that a tire will throw a rock sideways, and even if it could, it is unlikely that it would have enough force to travel far enough to hit and break a house window. A boy with a bat, on the other hand, is not subject to this concern. Therefore, $H_4$ is more conservative than $H_3$, and therefore, probably the better explanation.

## 3. Vandals versus Hardware

**$O_3$: My truck has a flat tire.**
$H_5$: Someone vandalized my car.
$H_6$: I ran over a nail or screw.

In this example, both hypotheses are independently testable, simple, fecund, and have high explanatory depth. $H_5$ has slightly less explanatory scope than $H_6$, because comparatively few cases of having a flat tire involve vandalism. The key difference in virtue, here, is conservatism. Given only the observation about the tire, it is much more likely to have a flat tire because of a nail or screw than because of vandalism. Similarly, $H_5$ violates our belief that vandals typically have some purpose to their destruction, either theft or wonton destruction. If only the tire is flat, then there is no sign of theft. And a flat tire is far short of wonton destruction. Therefore, because $H_6$ has more explanatory scope and is more conservative than $H_5$, $H_6$ is probably the better explanation.

## Getting familiar with … inference to the best explanation

**A. For each of the following, identify *both* the explanation *and* the observation being explained.**

1. Flowers are able to reproduce because bees transfer pollen from flower to flower as they gather pollen for honey.
2. Voters turned out in droves for candidate Jones because his television ads were so compelling.
   (Additional question: is this explanation causal?)
3. Of course your eyes no longer itch. Benadryl stops allergic reactions.
4. Geese fly south every winter. That explains why we've seen so many recently.
5. The car is out of gas. That's why it won't start.

**B. Using the theoretical virtues, construct one plausible and one implausible explanation for each of the following observations.**

1. I don't have my wallet.
2. That police officer is stopping someone.
3. I feel strange after drinking that glass of milk.
4. That meat looks undercooked.
5. My boyfriend just freaked out when I asked him about his sister.

**C. In each of the following there is an observation and two possible explanations. Using at least one theoretical virtue, identify the best of the two explanations.**

**1. Observation: This shrimp tastes funny.**

Explanation A: The shrimp is bad.
Explanation B: It is not shrimp.

**2. Observation: The dryer is making a knocking sound.**

Explanation A: The load is out of balance.
Explanation B: You trapped the baby inside.

**3. Observation: This guitar string keeps going out of tune.**

Explanation A: The string is old.
Explanation B: Someone keeps turning the tuner when I'm not looking.

**4. Observation: This shrimp tastes funny.**

Explanation A: The shrimp is bad.
Explanation B: I'm getting sick and food tastes differently when I'm sick.

**5. Observation: An oil spill in Prince William Sound, Alaska**

Explanation A: Members of Green Peace bombed the tanker.
Explanation B: The tanker hit a reef due to the negligence of an overworked crew.

**D. In each of the following there is an observation and two more-complicated possible explanations. Using at least 2 theoretical virtues, identify the best of the two explanations.**

**1. Observation: "That landscape is represented perfectly on this photo paper! How is that?"**

Explanation A: A small demon lives inside cameras and each has the unique ability to paint pictures very quickly and very accurately.
Explanation B: Thin papers, treated with chemicals to make them sensitive to the light of the three primary colors (yellow, red, blue), are exposed to the light reflected from a scene (such as a landscape). This produces a reverse image of the scene called a "negative." A chemical reaction with silver halide causes the negative to transfer (by a process called "diffusion") into a positive image, or, the image you wanted to capture.

**2. Observation: "The sun looks like it moves up into the sky in the morning, then down into the ground in the evening. Why is that?"**

Explanation A: The sun is a set of four fiery horses driven by Helios out of his palace by the River Okeanos every morning across the flat disc of planet Earth. It lights the sky for humans and animals and is then driven down into the land of Hesperides, where Helios rests the night in a golden cup that carries him back to his palace in the east.

Explanation B: The earth is spherical in shape and spins on a tilted axis. When the part of the earth you are on turns toward the sun, the sun appears to rise in the east. As your part of the earth turns away, the sun appears to descend in the west.

**3. Observation: "Hey, these two pieces of steel get warm when you rub them together quickly. Why is that?"**

Explanation A: There is a liquid-like substance called "caloric" that is warm. When an object has more caloric it is warmer than when it has less. Caloric flows from warmer objects to cooler just as smoke dissipates into a room. When you rub two pieces of steel together, the caloric from your body flows into the steel.

Explanation B: Objects are made of molecules. Heat is a function of the speed at which molecules in an object are moving. If the molecules move faster, the object becomes warmer; if the molecules slow down, the object becomes cooler. Rubbing two metal pieces together quickly speeds up the molecules in the metal, thereby making it warmer.

**4. Observation: "You say the flagpole is 50 feet high? Why is that?"**

Explanation A: Because the shadow cast by the flagpole is 50 feet long. The shadow's length given the sun's 45° angle to the ground plus the mathematics of an isosceles triangle logically entails that the flagpole is 50 feet tall. Given these conditions, the flagpole couldn't be any other height.

Explanation B: Because the town decided to make the flag pole one foot tall for each state in the Union.

[This one is tricky. Here's a hint: think about what each explanation is attempting to do. Then think about how well each answers what the question is asking.]

## Exercises

### A. Short answer and true or false on experiments.

1. In your own words, explain the difference between an observation, a hypothesis, and a test implication.
2. Explain the difference between an explanation and a causal argument.
3. True or false: in a simple model of confirmation or disconfirmation, controls protect the results from faulty assumptions.
4. Give an example of an auxiliary hypothesis and an example of an initial condition.

5. True or false: causal arguments are just more complicated deductive inferences.
6. Explain the morality problem for randomized studies.
7. Explain how prospective and retrospective studies avoid the morality problem.
8. True or false: retrospective studies begin with an effect and look for a cause, whereas prospective studies hypothesize a cause and watch for the effect.
9. Explain the difference between confirmation and deductively certain.
10. Are prospective studies as reliable as randomized studies? Why or why not?

**B. For each of the following informal experiments, explain which of Mill's Methods is being used.**

1. You worked on your radio by taking it apart, and now it won't work. You figure it was probably something you did to it.
2. There is a strong correlation between the summer months and the rise in criminal activities in big cities.
3. You wake up in the morning with a headache, which is unusual for you. However, the night before you had worked on several crossword puzzles in bed by the dim light of your nightlight. You infer that the headache has to do with straining your eyes while working on the crossword puzzles.
4. When ten mice were subjected to heavy metal music for ten days, they began biting at each other. After twenty days of heavy metal music, they began biting each other to the point of drawing blood. After thirty days, two of the mice had been eaten.
5. There's a strong draft in your room when the door is closed. You put a towel at the base of your door and the draft lessens a little. You then put weather stripping foam around the window and the draft lessens even more, but is still there. You figure that the ceiling vent, which leads directly to the space between your ceiling and the roof, is the cause of the remaining draft.
6. You notice that every time you spin in a circle for more than one minute, you feel nauseated. This has happened at least five times you remember. You figure that the nausea is brought on by your spinning.
7. You have been keeping track of the growth of your plants for six years now. For three of those years, you actually watered your plants weekly, and you noticed that they bore fruit. You figure that the water is what assists in helping your plants bear fruit.
8. You have two lawnmowers, and wonder what would happen to the engine of a lawnmower if it is used without oil. So, you mow a half-acre of lawn with lawnmower #1, which contains oil, and

you mow another half-acre of lawn with lawnmower #2, which does not contain oil. Then, you open up both engines and discover that lawnmower #2 (the one you used that did not contain oil) has engine parts that are all blackened, dented, and gritty-feeling, while lawnmower #1 (the one you used that did contain oil) has engine parts that are all shiny, smooth, and slick-feeling. You reason that the oil is responsible for the condition of the parts of the engine.

9. Moe, Larry, and Curly have keys to the store, and this morning the store is missing $10,000.00 from the register. The money was there last night, however, when you closed up the store with Moe, Larry, and Curly. Moe and Larry left the store with you last night and spent the night in your guest room, while Curly went his own separate way. You, Moe, and Larry conclude that Curly stole the money.
10. How many more studies do we need to perform in order to show the simple fact that the general increase in smoking leads to a general increase in lung-related and heart-related diseases?

**C. Set up your own Mill's Method to test the next five causal claims.**

1. "I think your driving makes me sick. How can we tell?"
2. "I know there are three things that could cause that noise in the attic: gremlins, a wild animal, grandma's ghost. Which do you think it is?"
3. "I think I'm allergic to shellfish. Is there a way to test for that?"
4. "One of these dogs has fleas. How could we tell which one?"
5. "The new speed limit seems to be reducing accidents. How might we tell if that is really true?"

**D. Short answer on inference to the best explanation.**

1. Explain the theoretical virtue of simplicity.
2. What is the difference between explanatory depth and explanatory scope?
3. Which explanation has more explanatory depth, the claim that astrological signs causes headaches or that stress causes them?
4. Imagine two explanations have competing and exclusive theoretical virtues (one has three, the other has the other three). What considerations could help us decide between them?
5. Which explanation has more fecundity, the claim that space aliens made crop circles or that conspiring artists did?

## Real-Life Examples

# 1. A Murder Mystery

**In their famous book *Web of Belief* (1978: 17), philosophers W. V. O. Quine (1908–2000) and J. S. Ullian (1930- ) offer the following example of evidence in need of explanation:**

> “Let Abbott, Babbitt, and Cabot be suspects in a murder case. Abbott has an alibi, in the register of a respectable hotel in Albany. Babbitt also has an alibi, for his brother-in-law testified that Babbitt was visiting him in Brooklyn at the time. Cabot pleads alibi, too, claiming to have been watching a ski meet in the Catskills, but we only have his word for that. So we believe.
>
> (1) that Abbott did not commit the crime,
>
> (2) that Babbitt did not,
>
> (3) that Abbott or Babbitt or Cabot did.
>
> But presently Cabot documents his alibi—he had the good luck to have been caught by television in the sidelines at the ski meet. A new belief is thus thrust upon us:
>
> (4) that Cabot did not.” (p. 17)

It seems clear that all four beliefs cannot be true: the conjunction of 1–4 is inconsistent. How should we proceed? Abbott might have had someone forge his name in the hotel register, Cabot might have manipulated the film footage, and Babbitt’s brother-in-law might have lied about his being in Brooklyn.

1. **Identify the two least well-supported claims. Using this information and the theoretical virtues choose a course of investigation.**
2. **What if we learned that Cabot has a twin brother, Davot, who also happened to be at the ski meet in the Catskills. Would this increase or decrease the likelihood that Cabot was at the meet?**
3. **Imagine we also learn that the hotel clerk in Albany is Abbott’s best friend from school. How might this affect your inference to the best explanation?**
4. **At what point should we decide to widen our search to other suspects? That is, what considerations would suggest that (3) is the weakest of the four claims?**

## 2. Experimental Models

**Read the following two excerpts and answer the questions that follow.**

- In the 1700s, scurvy plagued many British seamen, and various cures were tried, with unclear results, from vinegar, to sulphuric acid, to sea water, nutmeg, cider, and citrus fruit. On the 1747 voyage of the warship *Salisbury*, an exasperated navel surgeon named James Lind decided to find a cure that worked:

Lind chose a dozen sailors out of the three dozen that were then suffering from scurvy. To make his test as fair as he could, he tried to pick men whose illness seemed to be at about the same stage. Then he divided them into six pairs and gave each pair a different treatment. The pair being given oranges and lemons made a good recovery; those taking cider, acid or brine did not fare so well. It was not a perfect randomized clinical trial by today's standards, but it did the job. Scurvy, we know now, is caused by lack of vitamin C, so oranges and lemons are a sensible treatment.

1. **Construct a simple experimental model for each proposed treatment.**
2. **Explain the controls Lind used and why they are important for a successful experiment.**
3. **Explain some additional controls Lind could have used.**

- The Flemish chemist, physiologist, and physician Jan Baptise van Helmont (1580–1644) proposed the following test for the success of bloodletting as a medical treatment:

Let us take out of the Hospitals, out of the Camps, or from elsewhere, 200 or 500 poor People, that have Fevers, Pleurisies, etc. Let us divide them in halfes, let us cast lots, that one half of them may fall to my share, and the other to yours; I will cure them without bloodletting … we shall see how many Funerals both of us shall have.

1. **What is van Helmont's test supposed to show?**
2. **Explain why van Helmont's test might work.**
3. **Do a bit of research on the sorts of diseases bloodletting was supposed to cure. Construct a complicated experimental model to test bloodletting on one of these diseases.**

Passages excerpted from Tim Harford's *Adapt: Why Success Always Starts with Failure* (Farrar, Straus and Giroux, 2011), pp. 122 and 121, respectively.

# Informal fallacies

10

**Understanding the variety of ways arguments can go wrong helps us construct better arguments and respond more effectively to the arguments we encounter. Here, we distinguish informal fallacies from formal fallacies and then explain eighteen informal fallacies.**

## Formal and Informal Fallacies

We have spent a lot of time looking at how to reason correctly. We have also seen how a few good arguments can go wrong. For example, remember from our discussion of formal fallacies (Chapter 6) that *modus ponens* (If P, then Q; P; therefore, Q) becomes **invalid** if we affirm the consequent in one of the premises and try to draw a conclusion about the antecedent, as in the following two examples:

1. If it has rained (antecedent claim), the sidewalk is wet (consequent claim).
2. The sidewalk is wet (affirming the consequent).
3. Therefore, it has rained (concluding to the antecedent).

*Not necessarily!* This conclusion does not follow; it may be that it has snowed, or a water main broke below the sidewalk, or a very, very big dog peed on my sidewalk!

1. You win the lottery (antecedent) only if you play the lottery (consequent).
2. You play the lottery (affirming the consequent).
3. Hence, you win the lottery (concluding to the antecedent).

*Not necessarily!* This conclusion does not follow; just try playing the lottery and you'll see how much money you waste *not* winning the lottery!

We also saw that generalizing from a sample that is too small does not support the conclusion strongly enough for a good inductive argument—the generalization is *hasty*:

1. I had a lousy meal at Joe's Diner.
2. Therefore, all the meals at Joe's are lousy.

*Not necessarily!* This conclusion does not follow strongly; it may be that the meat loaf is terrible, but the chicken salad is amazing, in which case it's not true that *all* the meals at Joe's are lousy. Don't be hasty in your judgment of Joe's Diner food!

1. I had a bad experience with a person A of religion X where that person A was a zealot, and my friend had a similar bad experience with another person B of religion X where that person B was a zealot.
2. Therefore, all the persons C, D, E … N of religion X are zealots.

*Not necessarily!* This conclusion does not follow strongly. One or two bad instances are not representative of a whole group of people. Don't be hasty in your judgment of religion X.

In each of these examples, a **fallacy** has been committed. Recall that a *fallacy* is an error in reasoning whereby one draws a conclusion from a premise (or premises) when that conclusion does not follow logically or strongly from the premise(s). The error is about the *reasoning* that occurs between the premise(s) and the conclusion—not the *truth* of the premises. An argument can have false premises and still not commit a fallacy, though a fallacious argument certainly might have false premises. And an argument may have all true premises but still be fallacious.

All of the fallacies we'll talk about in the sections of this chapter are called *informal fallacies*. There is a fairly straightforward distinction between informal and formal fallacies.

**Formal fallacies** are mistakes in the *form* of an argument whereby one of the rules associated with that argument form has been violated, and a conclusion has been drawn inappropriately. Another way to say this is that, in formal fallacies, a conclusion does not follow from a premise or premises because the argument's *form* or structure is wrong. The argument's content (whether its claims are true or false, vague, etc.) is irrelevant.

**Informal fallacies** are mistakes in the *content of the claims* of an argument—that is, mistakes in either the *meanings* of the terms involved (e.g., ambiguity, vagueness, presumption) or the *relevance* of the premises to the conclusion—and a conclusion has been drawn inappropriately. Another way to say this is that, in informal fallacies, a conclusion does not follow from a premise or premises because there is a problem with the argument's *content*, not its structure or form.

Formal fallacies can be detected regardless of what terms are substituted for the variables. For instance, no matter what terms are substituted for the variables in a case of **affirming the consequent**—a distortion of the valid form called *modus ponens*—the form is fallacious. Consider these formally fallacious arguments:

| | | |
|---|---|---|
| 1. If P, then Q. | 1. If it's a cat, then it's a mammal. | 1. If it's icy, the mail is late. |
| 2. Q. | 2. It's a mammal. | 2. The mail is late. |
| 3. Therefore, P. | 3. Therefore, it's a cat. | 3. So, it's icy. |

*Not necessarily!* These conclusions do not follow. You can see this clearly when the Ps and Qs are filled in. It's a mammal; therefore, it's a cat? No way! The mail is late; so, it's icy. Not necessarily; the mail truck could have a flat, or the regular mail person could have been replaced by a slower substitute.

Informal fallacies, on the other hand, cannot be detected by merely looking at the argument's form. You need to know what terms are involved in the claims of an argument, the meaning of those terms, or the information that is being communicated by the claims or categories represented by the terms. Consider this argument's form, where the letters (terms) stand for claims:

1. A
2. B
3. C
4. D

Clearly, the conclusion doesn't follow deductively from the premises. The *form* is *invalid*. But it still might be a good argument if the argument is intended to be inductive. With inductive arguments, you can't tell one way or the other if the conclusion follows strongly from the premises by looking only at the form of the argument. But once you look at the content, you can evaluate the argument. This argument actually might be:

1. Drug X lowered cholesterol in 1,000 studies in the UK.
2. Drug X lowered cholesterol in 1,000 studies in Germany.
3. Drug X lowered cholesterol in 1,000 studies in the United States.
4. Therefore, Drug X will likely lower your cholesterol if you take it.

The conclusion would seem to follow with a high degree of probability and, if the premises were true, this would be a *cogent* argument (recall from Chapter 2 that a cogent argument is good inductive argument which is strong and has all true premises). Now consider this argument:

1. Drug X lowered cholesterol in one study performed in Europe.
2. Therefore, Drug X will likely lower cholesterol for anyone who takes it.

Remember from Chapter 8 that the argument above is a generalization because it draws an inference from a sample of a population to the whole population—the sample this one study performed in Europe; the population is anyone taking the drug. In this case, the generalization is hasty, because the sample size is too small. There would need to be hundreds of trials, if not thousands, before we could draw a qualified conclusion that drug X lowers cholesterol. But, we could not have known whether it was fallacious by merely looking at the argument's form.

Remember, just because an argument has a false premise, or false premises, does not mean it is fallacious. Consider the following argument in the deductive realm of reasoning:

1. Cats are dogs.
2. Dogs are squirrels.
3. Thus, cats are squirrels.

This argument is not fallacious; in fact, it is valid: The conclusion follows necessarily from the premises. However, it's not *sound* because the premises are false (See Chapter 2 for a refresher).

Here's another example of inductive reasoning:

1. Most Republicans are liberal.
2. Sam is a republican.
3. Hence, Sam is probably a liberal.

Since the conclusion receives strong support from the premises ("most"), the argument is not fallacious. The premises are relevant to the conclusion, and they do not mislead you about what the terms mean. You might not know what a "Republican" or a "liberal" is, but there is nothing misleading about the words or the structure of the claims—they have clear meanings. However, it is not a good argument, since the first premise is false: It turns out that most Republicans are not liberal.

Informal fallacies can happen for a lot of reasons, so they are not as easy to detect as formal fallacies. With formal fallacies, again, all you need to learn are a set of rules about what makes a form correct; then, if an argument does not follow those rules, the arguer has committed a formal fallacy.

However, there are *numerous* ways that arguments can go wrong informally. We can't learn them all, but there are a handful that pop up on a regular basis. If we get a good grasp of these, we will be less likely to commit them and less likely to fall for them. We will be in a much better position to reason well.

In this chapter, we will spend time looking at some very common fallacies and some of their variations. As a refresher, always start evaluating an argument by asking:

- First: What claim is the arguer trying to convince me to believe is true? This is the conclusion of the argument.
- Second: What other claims are being used to support, show, justify, or prove this conclusion claim? These are the premises of the argument.

## Hasty Generalization and False Cause

The informal fallacies of *hasty generalization* and *false cause* are very common, partly because they have the "feel" of being scientific (and even scientifically minded people can miss them if they are subtle enough). Recall from Chapter 8 that a **hasty generalization** is an informal fallacy that occurs when one inappropriately draws a conclusion about the characteristics (features, qualities, aspects) of a whole group or population based upon a premise (or premises) concerning characteristics of a small sample of the group. The problem is that such an inference includes too little information in the premises to grant a high degree of probability to the conclusion. A study indicating that a drug works is not enough to conclude that it will work for anyone who takes it; a poll of the people in a town, or even a state, indicating that Candidate X will win the election is not enough to conclude that she will in fact win the election; one bad apple doesn't mean, automatically, that the whole bunch is spoiled.

Many times, when we think to ourselves "They're all like that" in talking about anything—people, cars, restaurants, dogs, cats, movies—based upon a small sample of the group we're talking about, we commit a hasty generalization. There is no way to strongly conclude something about the characteristics of an entire group if we have too little information about the entire group. The next member of the group we encounter may turn out to have different characteristics from members of the group we know thus far. All forms of prejudice and stereotyping, by definition, constitute hasty generalizations. Not only is prejudice something that *morally* harms people, but it also *logically* "harms" people's thinking as well, and can lead to *epistemic injustices*—that is, dismissing people's claims or testimony based on faulty assumptions about their perspectives or cognitive abilities.

Here's a common hasty generalization that we often hear, that's also probably bad for your health: Johnny says, "My dad chain smoked 2 packs of cigarettes a day from the age of 14, and he lived to be 80; so, I'm not worried about getting lung cancer." Here, Johnny hastily generalizes his dad's good fortune of not dying of lung cancer to himself. And while we agree that genetics play a role in cancer risk, we also have good evidence that smoking significantly increases your risk independently of your genes. So, even if Johnny is somewhat less likely than, say, someone else similar to him, it is hasty to conclude that his dad's luck will also apply to him.

Here are some other examples of hasty generalization that you should be able to recognize easily:

- "I had a lousy steak at Floyd's Diner. I'm never going back again."
  Even good chefs have bad nights. One bad meal does not make a bad restaurant.
- "Look, there's no way I'm going to the West Side of town at night. Remember last time that your phone was stolen. And I value my phone."
  Unless there are other reasons for thinking the West Side has a crime problem, there is no reason to suspect that someone is any more likely to have something stolen there than anywhere else.
- "One study at the University of X showed that Squeaky Clean Toothpaste (SCT) removes plaque. So, using SCT means no plaque!"
  We don't know enough about this study. But even if it were large and representative of its target population, it is only one study. Many scientific claims have been retracted after subsequent studies overturned early findings.

The **false cause** fallacy is related to hasty generalization. In Latin, the false cause fallacy is called *post hoc ergo propter hoc*—translation: "after the fact, therefore, because of the fact." You've likely encountered this version of the fallacy: "Every time I get in the shower, the phone rings. It's like people know," or "Every time I wash my car, it rains, so there's no point in trying." Now, no one seriously believes that washing their car causes rain. But real-life cases are easy to find: Every time I wear my lucky hat, my favorite team wins; you made a joke about the band breaking up, and then they did, so it's your fault!

A false cause occurs when one incorrectly thinks that an event, condition, or thing A causes another event, condition, or thing B, when, in fact, there is not a causal connection. In Chapter 8, we discussed four mistakes that people commonly make when trying to determine causation: mistaking correlation for causation, mistaking temporal order for causal order, mistaking coincidence for causation, and mistaking indicators for causes. These are all ways of misidentifying causes or committing the fallacy of false cause. Here are some more examples:

- "I noticed that when it's warm outside, there are more criminal acts in the city. Therefore, the warm weather *causes* crime!"
  There are lots of reasons for why warm weather might be correlated with crime: More people are out in public spaces (where crimes like pickpocketing happen); people are homeless often (leaving their houses vulnerable to burglary); people are more active, including criminals. But that doesn't mean the warm weather itself is the reason that people commit crimes. The weather's being warm is far removed from more immediate, causal explanations.
- "My computer crashed right after I installed that stupid software! I wonder what's in that software that caused my computer to do that?"
  Computers crash for all sorts of reasons. Maybe it was the software, or maybe your computer couldn't handle the software, or maybe it was just an accident—there was a glitch already on your computer that just happened to make your computer crash at just that moment. At this point, with only this limited information, we don't have sufficient evidence of what caused the crash.
- "Jenny got a wart on her finger, so she rubbed a freshly washed potato on it, then buried the potato upside down, and in a week the wart was gone. Totally awesome! I got a wart now, so I'm going to the store to get a potato."
  Natural cures and alternative medicines have a long history. Their track record, however, isn't so good (depending on the remedy). Maybe rubbing root vegetables on warts makes them go away,

> but more likely this is a matter of base rate neglect or a hidden cause. We don't know how long Jenny had her wart, but we do know that some warts go away on their own. If Jenny's wart went away within the normal timeframe for warts going away, then there is little reason to believe the potato rubbing was the cause. Further, Jenny might have done something else that made the wart go away (started a new skin treatment, started or stopped eating a new food, etc.). But just because the wart went away after it was rubbed by the potato doesn't mean the potato was the cause.

## *Argumentum ad Hominem*, Abusive (Appeal to the Man/Person)

You've heard it said, "Character counts." And this is right when you are deciding whether to trust someone, for instance, when choosing someone to be responsible with your business's money or your parents' estate. You should be able to trust your accountant or your spouse, and for these decisions, character is paramount. If you find out the guy you're dating cheated on his last girlfriend, warning bells should be ringing in your head. Since character counts so much in so many areas, it is easy to be deceived into thinking it affects whether you should believe about what someone claims—but you must be careful here, for a fallacy lurks.

Imagine you are at a medical conference discussing a new vaccine for the flu virus. A prominent member of the medical community, Dr. X, has just given a thirty-minute presentation on the success of this vaccine and its lack of negative side effects. In response, another prominent member of the medical community, Dr. Y, comes to the podium and announces, "I had dinner with Dr. X last night, and he is obnoxious, selfish, and crude. You should not believe a word he says. This new so-called flu vaccine is nothing but the brainchild of an egotist." Dr. Y promptly leaves the podium, having soundly refuted his colleague. Right?

Hardly. In this case, Dr. Y has committed what is known as the ***ad hominem*, abusive** fallacy, or "attack on the person." The conclusion you are asked to draw is, "Dr. X is wrong." The evidence is that, "Dr. X is obnoxious, selfish, and crude." Dr. Y attacked Dr. X's character, not the evidence Dr. X presented in favor of his results. The truth of Dr. X's conclusions hangs on whether the experiments produced the results Dr. X claims; not whether Dr. X is a good person.

But character counts, right? So what should we do with Dr. Y's pronouncement about Dr. X's character? Well, even assuming it's true (which we don't know yet), we should ignore Dr. X's character in this case because it is irrelevant to whether his findings are legitimate. Claims stand or fall on the evidence that supports them. A person's character is (most of the time) irrelevant to what the evidence says. Someone can be a good accountant while being a nasty driver. Someone can be a good doctor while being a bad husband and absentee father. Look at these examples:

1. Dr. X is obnoxious, selfish, and crude.
2. Therefore, Dr. X's findings should not be trusted.

*Not necessarily!* It may be that Dr. X is the biggest jerk on the planet, but this has nothing to do with whether his findings count as good science.

1. Dr. X is a bad husband and absentee father.
2. Hence, Dr. X's claims about medicine should be dismissed as faulty.

*Not necessarily!* Dr. X might be a perfectly competent doctor or researcher. And even if he mistreats people in his personal life, he might not mistreat his patients. To be sure, you might not want to support someone who is bad to the people closest to him, or you may not want to work with him as a colleague. But presumably that is because you also have a relationship with your doctor or colleague, and you just don't want relationships with people like that. Fair enough.

Watch out for this fallacy when politicians and business leaders square off against one another. They will tell horrendous stories of personal failure and family conflict. But when it comes right down to it, this sort of information is not your primary concern; you want to know what the candidate will likely do in office, that is, *whether their platform is worth adopting*.

With that said, we have to be careful not to call an argument fallacious when it is not. There are times when it *is* appropriate to judge someone's character. For instance, if you find out that your boyfriend cheated on his last girlfriend and the girlfriend before that, and then says to you, "Honey, I've always been faithful to you," you have little reason to think his claim is true. (You don't know that it is false, either. But there are red flags with this guy.) His testimony is not good evidence because it has been corrupted by his poor character. The same goes for politicians when you have already decided their platform is worth adopting and want to know *whether they will do what they say they will do* once in office. At this point, you already agree with their claims about policies and values, but now you want to know whether the politician will keep their promises. And that *is* a character issue.

The point is that bad character about relevant issues prevents testimony from functioning as evidence; you just can't judge either way. If Dr. Y stood up and recited a list of reprimands given to Dr. X for falsifying test results, you would then have lost any reason believe Dr. X's conclusions based on his testimony. Again, you don't have evidence that his results are false; this may be the one time where Dr. X conducted his research properly and published the actual results—you just can't say either way. Thankfully, these kinds of claims can (sometimes) be evaluated independently of testimony. For instance, if there are doubts about Dr. X's character, other experts can at least check his results.

So, here's a way to tell the *ad hominem*, abusive fallacy from an appropriate appeal to character: if the person's character is relevant to whether what they are saying is true, then it is an appropriate appeal to character; if character is irrelevant to whether what they are saying is true, it is an *ad hominem* fallacy.

Some of you may remember that US President Bill Clinton was accused of having an affair with one of his interns, Monica Lewinski. Clinton said, "I did not have sexual relations with that woman." Let's suppose, for the sake of argument, we find out he was lying and that he did have an affair with Lewinski. Since Clinton is, and was, a married man, we can safely say this doesn't bode well for his character: he's an adulterer *and* a liar.

Now, let's also suppose that a lawmaker wants to convince his fellow lawmakers that a policy Clinton has proposed should be rejected. The gist of his argument is that, "I have good evidence that Mr. Clinton is an adulterer and a liar, therefore, this bill should not be passed." In this case, the lawmakers should disregard their colleague's argument—it is irrelevant to whether the bill should be passed; it is an *ad hominem*, abusive fallacy. The bill should be evaluated on its own merits and has nothing to do with Clinton's character even if, as we have supposed, his character is nothing to be proud of.

Now consider an alternative case. Sometime in the future, Clinton is, once again, accused of having a sexual relationship with another woman who is not his wife. Clinton, again, responds, "I did not have sexual relations with *that* woman." In response, a lawmaker says, "I have good evidence that Mr. Clinton is an adulterer and a liar." In *this* case, if the lawmaker can produce substantiate (back up) his evidence, we have reasons to disregard Clinton's testimony. However, we still *do not have reason to think he is lying*, but we also have no reason to think he is telling the truth. His testimony just ceases to count as evidence.

You should also know that the *ad hominem*, abusive fallacy doesn't just apply to appeals to *negative* character traits. Just because someone is a particularly good and honest person doesn't mean that what they have to say is true. It might mean that they will faithfully relay to you what they really believe, but what they believe may be false, or they may be in no position to speak on the matter. You might respect a scientist or philosopher as a moral person, a good friend, and a clear writer, but these have nothing to do with whether what she says is true. Her claims still have to be evaluated on their own merits. On the other hand, her credentials as a particular kind of scholar and the renown of her research do contribute to whether you should believe her testimony. Of course, if she turns out to be a liar, then her testimony without any supporting evidence cannot count as evidence.

The difficulties associated with character and credentials are reasons why expert testimony in legal cases is so controversial. A jury cannot be expected to make these fine distinctions without proper training, and of course the legal system can't afford to train citizens for these types of tasks—they depend on your taking classes that use books like this one.

In court cases, jurors typically *assume* that an expert is of good character ("I swear to tell the truth" and so forth). This presumption simply makes the likelihood of anything she has to say, zero (rather than negative, for instance, if you learned she was a liar). Then, a list of an expert's credentials and accolades serves to make her an *appropriate source* of evidence (you wouldn't want a seven-year-old musing on psychological disorders). Given both of these and your relative ignorance of the subject matter, you are justified in accepting the expert's testimony. Here are at three more examples of the *ad hominem*, abusive fallacy:

- "Senator Edwards has cheated on his wife. So, I don't believe a word that comes out of his mouth."
- "That doctor is an arrogant man. There is no way he knows what he is talking about."
- "Dr. Wilson believes all sorts of crazy things. So, all of his arguments must be taken with a grain of salt."

## *Argumentum ad Hominem*, Circumstantial

An arguer does not have to focus only on someone's character to commit an *ad hominem* fallacy. She can also focus on a person's affiliations or circumstances. If you attempt to discredit someone's claim by pointing out that they are affiliated with an unsavory group or that their socioeconomic status prohibits them from speaking truly, you have committed an ***ad hominem*, circumstantial** fallacy—*appeal to an arguer's circumstances*. Put another way, if someone responds to a claim by pointing to the arguer's *circumstances*, whether race, gender, political affiliation, religious affiliation, economic status or any other situation, they have committed an *ad hominem*, circumstantial fallacy. This sort of fallacy occurs regularly in many different contexts, so watch out.

You've heard political pundits like Keith Olbermann make claims like, "It's just another misleading conservative ploy." It doesn't matter what the policy is for us to evaluate this response. This claim does not give you any reason to believe that the "ploy" is misleading *except* that it was attempted by conservatives. "Ploy" is often used as a derogatory term for a "strategy," for instance, to indicate that it is somehow devious or deceitful or that someone is "trying to get one over on you." But, again, the only reason given for thinking it is devious or deceitful is that it is attempted by "conservatives," so we'll examine this aspect of the argument.

Is a strategy misleading *just because* it is proposed by conservatives? Not obviously. The arguer has committed an *ad hominem*, circumstantial fallacy. "Misleading-ness" is not part of what it means to be a conservative. The arguer might point to a long line of deception from conservative politicians as support for the claim, but that would not necessarily tell you anything about *this* strategy. Maybe this one is *not* deceptive. It must be evaluated on its own merits.

Consider this. One of the claims Rachel Carson made in her classic environmentalist text, *Silent Spring* (1962), was that certain pesticides commonly used at the time were harmful to the environment. This text is now recognized as the first significant contribution to the environmental movement. At that time, however, the Director of New Jersey's Department of Agriculture claimed the book was "typical" of the group of "misinformed … organic-gardening, bird-loving, unreasonable citizenry that has not been convinced of the important place of agricultural chemicals in our economy."[1] In associating Rachel Carson with groups his audience find distasteful or unappealing, the Director is attacking the context in which Carson's conclusions are presented. It was meant to get people to draw the fallacious conclusion that what Carson had produced was lousy scholarship or that she was somehow less than intelligent; hence, don't even listen to what she says. Of course, even if he was completely right to associate Carson with this crowd, it is irrelevant to whether her evidence supports her conclusions.

This fallacy is also common in race and gender debates. Consider the following hypothetical interchange:

[1]Quoted in Douglas Walton, *Ad Hominem Arguments* (Tuscaloosa: University of Alabama Press, 1998), p. xi.

| | |
|---|---|
| **Mr. Chauvinist:** | "The evidence just does not support the claim that women are paid less than men for the same jobs." |
| **Ms. Feminist:** | "As a man, Mr. Chauvinist cannot possibly know what he is talking about." |

Here are three more examples:

- "It is unlikely that Senator Wilkins can really help the poor because he comes from an Ivy League, oil family."
- "Dr. Perkins cannot possibly know anything about the origins of the universe since he is a dyed-in-the-wool atheist."
- "Mr. Obama's complaint about the rising price of arugula shows just how disconnected he is from his working-class constituency. His high-brow, idealist, Ivy-League values are so far from blue-collar struggles that it is implausible to think he will do anything to help low-income families."

## *Tu Quoque* (You, Too, or Hypocrite Fallacy)

Have you ever thought it was just too easy to win an argument by pointing out that someone is a hypocrite? Out loud you might have exclaimed, "Ha! You're a hypocrite. I win!" But in the back of your mind you were wondering, *Did I really get the best of that conversation? Did I really respond to win the argument?* In this case, the little voice in your head was the intuition that claims must be evaluated on the evidence, not on whether someone contradicts himself or does what she says not to do. In other words, the little voice was right.

Anyone who tries to win an argument against you by pointing out that you are a hypocrite commits a variation of the *ad hominem* fallacy known as *tu quoque*, or "you too" (pronounced: too-**kwo**-kway).

But, pointing out hypocrisy as a way of winning an argument is fallacious because it has nothing to do with the *truth* of the claim the arguer is defending. For instance, someone who is currently cheating on his wife might present a convincing argument that adultery is morally wrong. Pointing out the arguer's hypocrisy does not affect the likelihood that the claim is true or undermine the possibility that the argument is a good one. You are simply pointing out an inconsistency between the arguer's actions and beliefs. Big deal! We want to know whether what the arguer is saying is *true*—we need some *reasons* to believe or disbelieve *the claim*. Referring to irrelevant information, such as hypocrisy, just takes the discussion off course.

In fact, the arguer may agree with your assessment and respond, "Yes, that's right, I'm an adulterer. And since I believe that adultery is wrong, I am doing something wrong. But the fact that I'm doing it doesn't change the fact that it's wrong." When someone makes a claim like, "Adultery is wrong," a critical thinker does not evaluate the arguer, the critical thinker evaluates the claim and any evidence offered in favor of it. The proper strategy, whether you already agree with the claim or not, is to demand evidence for thinking the claim is true.

Look at three more examples of the *tu quoque* fallacy:

- *Officer*: "Did you know you were going 20 miles over the speed limit."
  *Driver*: "Yes, but officer, you had to go at least that fast to catch me. So, since you would be a hypocrite to give me a ticket, can I assume I'm off the hook?"
- *Counselor*: "I had an abortion and I have regretted it. I don't think you should do it."
  *Teenager*: "Who are you to tell me not to have an abortion? You had one!"
- "Senator MacMillan can't possibly be serious about his proposal for cutting spending. The senator has more personal debt than any other member of congress."

## *Argumentum ad Populum* (Appeal to the People)

You are regularly asked to believe something or to do something *just because* everyone else believes it or does it. You might think you are invulnerable to this move since your mother or grandmother probably taught you this fallacy long ago: "If everyone jumped off a bridge, would you do it?" Mothers everywhere have done a lot to foster awareness of this reasoning pitfall, but people are sly, and contemporary versions of it are somewhat disguised.

Perhaps you have been tempted to think that a politician is doing a bad job because everyone else thinks he or she is doing a bad job (the phrase, "job approval rating," should come to mind). Or maybe you have been persuaded to believe there are objective moral facts, like "murder is always wrong," on the grounds that every culture in history has agreed on at least a few basic moral principles. On the behavior side, there is a chance you have considered ingesting certain illegal substances since "*everyone* has tried it" (and, heaven forbid you miss out). And you have probably been tempted to buy something just because it is the "best selling X in America," or "Mothers in Europe have been giving it to their children for thirty years."

All of these arguments commit the ***ad populum*** fallacy, or, appeal to the people. Make sure you recognize that, in each case, the conclusion—"I should believe X" or "I should do X"—may be true or false. There may really be objective moral facts. Some politicians really do a bad job. But evidence that everyone believes something or that everyone does something cannot help you make an informed decision about whether the claim is true.

What if everyone suddenly came to believe that the world is flat or that God exists? Would everyone's *believing* these things *make* them true? Of course not. They are true or false regardless of what someone believes. Since someone's belief about a claim does not make it true or false, you will need a different sort of evidence to make a good judgment about its truth or falsity.

Be careful to note that an *ad populum* fallacy is an appeal to a large number of people, not specific groups. If an argument tries to sway you by pointing out a specific group—for example, "Republicans everywhere believe X" or "The discriminating shopper buys X"—the fallacy is a variation on the *ad populum* called an *appeal to snobbery or vanity*. We will look at this fallacy in the next section.

But first, let's look at more examples of the *ad populum*:

- *Reading—everybody's doing it!* (This is an actual PBS commercial.)
- "The majority of congressmen, including members from both parties, believe that Iraq is a threat to the United States. Therefore, we should probably go ahead with the invasion."
- "Everyone in the PTA believes that the superintendent's policies are biased against male teachers. Therefore, we should not reelect her."

## Appeal to Snobbery/Vanity

Someone who appeals to a group of people to justify a claim need not appeal to *all* people or even a very large group. She may appeal only to a select group. It might be a group you want to be a part of or a group you don't want to be a part of. For instance, if an advertisement appeals to "luxury" or "elegance" or something "fine," it is trying to convince you that you need to be a part of a special group, that you are elite or a VIP. The arguer is appealing to your vanity to get you to do something or believe something. For example, "All university professors believe that progressive policies are better for society." This claim implies that you should believe that progressive policies are better for society, since an envied class (intelligent, informed, dapper university professors) believes they are (well, maybe not because they're "dapper").

Similarly, if an arguer says something like, "Only an *amateur* beer-drinker would drink Pabst Blue Ribbon" or "No one of any *intelligence* would think that gay marriage is morally permissible," he is appealing to your sense of superiority over amateur beer-drinkers or unintelligent people.

These arguments all commit the fallacy of **appeal to snobbery or vanity**. If an arguer associates a belief or action with an attractive or unattractive group in order to persuade you to accept or reject the belief or perform or not perform the action, the arguer has committed an appeal to snobbery/vanity. A good argument does not depend on whether a group is well regarded or ill regarded, whether you feel superior to that group, or whether something strokes your ego. None of these are good reasons to accept or reject a belief. Be careful that you are not wooed by these tactics—some people *will* tell you anything you want to hear to get you to join their bandwagon.

Now, this fallacy is easy to mistake for an ad hominem, circumstantial fallacy. Remember, that fallacy associates a *person* (the arguer) with an *unsavory* character or set of circumstances or group in order to convince you to reject his or her claims. The appeal to snobbery/vanity associates an idea or action with a savory or unsavory *group* in order to convince you to accept or reject it or its claims.

Some textbooks include "appeals to celebrity" in this category. The idea is that, if a celebrity tries to get you to believe something—for example, if George Clooney tries to convince you that Global Warming is true—you are more likely to believe it. We take it that an appeal to celebrity is not an appeal to snobbery or vanity, but an *appeal to inappropriate authority* (we'll talk about this soon). This is because appeals to celebrity are typically about individual celebrities, and not the category of celebrities. This is a minor point, though, and secondary to your recognizing *that* appealing to someone's fame or celebrity as support for a belief is fallacious, regardless of how you categorize that fallacy.

Look at the three more examples of appeal to snobbery/vanity:

- "Only a religious fundamentalist would question Darwin's theory of evolution."
- "*Lunar Tan*—used by top supermodels!"
- "Buy ShamWow! Made in Germany!"

## *Argumentum ad Verecundiam* (Appeal to Inappropriate Authority)

Everyone loves to cite research. Advertisements for cosmetics, weight-loss supplements, car wax, and toothbrushes all cite some form of "research" that supports some claim about their product. One commercial for a diet pill actually had a piece of paper in the background with the words, "Journal of Research," written in bold at the top while the announcer explained the "amazing results!" Just after the terrorist bombings in London in 2005, a CBN (Christian Broadcasting Network) News anchor interviewed a guest, whom they labeled, "Terrorism Expert," to explain just how serious the attacks were. Political pundit Glenn Beck said repeatedly over the span of half an hour that evidence of global warming is "false science."

What do all these sources of evidence have in common? They are *not* authorities on the claim in question. The "Journal of Research" does not exist, so it can't be an authority, and even if a journal with this name existed, it's not clear why it is relevant to diet pills. It could be dedicated to agriculture or horticulture or veterinary medicine—who knows? Similarly, what is a "terrorism expert" and where does one go for these credentials? Would a radical Islamic suicide bomber count as a "terrorism expert"? Pasting these words under someone's name does not establish his authority to inform a lay audience about terrorism. And finally, Glenn Beck is not a scientist, he did not interview scientists, he did not read scientific research on the air, he cited no independent source whatsoever—he simply authoritatively pronounced a claim (made by scientists) as "false science."

To be clear, the diet pill may work, the terrorism expert may be legitimate, and global warming may, in fact, be a liberal myth. The problem is that you, as a critical thinker, have not been given *appropriate* evidence to think any of these claims are true. All three examples commit the fallacy of **appeal to inappropriate authority**. There are two ways an appeal to authority can be inappropriate: (1) the authority can be irrelevant, or (2) the authority can be biased.

If an authority is irrelevant, he or she is just not in any position to speak on the claim being evaluated. If an authority is biased, he or she pretends (knowingly or unknowingly) to be in a position of authority on the subject.

If your physics teacher drones on and on about the deplorable character development in Jane Austen novels, then it might be wise to take her opinions with a grain of salt. On the face of it, she is an *irrelevant* authority. Who cares what a scientist has to say about literature? She might be right, but you should look for independent evidence. On the other hand, if you also learn that one of her long-time hobbies is nineteenth-century literature, you can take her claims a little more seriously. In this case, she may be a relevant authority.

If a representative from the National Rifle Association (NRA) tells you that it is your constitutional right to own whatever gun you want, you should look for some independent evidence. Since the NRA is devoted to the promotion of firearm ownership, they are a *biased* authority. This does not mean they are wrong, it just means that they have a *vested interest* in promoting certain claims. This vested interest can bias their testimony, that is, it could lead them to exaggerate the truth or mislead you about a claim. This is tricky because it is not always the case. For example, the Environmental Protection Agency has a vested interest in promoting certain claims. However, it is better for them to be unbiased if they want to keep getting funding.

Consider a more difficult case. What if a publication called *The Journal of New Testament Studies* publishes an article on Jesus of Nazareth? Whether it is an appropriate authority depends on what else you know about the journal. If it is a journal that publishes based on "blind reviews" (the reviewer does not know the author's name) and its editorial board is made up of well-respected scholars who study the New Testament, then it might be a reliable source. On the other hand, if all the editing scholars are known to have a certain take on the New Testament (say, that Jesus didn't exist), or that they only publish scholars who agree with them, then the journal is less reliable—it is not an appropriate authority.

Jamie once saw a billboard with Tiger Woods wearing a Tag Heuer watch. He immediately wondered: *Why should* this *make me want to buy a Tag Heuer watch?* He decided there were two possible reasons, both fallacious. First, the billboard might have been trying to convince Jamie that he "should be like Tiger," join an elite club of celebrities who wear Tag Heuer. This would be the snob appeal twist on the *ad populum* fallacy we already mentioned: people of a select group you want to be part of believe X or do X, therefore you should believe X or do X—in this case, wear Tag Heuer. But then Jamie thought, *no one in their right minds* [snob appeal?] would really think they should (or could) be like Tiger, so he decided this was not the most likely reason.

Second, the billboard might have been trying to convince Jamie that Tiger Woods, being rich and famous, and having access to the finer things in life, has some *insight* into which things count as "finer." We are supposed to assume, implicitly, that Tiger is a connoisseur of fine watches (or at least fine things) and therefore, *recommends* Tag Heuer. But, Tiger Woods is a golfer. Golf is his realm of authority. If Tiger recommended a brand of golf clubs, fine; he's an authority. But a watch? Hardly. It's like Whoopi Goldberg telling us to vote for Barak Obama, or the Red Hot Chili Peppers telling us to *Rock the Vote!* What authority do these people have to tell us *anything* outside of their realm of expertise? The answer is: none.

So, here's the bottom line: If someone makes a claim without providing you good reasons to accept it, you should be wary. If the speaker is a relevant authority and asks you to believe on the basis of her authority, you might accept the claim tentatively (a physicist speaking about physics; a mathematician speaking about mathematics; a philosopher speaking about logic). If she is an irrelevant or biased authority and asks you to believe on the basis of her authority, she has committed an appeal to inappropriate authority. You have no more reason to accept her claim than if she didn't say anything at all.

Three more examples:

- Actor Edward Norton says: "Here's a way to save the environment: buy hybrid cars."
- "The president of General Motors recently said that American cars are built better than any of their Japanese competitors."
- "The *Journal of Paranormal Research* says that 75% of people experience psychic phenomena on a daily basis."

## *Argumentum ad Baculum* (Appeal to Force)

"If you don't make better grades, I'm cancelling your guitar lessons for a month!" This is a pretty compelling argument. Not compelling enough, we're afraid. Jamie never took guitar lessons again. Other arguments like this are much more motivating: "Clean up this mess or you're fired," "Now Timmy, a good little boy wouldn't put all his action figures in the toilet." The argument can also be made without words, for instance, when the bouncer at a bar gives you the angry death stare and points you outside. All of these arguments, compelling as they may be—you don't want to get fired, Timmy wants to be a "good little boy," you definitely don't want that bouncer to act on his inclinations—are fallacious. They all commit the ***ad baculum*** fallacy, or **appeal to force or threat** (in Latin, *argumentum ad baculum* means "appeal to the stick").

If someone attempts to persuade you to believe a claim or perform an action on the grounds that not doing so will have painful, deleterious, harmful, or otherwise bad consequences, this is an appeal to force. Appeals to force have been quite popular throughout history, for instance during the Spanish Inquisition when Jews, Protestants, and Muslims were "persuaded" to recant their religious beliefs by a machine called "the rack." And, more recently, there have been accusations that suspected terrorists have been waterboarded in an attempt to "convince" them to divulge certain information.

However successful these methods may be at eliciting the desired response, it is important to remember that the results are not necessarily related to truth. I might agree that my mother is a butterfly who likes bananas if you burn me with a red-hot iron rod over and over. Timmy might be a good little boy even if he does put his toys in the toilet and despite what his mother thinks. Arguments that appeal to evidence that do not support the truth of a claim, that is, for something you should believe or something you should do, are fallacious.

Consider these examples of the *ad baculum* fallacy (or else!):

- "Your answer on the exam was wrong. Why? I'm the professor, you're the student, and I'm the one handing out grades here."
- "I'd hate to see your career come to an end because you showed the President of sales what the Vice President of sales is up to; so, adjust the numbers."
- "I will let you go. But first I want you to say, 'I love crepes.'" [In other words: If you don't say, "I love crepes," I will break your arm. From the film, *Talladega Nights*.]

## *Argumentum ad Misericordiam* (Appeal to Pity or Other Emotions)

*Soft music is playing. A dark screen fades slowly into focus on the frowning face of a young dark-skinned little girl in tattered clothes. A fly crawls across her bottom lip, but the child doesn't respond; she just stares off in the distance. Then, a deep but gentle voice says:* "For just twenty-five cents a day, you can save a child like Cassandra from starvation." Of course, you and your (football player) roommates are crying and calling your parents to convince them to send money to Cassandra. "Less than two bucks a week, Mom! We can save lives!"

Well … maybe not.

Is it *right* that you help starving kids in Ethiopia? Probably. Should you believe this because you *feel bad*? Absolutely not. Your emotions have nothing to do with the truth of a claim. Just because you feel you deserve a new car for graduating, this does not place any moral obligation on your parents to buy you one. Just because you feel bad for criminals who are serving life in prison doesn't mean they shouldn't be there. Just because you don't like to go the speed limit doesn't mean you shouldn't. Your *emotions* have nothing to do with whether a claim is *true*. These arguments are fallacious because their premises are irrelevant to the truth of the conclusion. The conclusion might be true or false, but emotions cannot tell you which.

If someone tries to convince you that a claim is true by appealing to emotions, especially negative emotions like pity, she commits the fallacy called ***ad misericordiam*—appeal to pity**. Another way to put it is this: If someone attempts to defend a claim about someone by trying to make you feel sorry for them, he has committed the *ad misericordiam* fallacy. This also goes for any other emotions, such as "cuteness," "sexiness," "happiness," or "guilt." Cuteness is often used in advertisements for children's products.

Sexiness and happiness are often used in car commercials or beer commercials. Guilt is often used in public service announcements, for instance, about using too much electricity, second-hand smoke, greenhouse gas emissions, voting, and the like. Appeals to emotion have nothing to do with whether a claim is true, so be careful not to commit this fallacy or fall for it.

Appeals to pity show up in less conspicuous ways than in the starving kids commercials. Sometimes you can find talk shows where "noted" psychologists try to convince you and the audience that kids who have committed horrible atrocities are not *really* bad at heart, they have just had a difficult childhood and poor role models. They try to convince you to feel sorry for them and to not think they should be tried as adults or sent to juvenile detention.

Now, these cases are tricky because they can seem like *ad hominem*, circumstantial fallacies. Here's the difference: in the *ad hominem*, circumstantial fallacy, you are directed to a person's circumstances and asked to draw a conclusion about his character, positive or negative, which is then supposed to undermine or support the truth of any claim made *by* him (e.g., my dad might be the most honest person I know, but that does not mean he is always right). In the *ad misericordiam* fallacy, you are directed to a person's circumstances and asked to pity him, which is then supposed to support or undermine some claim made *about* him (e.g., "Mr. Smith can't be guilty; just look at that face. Is that the face of a stone-cold killer? I think not.").

Consider more examples of the *ad misericordiam* fallacy (Please, please, please!!!):

- "You'll support what we're saying as being true; you wouldn't want us to lose our land, would you?"
- *Student*: Please re-think my grade.
  *Professor*: But your response did not answer the question.
  *Student*: You have to change my grade. My mom will kill me if I flunk English.
- "Don't fire Jim, even if he is incompetent. He has a huge family to provide for."

## *Argumentum ad Ignorantiam* (Appeal to Ignorance)

"There's no evidence against extra-terrestrials. That means they're probably out there, somewhere!" Right? Who knows? The lack of evidence against something does not entail anything about its truth. Similarly, the lack of evidence for something does not entail anything about its falsity. An atheist may argue, “There is no evidence for God’s existence, therefore, it’s likely he doesn’t exist.” But even if he is right that there is no evidence, this tells you nothing about whether God exists. Maybe God really does require us to have faith without evidence. Lack of evidence alone is not compelling. What’s more, the theist could offer a counterargument along the same lines, “There’s no evidence that God *doesn’t* exist, therefore, it’s likely that he does.” But both of these arguments are fallacious. Though they may sound interesting, the evidence appealed to (in this case, the lack of any evidence) does not support the truth of either conclusion. Any time someone tries to convince you that a claim is true or false by *appealing to a lack of evidence against or for a claim*, they have committed an ***ad ignorantiam*** fallacy—an **appeal to ignorance**. This fallacy can be expressed in one of two argument forms:

| | |
|---|---|
| 1. There is no evidence for X. | 1. There is no evidence against X. |
| 2. Therefore, X is false. | 2. Therefore, X is true. |

Consider the following examples:

1. There is no evidence for the crime having been committed by Joe.
2. Therefore, Joe definitely, positively, absolutely didn’t commit the crime.

It still could be the case that Joe committed the crime, but that he was good at getting rid of any evidence, or others were lousy at exposing or finding the evidence. We’ll qualify this kind of reasoning in a minute, though.

1. I see nothing here to discount the possibility of you being a terrorist.
2. Therefore, you’re a terrorist.

This argument is clearly one where ignorance is appealed to. There’s a famous appeal to ignorance fallacy that occurred in 1950, when Senator Joseph R. McCarthy (Republican, Wisconsin), was asked about the fortieth name on a list of eighty-one names of people he claimed were communists working for the US Department of State. His response was, “I do not have much information on this except the general statement of the agency that there is nothing in the files to disprove his communist connections.”

This fallacy is also popular with conspiracy theorists. There are many people who believe that the terrorist attacks on the United States on 9/11 were part of a government plan to embroil the United States in a Middle-Eastern military conflict. The reasons for wanting such a conflict are various: to increase military payroll, to boost political relations with large corporations that produce military equipment, to secure more oil reserves, and so on. You might attempt to engage someone who holds beliefs like this, and attempt to explain that the terrorists who took responsibility for the attack express severe hatred for the

United States and that the consequences of anyone finding out would be more than devastating to the acting administration. If your conspiracy fan responds by pointing to pictures that apparently show bombs attached to the bottom of planes and documents apparently condoning insurrectionary activity, then you at least have some evidence to discuss. However paltry the argument, it is not fallacious. On the other hand, if your conspiracy fan responds by saying, “There’s no evidence the government wasn’t involved,” he has committed a fallacy.

Now, be careful here. Good scientific research can sometimes sound like an argument from ignorance. If a scientist says, “We found no evidence linking *x* and *y*” or “We found no evidence of cancer,” she is not appealing to ignorance. She has conducted experiments in an attempt to prove a hypothesis. There *is evidence*; it is just negative. If the experiments do not produce the hypothesized result, she has some reason to believe the hypothesis is not true. In this case, there *is* evidence; it just came up negative. An argument from ignorance would be to argue that there is no evidence of cancer *before* conducting the experiment.

Above, we mentioned this argument:

1. There is no evidence for the crime having been committed by Joe.
2. Therefore, Joe definitely, positively, absolutely didn’t commit the crime.

If we changed the conclusion to something more tentative—say, “Therefore, Joe likely didn’t commit the crime”—*and* if there really is no evidence for Joe having committed the crime, then we’re not really committing the *ad ignorantiam* fallacy. This is the kind of reasoning juries in court cases utilize when evidence (or lack thereof) is presented to them, and they need to render a verdict of guilty or innocent that any reasonable person who dispassionately and objectively considers the evidence would make. In a case like this, Joe has been prosecuted by some attorney who thinks that Joe has committed the crime, and it’s the attorney who has the so-called *burden of proof* to provide evidence for Joe’s guilt. If the attorney can’t provide that evidence because the evidence truly does not exist, then it’s likely that Joe is innocent. We’d never want to say that he’s *definitely* innocent “beyond a reasonable doubt”—in that case, we would be committing the *ad ignorantiam* fallacy.

Consider three more examples:

- You don’t have any evidence he isn’t cheating you. But you’d better start looking.
- *Student*: Ronald Reagan was a socialist.
  *Professor*: How did you arrive at *that* conclusion?
  *Student*: Show me the evidence that he wasn’t one.
- I’m not trying that new restaurant. I don’t have any reason to think I will like it.

## Getting familiar with … informal fallacies

**A. Short answer.**

1. Without looking back at the text, define the term "fallacy."
2. An informal fallacy is a mistake in the ___________of an argument.
3. Denying the antecedent is a distortion of which valid form of inference?
4. A fallacy's premises all must be false for it to be considered a fallacy in the first place.
5. Is it possible for the conclusion of a fallacious argument to be true? Explain why or why not.

**B. Use the fallacies we have discussed so far to identify the fallacy committed in each of the following arguments.**

1. "What an idiot! Mark never reads and he plays video games all day long. He is not qualified to advise the state's finance committee."
2. "Did you see that new family that just moved in? Well, there goes the neighborhood …"
3. "People who use heavy hallucinogens almost always started with marijuana, so marijuana is a gateway drug to heavy hallucinogens. And that's the main reason to ban marijuana."
4. "You should not adopt that conservative economic policy. Only greedy, blue-bloods adopt such policies."
5. Your English professor says, "Of course God exists. There's undeniable evidence for His existence."
6. "Senator McCain's plan to stimulate the economy cannot possibly benefit the working class because Mr. McCain is a Republican."
7. "It's obvious: violence in heavy metal music makes kids want to go out and commit violent acts in the real world."
8. "MonkeyTears Shampoo—used by more salons than any other all-natural shampoo. Shouldn't you shampoo this way, too?"
9. "Every swan I've ever seen has been white—in books, on TV, in the movies, on the internet—so all swans are white."
10. "That doctor smokes and drinks. It is unlikely that he can advise you about a healthy lifestyle."
11. The *National Enquirer* newspaper prints: "Monkey-boy is his own father!"
12. "If I don't get this promotion my wife will leave me!"
13. "You'll support what we're saying here, right? You wouldn't want your windows broken, would you?"
14. "You can't really expect me to believe that stealing is wrong. You steal all the time."
15. "You can't really expect me to believe that stealing is wrong. Everyone does it."

## Circular Argument (Begging the Question)

You will often hear the phrase, “that begs the question,” but few people use it the way philosophers and logicians do. This is because the phrase has come to have two uses in the English language. One is rhetorical, and means “raises the question” or “demands an answer to the question” and is typically followed by an actual question. This is the meaning you’re probably familiar with.

The other use is logical, and it means to assume a claim you are attempting to prove, that is, to present a circular argument. The latter is the phrase’s original meaning, but clever journalists co-opted it for rhetorical purposes, and now both meanings are accepted. We, however, will only use the logical meaning—a circular argument.

The fallacy of **circular argument,** or **begging the question**, is an argument that includes or implies the conclusion in the premises. In other words, any time someone assumes in the premises, implicitly or explicitly, a claim being supported in the conclusion, he or she has committed the fallacy of begging the question. For example:

1. Given that Sally is honest.
2. We know we can trust her to tell the truth.

In this argument, the conclusion is already assumed in the premises. The arguer assumes that Sally is honest in order to support the claim that she is honest! This is also called a “circular” argument for obvious reasons

1. Given that Sally is honest.
2. We know we can trust her to tell the truth.

What supports the fact that we can trust Sally to be honest? Sally’s honesty. And what does Sally’s honesty demonstrate? That we can trust her to be honest. Round and round and round it goes, forming (metaphorically) a circle.

Now, you might wonder: why in the world would anyone construct such a foolish argument? It’s actually much easier to commit this fallacy than you might think. Consider a subtler version of this fallacy. Imagine someone attempts to convince you that God exists by giving you the following argument:

1. The Bible says God exists.
2. <u>The Bible is true because God wrote it.</u>
3. Therefore, God exists.

The arguer is attempting to prove that God exists. But if God wrote the Bible, then God exists. So, God's existence is implied in the second premise, the very claim the arguer is trying to support in the conclusion. The next example is even subtler:

1. Abortion is unjustly taking an innocent life.
2. Therefore, abortion is murder.

In this argument, someone is attempting to convince us that abortion is murder because abortion is unjustly taking an innocent life. But "unjustly taking an innocent life" is pretty darn close to a definition of murder. So, really the argument looks like this:

1. Abortion is (unjustly taking an innocent life) murder.
2. Therefore, abortion is murder.

In addition to question-begging arguments, there are question-begging *sentences*. These sentences assume a claim that has yet to be supported. For instance, the question: "Have you stopped beating your wife yet?" presupposes that you have, at some point in the past, beaten your wife. Answering either yes or no commits you to this claim even if it is not true. Unless there is already evidence that you beat your wife, this question begs the question (Hah! A question-begging question!). Here, this is really what is known as the **loaded question fallacy** (or complex question, misleading question). Another example is: "Will you continue to support unnecessary spending?" This question presupposes that you have been supporting unnecessary spending. Again, answering either yes or no commits you to this claim even if it is not true. Unless there is evidence that you supported unnecessary spending, this question begs the question.

To sum up: if an argument presupposes or assumes in the premises the claim being supported as the conclusion, the argument begs the question. Similarly, if a sentence presupposes a claim that has not yet been established, that claim begs the question. Here are three additional examples:

- "I believe Professor Williams that *X* is true. Look; it's even in his textbook on page 322!"
- "Of course the government should provide health care for all citizens. Health care is a basic human right."
- An illegal abortion is the termination of a pregnancy during the last trimester which does not meet the requirements of a legal abortion. (Florida abortion statute.)

## Straw Person

Imagine that two boxers enter a ring to fight and just before the fight begins, one of the boxers pulls out a dummy stuffed with straw that's dressed just like his opponent. The boxer pummels the dummy to pieces, and then struts around as if he was victorious and leaves. Clearly no one would accept this as a legitimate victory.

Now imagine that two politicians are debating in front of a large crowd. One politician puts forward her argument X. The other politician responds by subtly switching X to a much-easier-to-reject X* (which is a superficial caricature of X) and proceeds to offer a compelling argument against X*. Everyone in the crowd cheers and agrees that X* is a bad argument and should be rejected. Has the second politician given good reasons to doubt X? Surely not. He has simply committed a fallacy known as the straw person.

A **straw person** fallacy is an argument in which an arguer responds to a different, superficially similar argument (X*) than the original one presented (X), though he treats it (X*) as the one presented (X). The superficially similar—and hence irrelevant—argument is then shown to be a bad one in some way (either one or all of the premises is/are shown to be false, or a fallacy is pointed out). It often looks something like this:

- Nikki argues that we should lower taxes on wine in the county because this will stimulate the local economy (this is the "real man" argument).
- Rajesh explains that wine is addictive, and that addiction ruins people's lives, and that, in suggesting that we lower wine taxes, Nikki is promoting alcoholism (this is the "straw person" argument).
- Rajesh concludes, since no one wants to promote alcoholism, we should not lower wine taxes.

Rajesh has turned Nikki's argument into something very different than it was originally—something easy to object to.

If the alternate argument is subtle enough, it is easy to be deceived by a straw person. Politicians often use straw person arguments to rally voters against their opponents. For instance, during the American invasion of Iraq, members of the Republican Party in the United States disagreed with members of the Democratic Party in the United States about the duration of the American occupation. Democrats accused Republicans of supporting an unqualified "stay-the-course" campaign, which would lead to great financial and political losses. Republicans accused Democrats of supporting a "cut-and-run" campaign, which would leave Iraq in political, social, and religious chaos. Notice that an extreme position is easy to "knock down"—so to speak—since no reasonable person really ever goes for extreme positions. Thus, each side was painting the other's argument as a superficially similar, much-easier-to-reject caricature of what they really were advocating. Interestingly, neither side advocated either of these extreme positions. Each committed the straw person fallacy against the other.

Consider a comment American political pundit Rush Limbaugh made on his radio show on January 15, 2009: "Joe Biden also said that if you don't pay your taxes you're unpatriotic. You're paying taxes, you're patriotic. It's a patriotic thing to do. Paying increased taxes is a patriotic thing to do, so I guess we're to assume under Biden's terminology that Tim Geithner was unpatriotic."

To be sure, Tim Geithner *might* have been unpatriotic to ignore several thousand dollars of tax debt, but this is not what Biden said. Biden was referring to the higher taxes for wealthy citizens proposed by then presidential hopeful, Barack Obama. The online news site MSNBC reported Biden's actual words in an article from September 18, 2008: "Noting that wealthier Americans would indeed pay more, Biden said: 'It's time to be patriotic … time to jump in, time to be part of the deal, time to help get America out of the rut.'" This is quite different from, "If you don't pay your taxes you're unpatriotic." Limbaugh gets it right the second time: "Paying increased taxes is a patriotic thing to do." But then he conflates *paying taxes* with *paying increased taxes*: "I guess we're to assume under Biden's terminology that Tim Geithner was unpatriotic." Geithner didn't pay at all, and Biden didn't comment on whether this was unpatriotic (though Biden supported Geithner's appointment as US Secretary of the Treasury). Therefore, Limbaugh has set up a straw person against Biden.

Here are more examples of the straw person fallacy:

- "Governor Cousino objected to the board's proposed increase of the school janitorial budget. In doing so, he denied a clear promise he made during his campaign to increase the quality of education in this state. Governor Cousino cares very little about education; you should not re-elect him."
- "Mr. Camacho argues that the potholes in the roads can wait until next season because the crack in the dam is a financial liability to the community. Mr. Camacho is saying that the welfare of this community's drivers is less important than its financial stability. You cannot vote for this man."
- "I talked to Neera this morning, and they said that the economic crisis was caused by people agreeing to loans they could not afford. But surely people know whether they can afford a home or not. Neera can't seriously think those people didn't know they might foreclose. I don't believe Neera."

## Red Herring

Google Chewbacca Defense and you'll be directed to "Chef Aid," a classic *South Park* episode with its cartoon Johnnie Cochran's "Chewbacca Defense," a satire of attorney Cochran's closing arguments in the O. J. Simpson case. In the episode, Alanis Morissette comes out with a hit song "Stinky Britches," which, it turns out, Chef had written some twenty years ago. Chef produces a tape where he's performing the song, and takes the record company to court, asking only that he be credited for writing the hit. The record company executives then hire Cochran. In his defense of the record company, Cochran shows the jury a picture of Chewbacca and claims that, because Chewbacca is from Kashyyyk and lives on Endor with the Ewoks, "It does not make sense." Cochran continues: "Why would a Wookie, an eight-foot-tall Wookie, want to live on Endor with a bunch of two-foot tall Ewoks? That does not make sense … If Chewbacca lives on Endor, you must acquit! The defense rests."

We laugh at Cochran's defense because it has absolutely nothing to do with the actual case. It is satire because it parallels Cochran's real defense regarding a bloody glove found at the scene of Simpson's ex-wife's murder. The glove didn't fit O. J., so Cochran concluded that the jury must acquit him … ignoring many other relevant pieces of information. The glove and the Chewbacca Defense are examples of the **red herring** fallacy, which gets its name from a hunting dog exercise in which ancient hunters, trying to discern the best trail hunters, would use strong-smelling red herring fishes in an attempt to throw dogs off the trail of a scent. In a red herring fallacy, someone uses claims and arguments that have nothing to do with the issue at hand in order to get someone to draw a conclusion that they believe to be true. So, the claims and arguments are the "red herrings" they use to throw you off the "trail" of reasoning that would lead to another, probably more appropriate, conclusion altogether.

A common example of a red herring happens almost daily in our more intimate relationships when someone A points out a problem or issue with someone B and B responds to A by pointing out some problem or issue that A has. Consider this exchange:

**Mary:** Bob, you're drinking too much and I think you should stop because it's affecting our relationship.

**Bob:** Oh yeah. Let's talk about some of *your* problems. You spend too much money!

Notice that Bob has used the "Let's talk about you" move as a red herring to avoid Mary's concerns, and her argument altogether.

Here are more examples of the red herring fallacy:

- "I know that it's been years since our employees got a raise, but we work really hard to provide the best service to our customers."
- Mario: That nuclear plant they're putting in may cause cancer rates to rise in our area.

  Hector: But look at all of the jobs it'll bring us.
- Professor: Let's talk about your poor attendance thus far in class, Jim.

  Jim: But I have gotten so much out of the classes I *have* attended. For example, your awesome lecture on existential nihilism was thoroughly enlightening.

## Slippery Slope

The **slippery slope** fallacy occurs when one inappropriately concludes that some further chain of events, ideas, or beliefs will follow from some initial event, idea, or belief and, thus, we should reject the initial event, idea, or belief. It is as if there is an unavoidable slippery slope that one is on, and there is no way to avoid sliding down it. Consider this line of reasoning which we often hear:

> If we allow a show like *Nudity and Drugs* to continue on the air, then it will corrupt my kid, then it will corrupt your kid, then it will corrupt all of our kids, then shows like this one will crop up all over the TV, then more and more kids will be corrupted, then all of TV will be corrupted, then the corrupt TV producers will corrupt other areas of our life, etc., etc., etc. So, we must take *Nudity and Drugs* off the air; otherwise, it will lead to all of these other corruptions!

We can see the slippery slope. It does not follow that the corrupt TV show will corrupt other areas of our life. Suddenly, we're at the bottom of a bad slope! What happened?

In a famous article from 1992 in *The Hastings Center Report* titled "When Self-Determination Runs Amok," bioethicist Daniel Callahan argues against euthanasia by making this claim: "There is, in short, no reasonable or logical stopping point once the turn has been made down the road to euthanasia, which could soon turn into a convenient and commodious expressway." Here, in absence of empirical evidence causally connecting euthanasia with these consequences, Callahan has committed the slippery slope fallacy here—it seems that there could be *many* reasonable *and* logical stopping points on the road to euthanasia.

Here are three additional examples:

- "Rated M for Mature video games should be banned. They lead one to have violent thoughts, which lead to violent intentions, which lead to violent actions."
- "Look, if we pass laws against possessing certain weapons, then it won't be long before we pass laws on *all* weapons, and then other rights will be restricted, and pretty soon we're living in a Police State! Let us have our weapons!"
- "I would just stay away from sugar altogether. Once you start, you can't stop … and pretty soon you're giving yourself insulin shots."

## False Dilemma

A **false dilemma** (also called the **either/or fallacy**) is the fallacy of concluding something based upon premises that include only *two* options, when, in fact, there are three or more options. We are often inclined to an *all or nothing/black or white* approach to certain questions, and this usually is reflective of a false dilemma in our thinking. In many cities and counties in the United States, for example, they will ban altogether Christmas trees, Nativity scenes (showing the baby Jesus in the manger), or the Ten Commandments in front of public buildings like courthouses because people reason:

1. "To be fair, we either represent *all* religions in front of the public building (something Christian *as well as* something Jewish, a star and crescent of Islam, a black, red, and green flag representing Kwanza, etc.), or we represent none."
2. <u>"We don't want to, or can't, represent all religions in front of the public building."</u>
3. So, we will represent no religions.

But what about a third option? Could the public building *include* a few religious traditions, instead of *excluding* all of them? Maybe checking to see which religions in the city have the most adherents and putting up physical symbols to represent only those religions? Or perhaps, the city need not do anything at all; it could simply let adherents of religious traditions set up a small token to their tradition themselves. Also, why think people have to be "fair" all the time? What if someone were offended? And why think exclusion is always *un*fair?

Here's another common example. If you're not an auto mechanic, you may go out to your car one day, try to start it, realize it won't start, and think: "Ok, either it's the starter that's the problem or it's the battery that's the problem." You check your lights and your radio—they both work, and so you immediately infer: "Well, it's not the battery that's the problem. So, it must be the starter." In argument form, it looks like this:

1. Either it's the starter that's the problem or it's the battery that's the problem.
2. It's not the battery that's the problem.
3. Therefore, it's the starter that's the problem.

Be careful here. If you're no auto mechanic, don't go running out to buy a starter just yet. Given your limited knowledge of cars, it may be something else altogether that's the reason why the car won't start. It could be some other part of the car that's the problem (option C) or it could be the starter and some other part of the car together (option D) that's the cause of the car not starting. The above actually happened to Rob, and after his car was towed to the mechanic shop, he confidently said to the auto mechanic: "It's the starter that's the problem." However, he was wrong, and had reasoned fallaciously that it was only one of two options. It turned out to be a spark plug issue.

The lesson here is always try to make sure you've considered any and all options when reasoning through a problem, situation, set of circumstances, or argument so that you avoid committing this fallacy. Here are a few more examples:

- "The prison conditions issue seems to be polarizing folks. One side says that prisoners should have all of the luxuries of a spa, while the other thinks that they should have a cot and a 'pot to piss in,' to use an old expression. Well, I think that they shouldn't live in the lap of luxury; so, let them have their cots and pots!"
- "If we let the Neo-Nazis march, there'll be violence in the streets. If we don't let them march, we're violating their right to free speech. Preventing violence is our number one priority, so I see no alternative but to not let them march."
- I heard a member of the Taliban say in an interview: "Either you're aligned with the will of Allah, or you're a wicked person."

## Composition and Division

Rob was in a conversation with his friend Jim one time about the fact that Jim liked cooked onions, mushrooms, and hamburger, but he hated a meatloaf made up of all of these things together. Rob found this puzzling and challenged

Jim's tastes, but Jim's response was, "Hey, I like them each individually, but it's totally different when they're all combined. The taste is weird." The **fallacy of composition** occurs when one draws an inappropriate conclusion about the *whole* from premises having to do with the facts or features of some *part* of the whole. Basically, Rob was committing this fallacy by thinking that because Jim liked each part that made up the meatloaf, he would necessarily like the whole meatloaf. Here are some examples:

- "A few screws aren't heavy; a piece of wood that size isn't heavy; metal like that isn't heavy. I'll be able to lift that old-fashioned school desk easily."
- "You ever see a lion eat? That sucker can chow down quite a lot. So I bet that lions, as a species, eat more than humans do on a yearly basis."
- "Look, that law worked perfectly fine in Dougal County. So it should work just as well at the state level."

The **fallacy of division** reverses the part-to-whole relationship just mentioned and occurs when one draws an inappropriate conclusion about some *part* of the whole from premises having to do with the facts or features of the *whole* itself. A classic example of this fallacy is recounted in a book from 1884 by John Masson, *The Atomic Theory of Lucretius Contrasted with Modern Doctrines of Atoms and Evolution*, where he discusses the pre-Socratic philosopher Anaxagoras (*ca*. 510–428 BCE):

> Anaxagoras and the Peripatetics held that the parts of a body are in every respect similar to the whole; that flesh is formed of minute fleshes, blood of minute drops of blood, earth of minute earths, gold, water, of minute particles of gold and water. This doctrine (with other similar ones) was called in later times *homoiomereia*, that is, the "likeness of parts (to the whole)."

Anaxagoras hypothesized that the characteristics, features, or qualities of whole things he saw around him must also be present in the parts that make up the wholes—a somewhat sensible assumption at the time, but we know better now.

The same kind of fallacious reasoning occurred for some 2,000 years with the idea of a *homunculus*, which is Latin for "little man." People thought that a fully formed—but incredibly small—man or woman was present in the man's sperm, and that this little person would grow inside of the woman's womb. Again, a sensible assumption at a time before electron microscopes and other advanced devices we use to investigate the microscopic world. Here are more examples of the fallacy of division:

- Tea with milk doesn't aggravate my lactose intolerance condition, so I guess milk by itself won't aggravate it.

- The University was implicated, so you know the Assistant Dean of Students' job is on the line.
- The Kansas City Royals' record was lousy last season; every member of the team must have had a lousy record.

It should be noted that it is not always fallacious to draw a conclusion about the whole based upon the properties of the parts, nor is it always fallacious to draw a conclusion about the parts of a whole based on the properties of the whole. Consider a field biologist who discovers a wholly new kind of beetle X with unique features A, B, and C. She then comes across several more beetles with unique features A, B, and C. Not only can she rightly categorize these as a new kind of species—namely, "beetle species X" (legitimate part-to-whole reasoning)—but she also can rightly conclude that the next instance of beetle X she comes across will likely have features A, B, and C (legitimate whole-to-part reasoning). This is an argument from analogy (see Chapter 8). The key here is the relationship between the parts and the wholes. In the case of taxonomy, species are sometimes defined by their parts, so there is a presumption that the parts and wholes are related in that relevant way. But see Chapter 8 for ways that analogies can go wrong.

## Exercises

**A. In each of the following exercises, identify the informal fallacy that is committed, and explain why each is an example of that fallacy.**

1. "Mr. Bush regularly works on his ranch and goes hunting. He is a down-to-earth, regular guy, just like you. You should vote for Bush for President."
2. "How could a blue-collar, state-college graduate responsibly protect the company's investments?"
3. Your math professor says: "You should be buying government bonds. They're really a good investment right now."
4. *Jury Foreperson*: "Listen people, we've been here for a month. Do you want to spend another month here? Let's find him guilty of the crime already!"
5. *Attorney*: "That guy's a sex offender. Why should you believe anything he says?"
6. *Barrister*: "My client is the victim of incest himself. How can you convict him of this crime of incest?"
7. "My doctor says the tests showed no cancer. So, I'm cancer-free!"
8. Your parents say: "Einstein's theory of special relativity is a load of bunk."

9. "I've known Mr. Smith for twenty years. He is a good, hard-working person. He is a deacon in his church and a good husband. There is no way he could have murdered Congressman Dooley."
10. "You support universal health care? That idea has been supported by God-hating liberals for the last fifty years."
11. "Jones is a left-wing, fascist pig. Falsehoods drip from his mouth like honey from a comb."
12. "It is immoral to assign grades according to relative student performance. Grading on a curve does just that! Therefore, grading on a curve is immoral."
13. "Jenny, you can't possibly believe that premarital sex is wrong. You've done it, like, a hundred times!"
14. "Everyone else is having sex. Therefore, I should be having sex, too."
15. "The *Journal of Psychic Research* showed that remote viewing was used successfully in military operations during the Cold War."
16. "Biologists argue that humans and chimpanzees share a common ancestor. But it is foolish to think that humans evolved from chimps. The theory of evolution says that new species are selected because they are better suited to their environments than their predecessors. So if humans evolved from chimps, the chimps would have gone extinct. Since there are still chimps, it is absurd to think we evolved from them."
17. "All the reports of alien abductions come from people of exceptionally low intelligence. This is further supported by the fact that they make claims about alien abductions."
18. "Are you still cheating on your exams?"
19. *Cop to suspect*: "Tell the truth now and it'll be easier on you later. Keep on lyin' and I'll make it even harder on you."
20. "Environmentalists think that the pipeline will be bad for the environment, but look at all of the jobs it will bring to the associated areas where the pipeline functions.
21. "The surgeon general says that smoking is linked to cancer. But I know lots of people who smoke and don't have cancer. So, it easy to see that it is false that *everyone* who smokes will get cancer. Thus, the surgeon general is just wrong."
22. We either nuke that country, or we continually deal with the terrorist attacks against our people all over the world.
23. "All the reports of alien abductions come from people of exceptionally low intelligence. This is further supported by the fact that they make claims about alien abductions."
24. That evolutionary principle works at the population level, so it affects each and every member of that species.
25. Dale Earnhardt, Jr. says: "I only drink Budweiser." [Of course, this is before he dropped their endorsement.]

26. "Introducing the Lexus HS 250h: The World's Only Dedicated Luxury Hybrid." (Found on the Lexus website.)
27. *Child*: "Why do I have to do it?"
    *Mother*: "You will not be happy if you don't!"
28. Of course aliens exist. There is no evidence that they don't exist!
29. "*GatorAde—is it in you?*"
30. "No one has ever shown me any evidence for evolution. Therefore, it must be false."
31. "Of course we should invade Austria. Everyone thinks so!"
32. "These diamonds would really set you apart. Your family would be so jealous. You should get them!"
33. "All of the evidence points to a correlation between eating fast food and obesity. You should probably not eat very much of that, if any."
34. "You know you shouldn't believe your brother about those investments. He is the most self-centered, arrogant jerk on the planet."
35. "I really can't believe my pastor that adultery is really all that bad. I mean, he had an affair for goodness sake!"
36. "Oh, honey, we should help that man. Because … well, just look at him. He's so sad and lonely. I bed he could use some money."
37. "Neil DeGrasse Tyson, a well-respected physicist, says that the universe is around 13 billion years old. So, that's what I believe, too."
38. "My Aunt Tilley, a noted horticulturist, says that the universe is around 13 billion years old. So, that's what I believe, too."
39. "Of course scientists are right about the age of the universe! They're scientists for crying out loud!"
40. "The current administration wants to cut funding for military airplanes. But this is a wonton disregard for national security. Anyone who cares about the safety of our country should be outraged."

**B. Read the following dialogue, and identify as many fallacies as you can.**

**Jimmy**: "You shouldn't have cheated on that exam."

**Rick**: "What are you talking about?"

**Jimmy**: "You studied with Casey, and then used her notes on the exam."

**Rick**: "Hey: you're no saint, either, you know."

**Jimmy**: "Fine. But we're not talking about me. It was a rotten thing to do."

**Rick**: "What do you know about things that are "rotten"? Every member of your family is known for being cheats!"

**Jimmy**: "All I'm saying is that we all know that cheating is dishonest and that dishonesty is immoral."

**Rick**: "Look, everyone does this. This is part of getting through college."

**Jimmy**: "Maybe. But a lot of people take cheating very seriously. They think it implies that you have a bad character."

**Rick**: "Why should it reflect on my character? Look, Jimmy, humans are mammals. Mammals do what they have to to survive. If cheating is part of it—then cheaters are more successful in nature."

**Jimmy**: "That doesn't make sense. There is no evidence that cheating is morally permissible. Therefore, you shouldn't do it."

**Rick**: "That's ridiculous! There is no evidence that there *aren't* space aliens, either, but that doesn't mean I believe in them."

**Jimmy**: "Well you at least can't deny that it's wrong to mislead someone."

**Rick**: "Why?"

**Jimmy**: "Because if you don't, I'm going to reveal your dishonestly to the administration. You wouldn't want that, now would you!?"

**Rick**: "Wait a minute. I think I just learned about this. Isn't that the fallacy of …"

## Real-Life Examples

### 1. The National Center for Science Education

**Find and explain at least three potential fallacies in the following article from the website of the National Center for Science Education (NCSE). This article is part of a larger discussion about the state of Texas's right to dictate the information about evolution in their biology textbooks. Note that there may be fallacies both from the author as well as those quoted, so be careful to note who is committing the fallacy.**

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"Consequences of the Flawed Standards in Texas?"
National Center for Science Education
April 17, 2009, http://ncse.com/news/2009/04/consequences-flawed-standa rds-texas-004735.

Since the March 2009 decision of the Texas state board of education to adopt a set of flawed state science standards, media coverage has increasingly emphasized the possible consequences. As NCSE previously reported, although creationists on the board were unsuccessful in inserting the controversial "strengths and weaknesses" language from the old set of standards, they proposed a flurry of synonyms—such as "sufficiency or insufficiency" and "supportive and not supportive"—and eventually prevailed with a requirement that students examine "all sides of scientific evidence." Additionally, the board voted to add or amend various standards in a way that encourages the presentation of creationist claims about the complexity of the cell, the completeness of the fossil record, and the age of the universe. The result, NCSE's executive director Eugenie C. Scott commented, was "a triumph of ideology and politics over science."

The board's antics seem to have caught the attention of legislators in Texas. There are now no fewer than six bills in the Texas legislature — … — that would reduce the state board of education's power. As the *Wall Street Journal* (April 13, 2009) reported, "The most far-reaching proposals would strip the Texas board of its authority to set curricula and approve textbooks. Depending on the bill, that power would be transferred to the state education agency, a legislative board or the commissioner of education. Other bills would transform the board to an appointed rather than elected body, require Webcasting of meetings, and take away the board's control of a vast pot of school funding." To be sure, it is not only with respect to evolution that the board's actions have been controversial, but the recent decision about the state science standards seems to have been the last straw.

Gaining the most attention recently is SB 2275, which would transfer authority for curriculum standards and textbook adoption from the board to the Texas Commissioner of Education; the bill received a hearing in the Senate Education Committee on April 14, 2009. The *Dallas Morning News* (April 15, 2009) reported that one of its sponsors, Senator Kel Seliger (R-District 31), told the committee, "The debate [over the science standards] went on with almost no discussion of children," adding, "The fact is there is nothing that makes the board particularly qualified to choose curriculum materials and textbooks." The Texas Freedom Network's Kathy Miller was among the witnesses at the hearing testifying to "the state board's unfair processes, divisive ideological history and outright ineptitude." Texas Citizens for Science's president Steven Schafersman (the *Houston Chronicle*'s Evo. Sphere blog on April 14, 2009) and the *Waco Tribune* (April 17, 2009, editorial) have both expressed their support for the bill.

Unless such a bill is enacted, it seems likely that the board will pressure textbook publishers to dilute the treatment of evolution in the biology textbooks submitted for adoption, probably in 2011. As Lauri Lebo explained in a story on Religion Dispatches (April 14, 2009), "With almost $30 million set aside in the budget, Texas is second only to California in the bulk purchase of textbooks. But Texas, unlike California, approves and purchases books for all the state's school districts. Publishers often edit and revise textbooks in order meet the specific demands of the Texas board members." NCSE Supporter Kenneth R. Miller, coauthor (with Joe Levine) of several widely used textbooks published by Prentice-Hall, told the *Wall Street Journal* that "We will do whatever we think is appropriate to meet the spirit and the letter of Texas standards," but firmly added, "We will never put anything in our books that will compromise our scientific values."

## 2. A *New York Times* Op-Ed

**In an interesting *New York Times* op-ed piece ("op-ed" means "opposite the editor," which means the article does not reflect the opinion of the publication), sociologist T. M. Luhrmann argues that Western "individualism" may be more a function of our social heritage than reasoned argument. But he makes some questionable claims along the way. Read through the following excerpt to see if you find any fallacies.**

* * * * *

"Wheat People vs. Rice People: Why Are Some Cultures More Individualistic Than Others?"

T. M. Luhrmann

*New York Times*, December 3, 2014, http://www.nytimes.com/2014/12/04/opinion/why-are-some-cultures-more-individualistic-than-others.html?smid=fb-share&_r=1

…

In May, the journal *Science* published a study, led by a young University of Virginia psychologist, Thomas Talhelm, that ascribed these different orientations to the social worlds created by wheat farming and rice farming. Rice is a finicky crop. Because rice paddies need standing water, they require complex irrigation systems that have to be built and drained each year. One farmer's water use affects his neighbor's yield. A community of rice farmers needs to work together in tightly integrated ways.

Not wheat farmers. Wheat needs only rainfall, not irrigation. To plant and harvest it takes half as much work as rice does, and substantially less coordination and cooperation. And historically, Europeans have been wheat farmers and Asians have grown rice.

The authors of the study in *Science* argue that over thousands of years, rice- and wheat-growing societies developed distinctive cultures: “You do not need to farm rice yourself to inherit rice culture.”

…

I write this from Silicon Valley, where there is little rice. The local wisdom is that all you need is a garage, a good idea and energy, and you can found a company that will change the world. The bold visions presented by entrepreneurs are breathtaking in their optimism, but they hold little space for elders, for long-standing institutions, and for the deep roots of community and interconnection.

…

Wheat doesn’t grow everywhere. Start-ups won’t solve all our problems. A lone cowboy isn’t much good in the aftermath of a Hurricane Katrina. As we enter a season in which the values of do-it-yourself individualism are likely to dominate our Congress, it is worth remembering that this way of thinking might just be the product of the way our forefathers grew their food and not a fundamental truth about the way that all humans flourish.

# part four

# Application

**In Chapters 11 and 12, you will have additional opportunities to apply the critical thinking skills you've learned in this book to real arguments. In Chapter 11, we introduce the problem of fake news, misinformation, and disinformation, and we discuss some closely related concepts, like satire and propaganda. In Chapter 12, we discuss the complicated problem of conspiracy theories. Bad conspiracy theories tend to fall apart, and so there's little need to worry about them. Good conspiracy theories are "self-insulating," in the rational sense, and thus tend to repel traditional strategies for evaluating them. We will explore some of the best available strategies for recognizing and avoiding conspiracy theories.**

# Thinking critically about fake news

11

**Here, we discuss a relatively new problem in the history of critical thinking: fake news. We explain what fake news is, identifying different types and distinguishing them from real news. We offer some tips and strategies for identifying and avoiding fake news, and then compare fake news to some older phenomena, such as parody and propaganda.**

## Fake News: Misinformation and Disinformation

Information is powerful. It includes ideas, concepts, and claims—all the things we've been reasoning about in this book. But information is a tool that can be used well or poorly. When used well, it can warn us of severe weather, so we can take shelter quickly. It can tell us what illness we have so that we can get the right treatment and get better. Good information can also help us make sound financial and political decisions. But in some cases, information is used poorly. It might contain false claims: "The 1969 moon landing was faked," "The MMR vaccine causes autism." These claims are influential but

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This chapter has benefitted greatly from Justin McBrayer's book, *Beyond Fake News: Finding the Truth in a World of Misinformation* (London: Routledge, 2021).

dangerous. They are examples of "disinformation" because they are false, and because they *dis*tract audiences. They turn people away from the truth and toward false claims or irrelevant information.

Information can also be manipulated to convey something true while leading you to believe something false: "Masks are Not Effective against Sars-COV-2." This headline turns out to be true for some types of masks but false for others, and it suggests there is some minimum level of "effective" that is agreeable to everyone. If we take it at face value, however, we might believe that *no* masks are effective against the virus. This is an example of "misinformation" because it "misleads" audiences from a more accurate view of the world. Other examples include "click bait" headlines that suggest one thing while actually saying something completely different. Consider the headline: "3 Reasons Why You Should Stop Eating Peanut Butter Cups!" The title suggests that you should stop. But if you read the article, the three concerns apply only in rare cases where people are sensitive to some of the ingredients, and it isn't clear how many peanut butter cups those people would have to eat before those effects took place. The article even ends with a recipe for making peanut butter cups!

Information can also be harmful. People who opposed vaccine mandates during the Covid-19 pandemic—for whatever reason—often did not adequately weigh their concerns against the costs of loss of health, financial stability, and lives that those mandates were aimed at offsetting. Claire Wardle calls information that's true but harmful "malinformation" (because "mal" is Latin for "bad"). The phenomenon of "revenge porn" is another example of information that is true but harmful.

So, what is "fake news"? Though there is still some controversy over how to precisely define it, we will follow philosopher Axel Gelfert (2018) and say it is "the deliberate presentation of (typically) false or misleading claims as news, where the claims are misleading *by design*" (85–6, italics his). In other words, "fake news" is intentional disinformation or misinformation. Note that there's nothing "fake" about malinformation. It does not deceive, nor does it aim to deceive, so we will set it aside for this chapter.

There are many different kinds of fake news. It can take the form of *propaganda* (which is fake news that supports certain political positions), *hoax websites* (websites created to distribute fake news), *fake social media accounts* (accounts that pretend to be people they are not), *born digital images* and *deep fakes* (images and videos that have been manipulated so well that it is almost impossible for non-experts to tell), and *fake news websites* (websites that pretend to be news sites, but that use outrage and hyperbole to distribute fake news).

## What Is Real News?

If fake news is disinformation or misinformation, what is plain old *news*? To understand why fake news is fake, we need a sense of what it's not, namely, *real news*. We might think that "real news" is just the presentation of objective facts by journalists who are committed to giving audiences the truth. Traditionally, journalists have been held to rigorous standards. Their stories were fact-checked by other writers and editors, their sources checked for accuracy and credibility. The goal was to minimize bias as much as possible to provide complete, relevant, and fact-based information to their audiences.

Unfortunately, things have never been this simple or straightforward. Even the best-intentioned news agencies have to make hard decisions about what information to publish and how to present it. The process of "filtering" information, that is, deciding what should be in a newspaper or newscast, has always been part of the news. One reason is that there has always been too much to report—if not in your hometown, then in the surrounding country or world. Why do Americans hear more news about Russia and France than Chile and Argentina, even though Chile and Argentina are closer to us? Because news agencies and public interest has led them to filter in favor of Russia and France.

Another reason is that news stories have to be framed by their audience's background knowledge and history, and this presupposes a certain way of viewing that history. A news agency could not report coherently about states tearing down US Civil War statues if it were not widely understood that the war's motivations were based largely in commitments that enslaved and oppressed Africans and African Americans.

Yet another reason the traditional news story is not simple is that some news has two aims, giving information and giving social commentary. The most common example of this dual-aimed news is satire. Satire focuses on current events and does try to provide at least a foundation of facts upon which to build their satirical commentary. It couldn't serve its function as humor and social commentary if there weren't a nugget of truth in it. But satire diverges from traditional news broadcasts in that it is not supposed to be taken as actual news. Popular satire news sites have included *The Daily Show*, *The Colbert Report*, *The Onion*, and *The Babylon Bee*. Programs like *The Daily Show* market themselves as entertainment and comedy first and "newscasters" and "journalists" only jokingly. What's interesting is that many Americans now choose to get news from satire sources, some, for example, preferring *The Daily Show* over *CNN*. Importantly, satirical news sources are not appropriately classified as "fake news" because their satirical purpose is clear—they are not engaged in disinformation or misinformation because they do not pretend to be presenting unbiased news. They are "fake" only in that they *look like real news broadcasts but aren't*. Since audiences are in on the joke, they're not "fake news" in our sense.

But putting aside transparency and good intentions, news agencies and reporters have always competed with one another for publicity and sales. As far back as the 1890s, some journalists began using sensationalized headlines and language to sell stories, a phenomenon that came to be called "yellow journalism," a term that some believe derived from a character in the comic strip *Hogan's Alley* (1895–1898). The field of advertising arose around the same time as corporate news, and news agencies immediately adopted the new advertising techniques to make their stories more attractive than their competitors'. In recent decades, news agencies have taken "attractiveness" literally, hiring good-looking anchors and multi-media specialists to create news segments that rival Hollywood films. Presenting the news became a distinct form of entertainment.

One of the most striking developments in the history of journalism came in 1996, when conservative businessman Rupert Murdoch cofounded *Fox News* for the express purpose of promoting conservative values and interests. The goal of Fox News was to present information with a strong conservative bias while pretending to be just another corporate news network. They adopted slogans like "fair and balanced" and "no spin zone," while explicitly doing the opposite. Not only did *Fox* look for attractive anchors, like other agencies, they hired professional models and trained them to be anchors. Tom Nichols explains that *Fox News* "made the news faster, slicker, and, with the addition of news readers who were actual beauty queens, prettier" (2017: 153). The only way for other corporate news agencies to compete was to play the game in the other direction. In the wake of *Fox News*, corporate news outlets became increasingly divided according to their political affiliations, with the *Weekly Standard* and the *Wall Street Journal* joining *Fox News* on the conservative side and MSNBC and the *Washington Post* promoting liberal political ideas. The rise of what's now known as "partisan news" has raised questions about the integrity of journalistic fact-checking. Look up the "Media Bias Chart" at adfontesmedia.com for a more detailed breakdown of media bias.

On one hand, this shift has some positive implications. It reminds us that no news is purely neutral. Everyone has an interest in some stories over others and some angles over others. It's why the United States reports more news about, say, England, and less news about, for example, Chile. All news outlets exert a gatekeeping role on information. But this also opens the door to a greater variety of information—different perspectives on different issues that can, in principle, help individuals live and participate in their communities better. And the internet has made it easy and inexpensive for many different perspectives to be represented in public spaces. This is sometimes called the “democratization” of news, where news outlets represent public opinion much the way politicians are supposed to. On the other hand, some voices are louder and more influential than others. And some bad information has detrimental effects on society.

What this shows is that fake news is not the only problem that critical thinkers face when trying to find reliable news stories. But it is a distinct problem. For all the concerns about filtering bias and political polarization, traditional news outlets still have gatekeepers (though some are better than others) that help fact-check information before it is released. And given that anything they publish can be checked by independent groups, like Snopes.com, there is at least some accountability that prevents many of them from going to extremes.

But more and more commonly, news outlets—even some respected news outlets—are trending toward the extremes, giving disinformation and misinformation. In early December 2021, the world was eagerly awaiting information on whether their vaccines against Covid would work against the new omicron variant. Consider a *New York Times* article from December 8: “Pfizer Says Its Booster Is Effective against Omicron” (LaFraniere 2021). The *New York Times* is one of the oldest, most reputable news outlets in the country, so this headline sounds like great news.

Interestingly, this is the headline posted to Google, which is slightly different from the actual headline: “Pfizer Says Its Booster Offers Strong Protection against Omicron.” Not much of a change, but enough to get your attention. It tells us that the shorter, Google headline was intended as “click bait,” that is, a phrase or sentence that is deliberately designed to encourage readers to click to the website. This isn’t “fake news,” but it’s a red flag. Unfortunately, when you read this news article, the actual information isn’t much better.

In a lab, Pfizer studied thirty-nine blood samples and found more antibodies in the blood with the booster than in the blood of people who only had the first two doses of the vaccine (which, scientifically, we would expect anyway). What’s more, the company didn’t release any data; they simply said that the data is “very, very encouraging” and “really good news.” The article acknowledges that the lab tests are “not proof of how the vaccines will perform in the real world,” but that seems in direct contrast with the headline: “offers strong protection.” For whom? Not people in the real world. And how much is “strong”? “Encouraging” does not imply strong.

While none of this is disinformation, the headline is *very* misleading. The only thing that saves it from being outright misinformation is that the author qualifies the claim as “Pfizer says …” It’s as if, the author says: This is a claim from Pfizer, and if they’re wrong, it’s on them. Unfortunately, no representative from Pfizer is quoted in the article as saying the booster “offers strong protection," which raises the question of where it came from: Was it from Pfizer or the journalist? The problem for critical thinkers is clear: Readers who only scan the headline will come away with false beliefs; readers who actually read the article won't find anything in it to support the headline. If it's not fake news, it's too close for comfort.

## Fake News or a Post-Truth World?

At this point, you might be thinking: All of this is interesting, but nothing much hangs on it because we live in a "post-truth" world anyway. For every perspective, there's an opposite perspective. For every expert's "fact," there's some other expert with a conflicting "fact." So, we should expect a lot of "fake" news, but what counts as "fake" depends on who you ask.

"Post-truth," or "post-fact," means that society has come to value appeals to emotion or personal belief more than objective reality, or "facts," and therefore, that emotions *are* more important than reality or facts. The idea was so influential during the US presidential election of 2016 that the *Oxford English Dictionary* named "post-truth" its word of the year (but the *Merriam-Webster Dictionary* still doesn't acknowledge it as a word!). Of course, concerns that there is no objective reality are not new. In ancient Greece, Pyrrhonian Skeptics doubted whether we could know anything for certain and advised people to speak only about our impressions of things. In the twentieth century, postmodern philosophers challenged the notion that science could provide a "metanarrative" (a single, true story) that would tell us what the world is like independently of what humans think about it.

In some cases, these challenges have been validated. Take the concept of color, for example. Though we typically think of objects being colored (a red ball, a green leaf, etc.), we now believe that what color something is has as much to do with the structure of our eyes as with the object itself. Some people whose eyes are structured differently don't see green things as "green." Which objects are green really is in the eye of the beholder. The only reason we say that leaves are objectively green is that the majority of us see them that way. If the majority of humans' eyes were different, it wouldn't be "true" that leaves are "green."

But we know that a claim is not objectively true simply because it wins a popularity contest. The appropriate conclusion is not that there is no color, or that color is not an objective feature of the world. It's simply that objects aren't colored *in themselves*. Color emerges from various interactions among things with eyes. There is an objective truth about color even if it's more complicated than we originally thought. The point is that we can't ignore or set aside the concept of truth just because it's hard to understand or inconvenient. As philosopher Justin McBrayer puts it: "You can disregard truth that the highway is full of traffic at your own peril. If you attempt to cross the road, the truth will run you over" (2021: 149).

The problem is that the news makes the truth even harder to discover. And fake news adds another layer of complication. Journalist Farhad ManJoo argues that news companies not only have the power to influence our beliefs about politics and culture, but they have also actually "shifted our understanding of the truth" (2008: 224). The amount of information available through the internet and the tools used to distribute it "haven't merely given us faster and easier access to news, but they've altered our very grasp on reality. The pulsing medium fosters divergent perceptions about what's actually happening in the world—that is, it lets each of us hold on to different versions of reality" (224).

The challenge for critical thinkers, then, is not to give into temptation to ignore the question of truth. Issues like MMR vaccines, climate change, and social distancing for Covid-19 are contentious and political, but they are also life and death—if not for you individually, for others, for wildlife, and for ecosystems. We can't ignore truth without getting hurt along the way. So, how can critical thinkers navigate the difficult waters of fake news and come out with responsible beliefs?

## How Can Anyone Tell Fake News from Real News?

One thing should be clear from this chapter: fake news is bad news for critical thinking. It should be identified and ignored. It does not make our epistemic situation (i.e., our belief system) better, and it can trick us into thinking our beliefs are strongly justified when they aren't. But if fake news is as rampant as it seems, how can critical thinkers distinguish it from real news?

There are a handful of methods for identifying fake news. No method is completely fool-proof, but any of the following will help improve your critical thinking about news.

### The CRAAP Test

CRAAP is an acronym that stands for **c**urrency, **r**elevance, **a**uthority, **a**ccuracy, and **p**urpose. It was created by Sara Blakeslee, a librarian at University of California at Chico, to help students distinguish reliable from unreliable sources when working on college projects. The idea is that if a source is recent (current), relevant to the topic, written by an authority on the topic, accurate according to experts in the field, and genuinely aimed at helping readers understand something (rather than aimed at satire, entertainment, propaganda, etc.), then that source should be treated as reliable.

Here's how it's supposed to work:

## Currency

The more recent the information, the more reliable it often is. Ask yourself: When was the information published? Has the information been revised or updated?

Scientific conclusions change quickly sometimes, especially in fields like medicine and epidemiology. So, to be sure you have the best information, you want to go to the most recent sources. Exceptions may include topics in history or classics. If you're researching "Boyle's Law" in chemistry or "the Battle of Chickamauga," older sources may be better than contemporary sources. Because of this, "timeliness" might be a better way to think of "currency." But even in history and classics, more recent interpretations of concepts, claims, or events may be updated in relevant ways. For example, historical claims about "oriental" people (instead of Asian) or "Mohammedans" (instead of Muslims) reflect cultural assumptions about those people that are now largely believed to be false and that should not be perpetuated today.

## Relevance

The information should bear directly on your topic. Ask yourself: Does this information relate to my topic or answer my question? How important is it to my point?

The idea here is to avoid fallacies like *ad populum*, red herring, and *ad hominem* (see Chapter 10 for more on these fallacies). If your research question is whether "school vouchers" are *effective*, an article on how *rarely* school districts offer vouchers for parents to send children to the school of their choice would not be relevant to answering the question. Perhaps school districts do not make such decisions based on effectiveness, or perhaps the decision is out of their hands. Whether school districts offer vouchers is a red herring for the question of whether voucher systems are effective.

## Authority

In general, information written by experts (authorities) on a topic is more reliable than information written by laypeople or politicians. This is because experts have been specially trained to understand issues related to the topic and solve problem related to the topic. Ask yourself: What are the author's credentials or organizational affiliations? Is the author qualified to write on this topic?

This doesn't mean experts are *always* right. In the 1980s, AIDS activists prompted experts and politicians to redesign clinical trials to study drugs in way that ended up helping millions of people. To be sure, those activists worked closely with scientists to be sure they understood what they were advocating for, but it was laypeople—not experts—who led the charge. But these are rare cases. Further, in some cases, genuine experts lead people astray. Physicians and scientists who promoted the use of Ivermectin to treat Covid-19 were roundly criticized by the majority of the scientific and medical community. But this did not mean that those physicians were less authoritative in the roles as physicians and scientists. In that case, other elements of the CRAAP test had to be used to debunk their false claims about Ivermectin. Nevertheless, the point is that, in most cases, laypeople don't have the time or training to understand complicated scientific or political issues. So, when information is written by an expert, that's a point in its favor.

## Accuracy

Accurate information is, obviously, more reliable than information that is inaccurate. A better way of putting the point is: Information supported by evidence is more reliable than information that is not. Ask yourself: Where does this information come from? Is the information supported by evidence?

Sometimes the information you're reading makes claims you can check for yourself alongside those you can't. If the information is not reliable on those issues you can check for yourself, you shouldn't trust it on those issues you can't. Further, reputable information will usually include the sources of its claims, whether they came from empirical research, whether they were made by experts in the field, or whether the person writing it is the relevant expert. If an article does not do this, and especially if there is no author or sources listed, the information is less likely to be reliable. Even sources of information that are known for reliability—such as the Centers for Disease Control and public health agencies—will sometimes distribute information that doesn't include an author or the material's sources. This is bad practice, and it makes it hard for non-experts to trust them.

## Purpose

Understanding the context of information is critical to assessing its reliability. Information intended for education is different from information intended for entertainment, satire, propaganda, social order, and for commercial purposes. Ask yourself: What is the purpose of this information (to sell me something, to educate me, to entertain me, etc.)? Is the purpose clear?

In some cases, the purpose of information is clearly stated. The satire blog the *Borowitz Report* has a subtitle: "Not the news," clearly signaling that what you're about to read should not be taken as reliable information. In other cases, the purpose is not so clear. The *Hannity* show on *Fox News*, for example, presents itself as a news show rather than as political propaganda, and only by understanding the content can viewers figure that out.

## Limitations of the CRAAP Test

For many contemporary scientific issues, the CRAAP test does a passable job. Articles on climate change from 2017 are likely more reliable than articles from 1997. Articles written by climatologists are more likely to be reliable than articles written by activists or politicians, and so on. In some cases, one or two of the criteria will weigh more than the others. For example, when it comes to basic claims about mathematics, purpose and accuracy will be more important than whether someone is a renowned mathematician or whether the information is current.

However, this is also where the CRAAP test faces some difficulties. If you can tell that a piece of information is accurate, why should you bother to work through the rest of the test? Wouldn't that be a waste of time? Further, the CRAAP test is not always easy to use, depending on the topic or field of study. For example, if the field of study is chemistry, and the topic is alchemy, current scientific research won't help you much. Further, there can be reputable sources all the way back to the seventeenth century. In fact, if the topic is the *history* of alchemy, you'll probably *prefer* sources closer to the seventeenth century. Further still, given that alchemy isn't part of contemporary chemistry, it will be hard to determine whether a source that talks about alchemy is accurate. Claims *within* the study of alchemy are already considered false, so you already know that you shouldn't believe some claims. Yet, since no one today was alive in the seventeenth century, you're stuck taking a lot of historical claims *about* the study of alchemy on trust.

In short, the CRAAP test is a solid tool for quickly evaluating most contemporary information. Unfortunately, the more controversial the issue, the more difficult it will be for laypeople to apply the CRAAP test usefully—they either won't be able to tell who the authorities are, won't be able to tell whether a cited source is reputable, or they won't be able to accurately identify the information's purpose. So, while the test is good, it is often not enough for forming robust beliefs about a piece of information, especially when that information matters to us in some way, such as affecting our health or livelihoods.

## The "Four Moves and a Habit" Strategy

Mike Caulfield, research scientist at the Center for an Informed Public at the University of Washington, has been studying the effects of media on public opinion for a long time. He actually worries that teaching critical thinking—as we're attempting here—can do more harm than good in today's media climate. That's because misinformation and disinformation are created for the purpose of seeking attention. And critical thinking, as you now know, involves giving serious, sustained attention to claim and arguments. (Caulfield explains all this in his short YouTube video called "Myths of Online Information Literacy.") In other words, simply applying critical thinking skills to evaluate fake news gives its creators the attention they were looking for in the first place—it raises their "engagement" stats (through clicks and shares), and thereby further supports their political and commercial efforts (through visibility and buying the products advertised on their pages).

It sounds like a no-win situation for people who want to think critically about the world around them. So, what do we do? Caulfield argues that fake news should challenge us to understand the importance of reputation when encountering new information. The "Four Moves and a Habit" strategy explained below is a good place to start when trying to figure out if a bit of information is trustworthy. It, along with many examples, can be found in Caulfield's free online book, *Web Literacy for Student Fact-Checkers* (2017).

**Move 1: Check for previous work**
**Move 2: Go upstream**
**Move 3: Read laterally**
**Move 4: Circle back**
**Habit: Check your emotions**

### Move 1: Check for Previous Work

The key to this advice is: Use fact-checking websites. The easiest way to get started evaluating any piece of information is to see what other people say about it. You don't have to believe the results, but you will very likely at least get a perspective on why the bit of information you're evaluating is likely true or false. Instead of having to do all the legwork yourself, you're acknowledging that other people have probably done most of the work for you, and all you have to do is sift through it for the most plausible analysis. Later in this chapter, we provide a list of "Websites That Can Help," and many of these are fact-checking sites.

## Move 2: Go Upstream

If fact-checking leaves you unsatisfied, look for any sources cited in the piece of information itself. If there's nothing mentioned, that's a red flag! Most national news is covered by a handful of highly seasoned reporters or scientists whose work has been either syndicated or summarized by other sources. There should be a link to the original information that you can go read yourself, and then evaluate that version of whatever claims are being made. If there is no original, or at least corroborating, story, it's good advice to suspend judgment until more evidence comes in. Caulfield's book (don't forget, it's free) gives excellent tips on how to go upstream.

## Move 3: Read Laterally

This move begins from the assumption that you probably won't be able to tell whether a source is reliable just by evaluating the source. Mis- or disinformation that's done well will be indistinguishable from authentic information sites. Computer and design technology puts the ability to make professional-looking web content straight into the hands of deceivers. Therefore, in order to evaluate whether a source of information is reliable, you will need to see what other sources of information say about that source. If multiple sources say the source you're looking at is reliable, that's a mark in its favor.

## Move 4: Circle Back

In some cases, all this lateral checking and double-checking leads you in a circle. One website confirms a story by citing another story that cites the original story. What do you do then? Start over. Change your search terms. Pay attention to when the story supposedly happened and look at the date of publication. Remember, too, that some of the doctors who are part of the Front Line COVID-19 Critical Care Alliance are real doctors at reputable places, even though the website is a political tool that promotes bad science (this is a fun one to investigate on your own; have fun). So, you may need to do some extra creative searches to understand whether some websites are reliable.

## Habit: Check Your Emotions

The philosopher W. K. Clifford once pointed out, rather insightfully, that feelings of safety and power have a great deal of influence over what we believe ("The Ethics of Belief"). We not only like what we want to be true, but we get very protective of it. We often let it become part of our identity so that, when the belief is threatened, we feel personally threatened. Clifford said that when we realize we don't know something we were sure about, we feel "bare and powerless where we thought we were safe." And that we feel "much happier and more secure when we think we know precisely." Part of the comfort of knowing something truly is that it makes us part of something bigger than ourselves. "We may justly feel that it is common property, and holds good for others as well as for ourselves." The problem is that, when our certainty is gained through misinformation or disinformation, and our belief turns out to be false, that "pleasure is a stolen one … stolen in defiance of our duty to [humankind]." What is our duty? "To guard ourselves from such beliefs as from pestilence, which may shortly master our own body and then spread to the rest of the town." This is ironic given how many people also failed to guard themselves against the recent Covid-19 pestilence because of their commitment to fake news.

Caulfield's final step, the habit of checking your emotions, aligns with cautions we've offered in other places in this book. If you feel a strong emotion about a claim, that's a clue that you're too invested in the claim to evaluate it well. Stop before you re-tweet it! Take thirty seconds and breathe. Acknowledge that the claim is likely framed precisely to incite that emotion or its opposite, and that responding to it is probably exactly what its propagator wants. Consider your next move carefully. Maybe it's applying critical thinking skills, maybe it's checking the reputation of the source. But, more likely, maybe it should be to just move on.

# Limitations of "Four Moves and a Habit"

As with any strategy, "Four Moves and a Habit" has its limitations. Fact-checking websites may not speak to a nuance of the information you're evaluating. And you may be concerned that certain fact-checking websites are more left- or right-leaning than others. This limitation also affects the "Read Laterally" move. If all the conservative websites say your source is reliable, and all the liberal websites say your source is unreliable, which do you believe?

Caulfield's book does a good job of guarding against these limitations, and we recommend looking at his examples for different ways to use this strategy effectively. But we wouldn't be doing our jobs if we didn't point out that the world is messy, and no strategy is foolproof. We've all been the victims of misinformation and disinformation, and things are likely to get worse. All we can do is keep working at it. Here's one more strategy for good measure.

## The Old School Strategy

This is the hardest strategy to use, but it is by far the most effective. It requires developing a sort of expertise in critical thinking (but hey, you're reading this book, so you're on your way!). The goal is to bring everything you know about good reasoning together with everything you know about how good and bad the internet can be to evaluate a piece of information.

Start with a simple search, something you do every day. You might use Google or Google Scholar, or Wikipedia. If you're into medicine and your question is medical, you might try PubMed. If you're into law and your question is legal, you might try WestLaw (if you or your local university has access). From then on, it's a simple matter of checking the claims you find against those of other sources you consider reputable. The goal is to come up with claims that are roughly agreed upon by everyone who is taking the question seriously. Here's a rough guide, but the point is really to knuckle down and test each claim.

### 1. Start with a simple search (Google, Google Scholar, or any simple online or library search)

This is the quickest way to find the most common perspectives on an issue. Make a list. Then start asking questions.

### 2. Know who is writing/talking

Check the credentials of panel members, pundits, and so-called experts. If they don't tell you somewhere in the article, that's concerning (a red flag). They should have some sort of education or training, some professional credential, or hold some reputable position a university, research institute, governmental organization, and the like. If you cannot find information about them, search their name and whatever question you're asking.

### 3. Search national news sites, both in your own country and in a few other countries

News outlets frame questions in interesting ways. Some are inflammatory and completely distort the issue. Some offer a new perspective on a topic you hadn't thought of. This gives you more things to search for and more experts to draw on.

## 4. Always compare a variety of sources

You will never get the whole story from one source of information—not even Wikipedia. Look at sources from different political perspectives, from religious and non-religious perspectives. Again, the key is to get a sense of the different angles that are possible so you can then go check them out. Know your sources, too. International news outlets are (typically) going to have more facts and less editorial/opinion pieces. Blog posts are almost always strongly slanted to one position or another.

## 5. Look for the overlap

Compare the sources against one another and see what they agree on. The truth is sometimes caught in the middle.

## 6. Know an expert? Use them

Ask some folks who work in the area you're asking about, or in areas closely related. Get a sense of how the "insiders" think and talk about the issues. Maybe the public conversation has just blown up an issue into a firestorm that's really very mundane.

## 7. Don't let your eyes and ears fool you

Images about controversial issues, whether Facebook memes or GIFs or bumper sticker slogans and inherently biased. They make a complex issue seem simple and obvious. Pictures, videos, and sounds are also very easy to manipulate these days. So, don't trust your feelings when it comes to images or sounds.

## 8. Keep your emotions in check

Most of the issues you're researching are ones you care about, and once your emotions are invested, you're in dangerous territory. If the news make you angry, afraid, or anxious, take some time away from it before diving into research. Your emotions have primed you to find one perspective on the issue more correct than any other. And someone may have designed a story to invoke just that response in you, so be wary.

## 9. Doubt, doubt, doubt

You're getting good at this logic stuff, but that doesn't mean you should stop double-checking yourself. While *they* (whomever they are) might be wrong, it's also possible that *you* are wrong. Keep digging until you have the evidence you need for a strong conclusion.

## 10. If you can't see it, don't believe it

There is no reason you have to come down on one side or another on any issue. If you don't have enough evidence, or if the evidence you have doesn't point clearly one way or the other, suspend judgment. Hold off. Wait until the rest of the evidence is in. You may have to make some decisions about what to do in the meantime (as when pandemics spread quickly, and the experts are still trying to figure out all the details), but you can still hold off one what you believe. Giving yourself the freedom to suspend your belief also saves you a lot of stress.

# Websites That Can Help

We obviously cannot do all the legwork necessary to distinguish fake news from true claims. We need help, and we can get from lots of places: experts, eyewitnesses, textbooks, scholarly journals, and so on. Most of us, however, start with the internet. And while there are a lot of bad websites out there, a few can be especially helpful when trying to identify fake news. It's still true that you can't believe everything on the internet, and even good websites have problems. But here are a few that we find helpful when we're sifting through the news:

FactCheck: https://www.factcheck.org/
Fact Check Review @ RealClearPolitics: https://www.realclearpolitics.com/fact_check_review/
Lead Stories: https://leadstories.com/
Media Bias Chart: adfontesmedia.com
Media Bias / Fact Check: https://mediabiasfactcheck.com/
Open Secrets: https://www.opensecrets.org/
PolitiFact: https://www.politifact.com/
Poynter Institute: Fact Checker News: https://www.poynter.org/media-news/fact-checking/
Poynter Institute IFCN: International Fact Checking Network: https://ifcncodeofprinciples.poynter.org/signatories (a list of fact-check agencies that have publicly committed to ethical fact-checking in journalism)

RationalWiki: https://rationalwiki.org/wiki/Main_Page
Snopes: https://www.snopes.com/
Truth or Fiction?: https://www.truthorfiction.com/
Washington Post Fact Checker: https://www.washingtonpost.com/news/fact-checker/

## Some Other Important Distinctions

Misinformation and disinformation are closely associated with other concepts used to convey or manipulate information, and it can be helpful to draw some distinctions for the purpose of making clear arguments. In what remains of this chapter, we briefly review *parody*, *photo and video manipulation*, and *alternative facts* in light of our discussion of fake news.

### Parody

Parody is very similar to satire (which we explained earlier in this chapter). Like satire, most effective parody pieces often mimic the look and feel of whatever media they are parodying (e.g., if a newspaper article is being parodied, the finished piece will look almost exactly like a 'real' newspaper article). Like satire, parody might also incorporate the use of various statistics and quotations from external sources in order to establish a baseline between the author and the audience. Where the two differ, however, is that parody relies extensively on non-factual information. In fact, parody pieces walk a fine line between plausibility and absurdity. And the true difficulty comes for parody authors to make their absurdities plausible, thus enabling both the author and the audience to share a chuckle. That's the rub, as Hamlet might say. That is where the entertainment and fun factor of parody lies. If the author is too subtle in their parody, then the audience misses out on the shared gag and, thus, the comedy is ruined. Thus, parody can be considered "fake news" in two ways. First, like satire, it mimics real news broadcasts but is, in fact, not a news broadcast; second, it can mislead the audience into believing outlandish claims if not presented properly.

### Photo and Video Manipulation

Another common type of "fake news" that you have likely encountered, especially concerning a certain president who boasted of crowd sizes and, yet, pictures provided contradictory evidence, is *photo manipulation*. Photo manipulation refers to altering a photo or video to create a false narrative.[1] This could range from blurring out a tall figure in the background to fake a Sasquatch sighting to the superimposing of several different images to mislead viewers. One example of the latter was during Hurricane Sandy in 2012. A particular photo made the rounds on social media: it showed the Statue of Liberty in New York being pummeled by waves and even had a fake “NY1” broadcast logo on it to lend credence to the image. The problem with that image was that it was actually a combination of a still shot from a disaster movie and actual images of the carnage wrought by Hurricane Sandy. Thus, if you did not know any better, you might see the fake image and think the apocalypse were happening or something. That’s no bueno!

A similar issue with photo manipulation arises with something called *misappropriation*. Misappropriation, in this context, refers to using an image out of context to make it easy to spread a false story, regardless of whether the user intended the story to be false or not. While the Hurricane Sandy fake-out was deliberate, misappropriated images can bud from honest mistakes. To illustrate how easy these sorts of scenarios are to mistakenly concoct, think about how often assumptions can lead to embarrassing outcomes.

Imagine someone who is primed by their cultural surroundings to be suspicious of anyone with dark skin color. If they are white, for example, and they see a group of Black men standing near a car at night, they might be tempted to assume something negative, like that the men are trying to break into it. The truth of the situation, however, could be almost anything: Perhaps they were stopping to talk after work. Maybe they were trying to help fix someone’s car. It doesn’t matter because there are infinitely many reasons for those men to be standing there like that—none of which are relevant to race or skin color. Now, imagine that someone were to take a photo of that moment, give it a harmful caption, and post it on social media instead of just thinking those negative thoughts to themselves. If other people, who are also primed to be suspicious of certain skin color (like so much of culture continues to do), see the photo—they might form the same negative belief and then share it. Suddenly, a negative, unmotivated story springs up around the photo and becomes an ordeal online. Were those men *actually* trying to steal that car? No, but our mistaken photographer didn’t think that far ahead—and didn’t bother to verify their assumption before posting it to the entire world. That is

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[1]It should be noted before we dive too deeply into this topic, however, that some photo “manipulation” is allowable even by the standards of professional journalism. Journalists are typically only allowed to make “presentational changes” to an image (e.g., adjust the tone and/or contrast of an image to make it easier to see), though. They are typically forbidden from making any additions to the image.

an example of misappropriation: an image taken out of context and used to spread a false narrative.

## Alternative Facts

In January of 2017, the White House Press Secretary, Sean Spicer, said that the audience for the latest Presidential inauguration was "the largest audience to ever witness an inauguration, period, both in person and around the globe." This was, by all estimates and to the naked eye, not a fact. It was, in fact, false. However, the president's counselor Kellyanne Conway explained that this statement was not inconsistent with facts, it was simply an "alternative fact": "You're saying it's a falsehood and Sean Spicer, our press secretary, gave alternative facts to that" (Jaffe 2017). What could she have possibly meant?

In all likelihood, Conway made up the term on the spot in an unfortunate attempt to defend Spicer. But afterward, the term was adopted into the social conversation. The most likely interpretation is that reality is whatever you want it to be, or perhaps more accurately, whatever people in power say it is. When journalist and unofficial White House spokesperson Scottie Nell Hughes was asked whether the US President was free to make up lies about who won the popular vote, she said, "there's no such thing anymore unfortunately as facts" (Fallows 2016). In other words, the president can make up whatever he wants, and no one can call it "wrong" or "false." The whole situation was reminiscent of George Orwell's *1984*, when the government changed its position on who it was at war with. While they had been saying they were at war with Eurasia, they were actually at war with Eastasia, and all media should be changed to reflect that:

> A large part of the political literature of five years was now completely obsolete. Reports and records of all kinds, newspapers, books, pamphlets, films, sound-tracks, photographs—all had to be rectified at lightning speed. Although no directive was ever issued, it was known that the chiefs of the Department intended that within one week no reference to the war with Eurasia, or the alliance with Eastasia, should remain in existence anywhere. (Orwell 1948: 121)

The difference in the Conway case is that government spokespeople are simply saying that everything is a fact: political analysts say the crowd was not the biggest in history; Spicer says it was. These are alternative facts about the same event.

Of course, we know there are no alternative facts. As McBrayer pointed out above: If the highway is full of traffic, it is *not* also not full of traffic, and getting the fact wrong will put in you danger. Thus, claims that there are alternative facts, when included in news stories, are a type of fake news because they are disinformation.

## Exercises

**Apply the CRAAP test to each of the following news stories.**

**Example:**

1. "This Isn't Jim Crow 2.0," Larry Hogan (https://www.theatlantic.com/ideas/archive/2022/01/challenge-americas-electoral-system-college-count-act/621333/).
2. "Alabama Makes Plans to Gas Its Prisoners," Elizabeth Bruenig. (https://www.theatlantic.com/ideas/archive/2022/12/alabama-botched-executions-2022-gas/672607/).
3. "Why Yale Law School Left the U.S. *News and World Report* Rankings," Adam Harris (https://www.theatlantic.com/ideas/archive/2022/12/us-news-world-report-college-rankings-yale-law/672533/).
4. "Why I Joined, Then Left, the Forward Party," Joseph Swartz (https://www.theatlantic.com/ideas/archive/2022/12/forward-third-party-andrew-yang/672585/).
5. "Poverty is Violent," Nicholas Dawidoff (https://www.theatlantic.com/ideas/archive/2022/12/new-haven-connecticut-gun-violence/672504/).

**For each of the following <u>pairs</u> of news stories, apply the CRAAP test and decide which is more reliable.**

**Example:**

Answer:

1. **The American Economy**
   a. "The Economy's Fundamental Problem Has Changed," Annie Lowrey
   https://www.theatlantic.com/ideas/archive/2022/12/new-haven-connecticut-gun-violence/672504/
   b. "The Curse of the Strong U.S. Economy"
   https://hbr.org/2022/10/the-curse-of-the-strong-u-s-economy

2. **Putin's Attack on Ukraine**
   a. "Missiles Rain Down on Ukraine as Putin Gives Combative New Year Speech"
   https://www.washingtonpost.com/world/2022/12/31/ukraine-putin-zelensky-missiles/

b. "Russia Fires 20 Cruise Missiles at Ukraine on New Year's Eve, At Least 1 Dead, Dozens Injured," Caitlin McFall
https://www.foxnews.com/world/russia-fires-20-cruise-missiles-ukraine-new-years-eve-least-1-dead-dozens-injured

3. **Racially Biased News**
   a. "In Ukraine Reporting, Western Press Reveals Grim Bias Towards 'People Like Us'." Lorraine Ali
   https://www.latimes.com/entertainment-arts/tv/story/2022-03-02/ukraine-russia-war-racism-media-middle-east
   b. "NY Times Journalist Suggests Media Concern for Russian Invasion of Ukraine Demonstrates Racial 'Biases'." Linsday Kornick

   https://www.foxnews.com/media/nyt-journalist-media-russia-ukraine-racial-biases

4. **Musk and Twitter**
   a. "Why Is Elon Musk Lighting Billions of Dollars on Fire?" Annie Lowrey
   https://www.theatlantic.com/ideas/archive/2022/12/elon-musk-twitter-finances-debt-tesla-stock/672555/
   b. "Americans Weigh Pros and Cons as Musk Alters Twitter." Matt Haines
   https://www.voanews.com/a/americans-weigh-pros-and-cons-as-musk-alters-twitter-/6893983.html

5. **Critical Race Theory**
   a. "What is Critical Race Theory, and Why Is Everyone Talking About It?" Susan Ellingwood, Columbia News,
   https://news.columbia.edu/news/what-critical-race-theory-and-why-everyone-talking-about-it-0
   b. "What Is Critical Race Theory?" Sam Dorman, Fox News,
   https://www.foxnews.com/us/what-is-critical-race-theory

**For each of the following news stories, use the website Snopes.com to help you determine whether the event actually happened. Explain your reasoning.**

**Example:**
Answer:

1. Combination Covid and Flu Tests proves that they are the same virus.
2. Masking is ineffective against the spread of Covid-19 or any of its variants.
3. Covid-19 vaccines are gene therapy.
4. The EU is imposing a "personal carbon credit" system.
5. Hooters is shutting down and rebranding due to changes in Millennial tastes.
6. The moon landing was staged.
7. Covid numbers were inflated due to medical professionals counting flu cases among Covid cases.
8. Benedict XVI was forced to retire.
9. Romanian authorities were only able to arrest Andrew Tate due to the Twitter feud he had with Greta Thunberg.
10. The 2020 election was rigged, and votes were counted illegally.

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# Thinking critically about conspiracy theories

12

**In this final chapter, we apply many of the concepts and discussion from the rest of the book to conspiracy theories. We explain what a conspiracy theory is, offer some tools for identifying them, and then discuss ways of responding to conspiracy theories, both as individuals and as a society.**

## What's a "Conspiracy Theory"?

There is widespread belief that conspiracy theories are bad. People often say they are bad because they encourage people to believe false claims about things that matter and that they can incite violence. In other words, they are disruptive to society (Sunstein and Vermeule 2008). We agree that when they do these things, they are bad. But we go a step further. Even when they aren't disruptive to society, they are bad for the individuals who have to deal with them—that is, they are bad for those who believe them, those who are tempted to believe them, and those who have to spend time debunking them. In this chapter, we define "conspiracy theories," explain how they refer to something different from real conspiracies, and show why conspiracy theories are bad for those who have to deal with them. We close with some strategies for how to distinguish conspiracy theories from well-supported accounts of events.

A *conspiracy* is an action committed by a small group of people in secret to achieve a shared goal. Anytime a group of people has secretly planned to rob a bank, rig a boxing match, assassinate a political leader, and so on, they have conspired to bring about the desired event. The desired event may be, objectively speaking, good or bad. Most agree that the conspiracy to kill President Abraham Lincoln was bad. And most agree that the conspiracies to assassinate Adolf Hitler during the Second World War and to overthrow apartheid in South Africa were good.

A ***theory*** is just an explanation of some state of the world. The theory of evolution, for example, aims to explain the current state of biodiversity. The theories of relativity (special and general) aim to explain things like the movement of the planets and the path of light. So, a *conspiracy theory*—we might think—is an attempt to explain an event in terms of a conspiracy, that is, the explanation is that the event was caused by a conspiracy. For example, consider the real conspiracy known as "Watergate": "Nixon wanted evidence that would help sway the upcoming election, so he conspired with people to place recording devices in the Democratic National Convention offices at the Watergate Hotel." This would make the term "conspiracy theory" neutral. Some are good; some are bad. And it's understandable why we might like this definition. The use of "theory" suggests that a conspiracy theory is a type of explanation that is open to evidence, a dispassionate, scientific investigation. That doesn't seem so bad. And, as examples such as Watergate and Hitler assassination attempts show, we know there have been real conspiracies. Thus, "conspiracy theory" seems an apt label for explanations of these conspiracies.

However, this is not what people usually mean by conspiracy theory. To see this point, we need a new distinction. We should distinguish between a ***lexical*** **definition** and ***technical*** **definition** of a term. A lexical definition expresses the widely accepted meanings of a term. This is the meaning usually found in dictionaries (also called lexicons). Dictionaries track how people use words over time, and how those meanings change. Technical definitions (sometimes called "**terms of art**") are defined in very specific contexts for a specific purpose. They mean either what the author specifically defines it to mean ("By expert, I will mean …") or what a specialist group defines it to mean ("debit" means something different to accountants than it does to the person on the street).

While the terms "conspiracy" and "theory" could be combined to describe Lincoln's assassination plot and the Watergate scandal, when people use the phrase "conspiracy theory," they are typically talking about explanations widely believed to be false, for example, the moon landing was faked, the fall of the Twin Towers on 9/11, 2001, was caused by the US government, and the virus SARS-CoV-2 was created as part of a secret government program.

This means that the phrase "conspiracy theory" has come to mean—lexically speaking—a *weak* or *faulty* explanation of an event that involves a secret plan by a powerful group. Conspiracy theories, in this sense, are typically not supported by standard forms of evidence (or the standard forms of evidence are manipulated to look stronger than they are), and they are intentionally constructed to resist disconfirmation by standard forms of evidence. For example, on this definition, someone who believes a conspiracy theory might say something like: "Of *course* there's no evidence; they covered it up!" Further, conspiracy explanations are considered faulty by the relevant authorities on the subject. We say "considered faulty" because, of course, even the relevant authorities could be wrong. Nevertheless, if all available evidence suggests the explanation is faulty and the relevant authorities on the subject agree, then we are justified in rejecting the proposed conspiracy explanation.

So, while we can define conspiracy theory in a neutral way (a technical definition), people don't tend to use it that way. To keep things simple, we will use "conspiracy theory" in the lexical sense, as something bad—or, at least, as problematic from a critical thinking standpoint. In most cases, the event in question wasn't brought about by a conspiracy at all.

## What's the Problem with Conspiracy Theories?

On the face of it, we might think: "Well, if that's what conspiracy theories are, they are quite irrational. If the evidence doesn't support the theory and the *relevant* authorities do not accept the theory, why would anyone believe it?" Believing a conspiracy theory seems like disagreeing with your lawyer over some legal matter when you had no legal training or experience. Or disagreeing with a computer technician over some bit of code even though you know nothing about computers. Relevant authorities—that is, *experts*—usually have a better grasp of the issues at stake in areas where we aren't experts. And in most cases, we have no trouble deferring to doctors, lawyers, accountants, mechanics, architects, and the like, when we know very little about the issues. Nevertheless, belief in conspiracy theories is pretty common. A 2006 poll of Canadians showed that 22 percent believed that the 9/11 attacks were a plot by the US government. Another poll of seven Muslim countries suggests that 78 percent believe that the 9/11 attacks were orchestrated either by the United States or by Israel (Sunstein and Vermeule 2008: 202–3). Why are conspiracy theories so common?

We agree that it is irrational to reject relevant authorities when we know very little in their areas of specialization. But is that what conspiracy theorists do? It turns out that it's hard to say what social and cognitive processes cause people to believe conspiracy theories. There is growing literature from psychologists that attempts to explain the conspiracy theory mindset, but there is not yet a firm consensus. Importantly, we don't think that all conspiracy theorists are gullible. It's possible that conspiracy theorists are quite savvy in many areas. And we don't think conspiracy theories are especially irrational. Further, we are all irrational in a number of ways, yet most of us do not believe or spread conspiracy theories. For our purposes here, we will focus on just one aspect of why people believe conspiracy theories: their reasoning.

It turns out that believing a conspiracy theory has less to do with whether a person believes there are experts or trusts experts and more with what's at stake for them on the topic in question. In fact, many conspiracy theorists point to experts to support their claims. The real problem—for both conspiracy theorists and those who have to deal with them—is the concern that experts are saying what they are saying not because they have good evidence, but because they want to deceive people.

Conspiracy theorists typically claim there's a group that has something to lose and a group that has something to gain from the conspiracy. It doesn't matter whether anyone is an expert because, in some cases, experts use their expertise to perpetrate conspiracies. The claim of conspiracy theorists is that, in many cases, the mainstream experts are getting something at other people's expense. Those who believe that climate change is a conspiracy claim that climate scientists are incentivized by research funding, prestigious jobs, and political motives to exaggerate threats to the climate. Those who believe that GMOs (genetically modified organisms) are harmful to human health claim that large agricultural companies have colluded with government regulators to cover up evidence regarding their safety in order to ensure continued profits. In most cases, so say conspiracy theorists, the conspirators then silence or alienate any experts who would try to contradict the plan.

Consider the number of conspiracy theories that have arisen in response to governmental and public health measures aimed at stopping the Covid-19 pandemic. The primary goal of public health officials during a pandemic is to delay the spread of the virus until a vaccine can be developed. Unfortunately, many of the public health initiatives used to do that (masks, social distancing, stay-at-home orders, etc.) are viewed as threats to individual freedom and, therefore, part of a conspiracy aimed at social control. Here's an example from a prominent critique of almost every health-related claim about Covid-19, Jeffrey Tucker:

> Please remember that Anthony Fauci and Francis Collins are not just two scientists among hundreds of thousands. As the NIH [National Institutes of Health] site says, it "invests about $41.7 billion annually in medical research for the American people." With that kind of spending power, you can wield a great deal of influence, even to the point of crushing dissent, however rooted in serious science the target might be. It might be enough power and influence to achieve the seemingly impossible, such as conducting a despotic experiment without precedent, under the cover of virus control, in overturning law, tradition, rights, and liberties hard won from hundreds of years of human experience.(https://brownstone.org/articles/faucis-war-on-science-the-smoking-gun/)

Note that there's no argument here. There is only speculation that, because the government funds most scientific research, they could control the results of that research. And the implication (unstated) is that they *do* control that research. Note also the size of this conspiracy. It implicates not just those in the highest positions at the National Institutes of Health (NIH), but every working scientist on grants funded by the NIH. We will say more about how the size of a conspiracy affects its plausibility later in this chapter.

Less outlandish versions of the conspiracy theory claim that Covid-19 is a ploy to make millions of dollars from vaccine sales—for the pharmaceutical companies that make them and for the politicians who have substantial investments in pharmaceutical companies. Some even claim that the virus was created in a lab and released into society precisely for this reason. In these versions of the conspiracy, mainstream experts are simply pawns in the bigger plot. Non-mainstream experts (such as the Front Line Covid-19 Critical Care Alliance, FLCCC) who try to reveal the "truth" about the conspiracy or promote alternative, non-vaccine-related treatments are ridiculed by the mainstream and prevented by social media platforms from having a voice. This further strengthens the Covid-19 conspiracy theory that the government is trying to cover up their plan.

We might say, then, that the problem is not that conspiracy theorists don't trust experts—they often point to people that would pass as experts, that is, people with credentials and experiences related to the debate. Instead, we could say that conspiracy theorists use experts *poorly*. For example, members of the FLCCC are *real* doctors who have certifications from *real* medical societies, who practice in *real* medical institutions. They certainly seem relevant. But the FLCCC's main goal is to promote the drug ivermectin as an alternative to vaccines to reduce the symptoms of Covid-19. Yet, a majority of mainstream experts claim that the evidential support the FLCCC offers for ivermectin is paltry and insubstantial.

But wait. This raises an important question: Which group of experts should we non-experts believe, those from the FLCCC or those from mainstream health sciences? This disagreement between the FLCCC scientists and mainstream scientists doesn't seem like a disagreement related to conspiracy theories. It seems like a typical scientific dispute, such as the debate over evolution or the question of whether drinking wine lowers your risk of heart disease. In all these cases, there are just "experts on both sides." But there *is a difference*.

Whereas typical debates over scientific claims involve competing experts pointing to different pieces of evidence and methodology, conspiracy theorists like Tucker and the FLCCC claim not just that they are right on the basis of the evidence, but that *a powerful group is conspiring against them*. The president of the FLCCC, Pierre Kory, writes that the government is suppressing research on generic drugs in order to give preference to vaccines:

> "Since the summer of 2020, U.S. public health agencies have continually shut down the use or even discussion of generic treatments that are minimally profitable." And doctors who want to use generic drugs in clinical research are "doctors who don't toe the line" and who are "subjected to censorship and threatened with the loss of their livelihood, regardless of their clinical experience."(https://thefederalist.com/2021/12/16/studies-proving-generic-drugs-can-fight-covid-are-being-suppressed/ )

Rather than simply pointing to evidence, conspiracy theorists attempt to bolster their claim by undermining the credibility of mainstream experts. The more that's at stake for the conspiracy theorist, the harder they work to make the mainstream conspirators look nefarious and evil. In Chapter 10, we explained that this is a kind of *argumentum ad hominem* fallacy—an appeal to the character of the arguer, or their intentions, rather than to the reasons the arguer gives.

Of course, if the *ad hominem* fallacy were the main problem with conspiracy theories, they wouldn't be very worrisome. Critical thinkers would simply point out the fallacy and move on. Unfortunately, conspiracy theories present a more serious problem for all critical thinkers.

## So … What's the Main Problem?

As we said in the opening of this chapter, some claim that the problems with conspiracy theories are that they often lead people to believe false claims about things that matter, and they can incite violence. Although we don't think of the claim that the moon landing was faked as very significant today, people in the 1960s faced different political concerns. If the United States hadn't demonstrated that it was on the cutting edge of science, fear of Communism and a nuclear war might have led to mass panic about the ability of the United States to fend off Russia. It might even have led more US citizens to support Russia against the United States than there already were. The conspiracy theory claims that the United States did not have the technology to get to the moon but fabricated it to keep civil order. Similarly, people who accept conspiracy theories about Covid-19 put many people at risk of contracting the illness and, because they often require hospitalization, prevent people without Covid-19 from getting needed medical help in hospitals.

However, fear of social danger is not the only—or in most cases the primary—concern about conspiracy theories for critical thinking. It is still a problem that people still believe the moon landing was a hoax even if the fabric of society is not in danger. Few people really care whether the US government covered up an alien landing in Roswell, New Mexico, in 1947, yet the way they come to this belief has an impact on the way they think about other events. The central problem with conspiracy theories is that *they distort our ability to form well-supported beliefs when we need them*. In other words, conspiracy theories are often clever enough to undermine people's ability to think critically. Rather than simply convincing people of false beliefs, conspiracy theories are *designed to make bad reasoning seem like good reasoning*. This gives people the feeling that they are forming responsible beliefs when, in reality, they are reasoning worse than they would have had they not been presented with the conspiracy theory. This hurts their ability to think responsibly in the future and about things that really do matter. To see how conspiracy theories distort our belief-forming processes, consider some key features of conspiracy theories.

## Key Features of Conspiracy Theories

Those who perpetuate conspiracy theories rely on the fact that things often aren't the way they seem. It is the very hidden nature of conspiracy theory explanations that allows them to get a foothold in our belief systems. "It's possible," conspiracy theorists say, and we are inclined to agree. But then they say, "It's more than possible; my theory is the *best* explanation." And *that* is the leap we have to guard against. This leap demonstrates that conspiracy theories are not *responsible* attempts to explain an event. But why might we be tempted to take the leap alongside the conspiracy theorist?

There are at least *five features* of conspiracy theories that make them seem plausible, and they work together to protect the conspiracy theorist's belief from contrary evidence:

- They appeal to psychological needs other than truth
- Their explanations are simple (compared with mainstream accounts)
- They rely on cascade logic
- They presume the conspirators have an extensive amount of power
- They often require a heroic lone wolf

A primary feature of conspiracy theories is that they appeal to **psychological needs other than truth**. In many cases, conspiracy theorists express concern about being victims of some element of society—most commonly, the government but often big corporations—and being powerless to do anything about it (see Gorman and Gorman 2017). Reputation and trust relationships play a big part in identifying the key figures in a conspiracy theory. For example, conspiracy theorists often point out the conflicts of interest that powerful people have that give them motive for participating in the conspiracy. They then contrast these people with people who align with their beliefs and values. Their religious leaders, their family members, and politicians who are willing to "buck the system."

In the case of Covid-19, certain religious groups interpreted the social restrictions imposed by politicians as attempts to prevent them from worshiping. Though they never say this explicitly, for them, this outweighs the risks to members of their church and their church members' families. Early in the pandemic, some restaurateurs complained that social restrictions were unwarranted because they would make it impossible for their businesses to survive. Again, from their perspective, losing their business outweighs the risks to their customers. The problem is that they don't have evidence that their values outweigh the risks because (1) they don't acknowledge the risks, and (2) they focus on the impact on their individual lives rather than the lives of others who have a stake in the belief. Whereas public health authorities are trying to make decisions for all members of the population (even though they don't always get it right), conspiracy theorists focus on one group's values to the exclusion of other groups' values.

These psychological needs make theories of nefarious power and social manipulation attractive: "It's not just bad luck that things are the way they are (that's not satisfying). And it's not my fault (I don't want to give up what I value for the sake of solving social problems). So, it must be a cover-up." Focusing on values instead of evidence clouds judgment making conspiracy theories seem much more powerful than they are.

Conspiracy theories are also usually **simpler** than their mainstream counterparts. If expert-level information is required to understand something, we feel powerless when people talk about it. Simple explanations make us feel powerful. We can think about them, comment on them; we can speak authoritatively about them in ways we can't speak about physics, biology, epidemiology, climate science, etc. The appeal to simplicity is evident when conspiracy theorists use phrases like, "If you think about it, it's obvious" and "You have to think for yourself. Don't be a sheep."

While not all conspiracy theories are simple in general (the machinery necessary to explain the origin of Covid-19 and all the subsequent deaths in terms of a conspiracy is gargantuan), they are still usually less complicated than real life. For example, the idea that a few money-hungry politicians conspired with some pharmacy executives to create the Covid-19 pandemic is much more satisfying and comprehensible than all of the science jargon that epidemiologists and infectious disease doctors tried to explain about SARS-CoV-2. While most of us were trying to understand the complexities of infectious disease, as experts tried to explain R-values (the measure of a virus's ability to spread), K-values (the rate of infection spread), what a PCR test is and its reliability, what triage protocols are, and which kind of masks actually work, conspiracy theorists could appeal to common sense: "You know what freedom feels like, right? Those people are trying to take it away." The simplicity of the conspiracy theory gives power to people who couldn't understand epidemiology because none of that matters if there's a very clearly understandable nefarious plot behind it all.

Consider also the question of whether GMOs are safe. According to public health experts Jack and Sara Gorman:

> The overwhelming scientific consensus is that GMOs are not harmful to human health, but the details of how a gene is inserted into the genome of a plant to make it resistant to insects, drought, or herbicides and pesticides requires explaining some complicated genetics. On the other hand, Monsanto is a huge company and its business practices are aimed at bigger and bigger profits. Corporations can and have indeed ignored all kinds of health and safety issues in favor of profits. … Hence, rather than get into the complexities of genetic modification, we are swayed by the simple belief that Monsanto has a plausible motive to deceive us—there is, a profit motive. (2017: 54)

Here we see clearly that the conspiracy theory appeals to values other than truth (risk to public safety vs. the desire for profits) and the *ad hominem* fallacy (the fact that companies like Monsanto have a profit motive settles the issue of whether GMOs are safe).

The same kind of simple reasoning is involved in all kinds of conspiracy theories, from the moon landing to aliens at Roswell, to the governmental plot to destroy the Twin Towers. The idea that the government was more concerned about public opinion than confident that it could put people on the moon was something the public at large could understand. The harrowing scientific uncertainty and incomprehensible mathematical complexity that it took to make the actual event happen was not.

**Cascade logic** is another key feature of conspiracy theories. The process starts with raising suspicion based on common sense. If one piece of common sense holds, then another closely related suspicion is raised. The collection of suspicion, reinforced by multiple voices, makes a very implausible claim seem likely to be true.

Cascade logic often occurs when we have very little information on a topic but are pressured to make a decision in very little time about what to believe based only on a conspiracy theorist's reasoning. The pressure to make a decision makes the jump from suspicion to suspicion easier to accept. The event is framed for us non-experts by the conspiracy theorist. Let's take the SARS-CoV-2 virus as an example. Conspiracy theories are usually at least *possibly* true, and so we start from that reasonable assumption ("Think about how many politicians have stock in pharmaceutical companies, and how much money pharmaceutical companies could make off of a worldwide vaccine mandate"). We are then given a simple, "common-sense" explanation in terms of a conspiracy ("Dr. Fauci was working in Wuhan, China. Don't you find that a little suspicious that the virus originated there and that Fauci is the one advising the government?"). If that explanation makes sense to us (or if we are driven primarily by psychological needs other than truth—including the conspiracy theorist's reputation), we may concede (even if only weakly) the conspiracy theorist's point. We might even construct our own, weaker version of it because, of course, we are critical thinkers, too ("My friend wore a mask and got Covid anyway. I bet masks are just a test. If the government can get us to trust them about masks, they can enact all kinds of social control measures. If I refuse to wear a mask, I'm showing how shrewd a thinker I am and standing with free people against the government"). All this is bad enough, but here's where it gets complicated.

First, there isn't just one conspiracy theorist saying this; there are dozens. And some of them are people we trust. So, without any additional information, without getting any more evidence, the weak evidence for the conspiracy suddenly seems much stronger. Weak evidence bolstered by reputation cascades on top of (is added to) previous weak evidence, and suddenly the conspiracy theory doesn't just look possible; it starts to look plausible.

Second, even if we decide to dig in and look for conflicting evidence, any new information we look for or come across must now *overcome* our initial suspicion. To ease our concerns, we would have to find reasons for thinking that our plausible-sounding theory doesn't fit with the evidence. But, as you might imagine, the information put out by official, mainstream experts—the Centers for Disease Control, the World Health Organization, independent doctors, Dr. Fauci, and so on—*is not designed to address these concerns*. That information is focused on issues the mainstream experts think the public needs to know about. In the case of Covid-19, it was the nature of the virus, how dangerous it is, possible preventive measures, and the race for a vaccine. Since the mainstream experts don't address our suspicions, we become even more suspicious because maybe they don't want to accidentally admit they're lying. The seeming evidence against the mainstream experts mounts: "All these experts act like nothing is suspicious, and they're treating us as if we can't think for ourselves!" By the time that disgruntled doctors join the conspiracy theorists (see heroic lone wolf below), the cascade effect moves the needle on the conspiracy theory from merely plausible to slightly more plausible.

Conspiracy theorists then assume that **the conspirators have an immense amount of power** to keep their plot secret. Both conspiracy theorists and those who oppose them agree that the only way large-scale conspiracies can be executed is with large-scale power. But, in order to pull off some of what's claimed, the power required is truly not credible. Consider how many people would have to buy in or be bought off to conceal a conspiracy as large as the United States destroying the Twin Towers or the Covid-19 pandemic. It's not just one or two key people, but hundreds of thousands, in some cases—millions in others. Recall Jeffrey Tucker's claim about the NIH earlier. That's grandiose enough—the whole US scientific community is under the sway of the NIH. What he didn't mention was that the conspiracy he's concerned about would require collusion among the governments and health organizations of every industrialized country in the world, from England to Japan, Argentina to Australia. Such a conspiracy, if it were real, would be so large and monumental that there's nothing any of us could do about it anyway. The more plausible story is that the world is complicated, and whatever fraud, deception, or error is taking place during the Covid-19 pandemic (for there surely is some), it's taking place on a much smaller scale.

So far, we have seen that conspiracy theorists identify a psychological need; give us a simple, common-sense explanation; put us in a defensive position that is not addressed by mainstream experts; and then exaggerate the power of the players. A final key element is the emergence of **a minority of heroic nay-saying experts**, lone wolves who stand on the side of the conspiracy theorists. For any debate, as you might guess, there are experts on both sides. And in the case of conspiracy theories, the number of people on their side is often small. But it is precisely their small number that is taken to be evidence of a conspiracy. Only a few would have the courage to speak out against such powerful enemies. And when these lone wolf experts join the conspiracy theorists, their small numbers make their testimony seem stronger than it is. If experts are on board, maybe there's something to the conspiracy theory after all.

The problem is that the experts who support conspiracy theories rarely represent the current state of evidence on the issue. In the case of the FLCCC, their evidence that ivermectin works against Covid-19 is scant and, according to other experts, poorly conducted. As of this textbook, two of their primary research articles aiming to demonstrate the effectiveness of ivermectin and other controversial treatments have either been retracted or required to submit corrections indicating lack of clinical efficacy ("Review of the Emerging Evidence Demonstrating the Efficacy of Ivermectin in the Prophylaxis and Treatment of Covid-19," 2021, correction issued with disclaimer; Clinical and Scientific Rationale for the "MATH+" Hospital Treatment Protocol for Covid-19," 2021, retracted).

Some might argue that this is further evidence of the conspiracy. The problem for novices is that the experts in the field—namely, those who have raised concerns about the accuracy of the research—are the only people in a position to know whether the paper was retracted for legitimate scientific reasons. In most cases, the question, "Which set of experts should we believe?" is easy to answer. When a majority of experts in a domain agree on something, that reflects the current state of understanding in the field. The minority experts are usually tinkering, pressing, challenging the status quo. They're often wrong. But sometimes they're right. And only time (after the majority of experts have reviewed their work) can tell whether they were right. In those cases, novices can do no better than accept the state of the field.

In a few cases, the question is slightly different. For example, when an issue is time-sensitive, like the Covid-19 pandemic, the problems and questions are so new that one of two things can happen. (1) There is no consensus because there is no agreed on interpretation of the events. This was true early in the Covid-19 pandemic when the virus was spreading quickly but experts knew very little about it and how best to avoid it. Time-sensitive cases are playgrounds for conspiracy theorists because they have an opportunity to plant the seeds of their non-truth-based, relatively simple explanation. By the time the experts have agreed on the basic facts, conspiracy theories are already entrenched in some people's beliefs.

(2) The consensus is based on political expediency rather than independent review. Experts are supposed to speak on topics based on their understanding of the field and on their own research. This is why the more experts who agree on something, the more likely that thing is to be true. But experts are human. So, for any topic where the stakes are high, some experts will agree with

other experts simply in order to display a "unified front" to the public. For example, while we now have overwhelming evidence that climate change is happening and is accelerated by humans, it wasn't always the case. However, the stakes were always super high. If greenhouse gas emissions were causing global warming, then it was imperative to lower them as quickly as possible, even before all the evidence was in. Further, lowering greenhouse gas emissions wouldn't be bad for the environment, so the only expense would fall to companies who produce lots of emissions. This possibility was fertile ground for conspiracy theorists. Many were concerned that scientists were simply supporting the mainstream view of global warming for the sake of inciting political action or securing positions of authority in universities rather than because of the best science. Whether this was true or not is unclear. Nevertheless, given that such a decision would be made for a reason other than truth and involves a kind of conspiracy (scientists secretly agreeing among themselves to say the earth is warming), if it were true, conspiracy theorists would be right to point out a problem for expert consensus.

## What Can We Do about Conspiracy Theories?

As you might have noticed, while conspiracy theories have these features, they aren't the only theories that have them. Even in this book, we have encouraged you to "think for yourself" and to consider simple, elegant theories plausible (see Chapter 9 on "simplicity" in scientific reasoning). The problem is that conspiracy theorists are quite clever, and the explanations they come up with are not very different from the way real conspiracies play out.

Consider one of the most famous real conspiracies: the collusion of scientists with the tobacco industry to prevent people from finding out how dangerous smoking is. Here's a version of it from public health experts Sara and Jack Gorman:

> Let us imagine that in 1965 a crusader goes on the radio and television talk show circuit insisting that nicotine is a powerfully addicting substance and that smoking cigarettes is a deadly addiction. Furthermore, this crusader declares that tobacco companies, which usually compete against each other, had joined forces to finance a cadre of scientists with impressive credentials to promote false and misleading science supposedly showing that cigarettes are harmless. In addition, this conspiracy of tobacco companies and scientists was prepared to use its vast financial resources and scientific influence to ruin the scientific careers of anyone who dared claim otherwise and even to

> spread around lavish political contributions … to government officials in order to induce them to back away from legislating against tobacco products. (2017: 36–7)

This story hits almost all the key elements of a conspiracy theory: the psychological need of safety, simplicity, exaggerated power, a heroic lone wolf. If we didn't know it was true, it might sound like fantastical political fiction. But if real conspiracies have many of the marks of conspiracy theories, what are we outsiders to think? Is there any way to avoid the traps that conspiracy theorists set?

The first step in responding to the problem of conspiracy theories is to give ourselves a little charity. Some conspiracies are real, and some conspiracy theories are especially compelling—especially if you live in a community where one or more is common among people you trust. Plus, since we know we are susceptible to fallacies, we shouldn't be surprised when we find ourselves believing things for bad reasons.

Once we've admitted this, we can (a) approach the question more humbly, and (b) prepare ourselves to do the hard work of gathering and weighing evidence. Here are five strategies to help you determine whether an explanation is genuine or a conspiracy theory. These strategies aren't foolproof. Every conspiracy theory is a little different, and in some cases, evidence is difficult to find or understand (such as the evidence surrounding climate change). Nevertheless, the more careful you are, the more thorough you are, and the more even-handed with the evidence you are, the better your chances of avoiding believing something for bad reasons.

## Strategies for Thinking Critically about Conspiracy Theories

### Dive in; Don't Cop Out

When an issue matters, it is easy to feel overwhelmed by the work it would take to sift through all the diverse voices. And when you think there might be a conspiracy involved, it's easy to feel demoralized and want to throw your hands up. You may reason that "there are experts on both sides of anything, so believe whatever you want." Or you may convince yourself, "the media will tell you anything; you can't trust anyone." Still yet, you may see some inklings of truth in the conspiracy theory and think, "just follow the money; whoever's benefitting controls the story."

The problem with all of this reasoning is that it's too easy. You may feel like you're thinking for yourself, but really you're not thinking long enough or hard enough. You aren't doing the hard work of seeing whether one side of the debate has better evidence. No belief you form about the issue will be well-supported. Sure, there are experts on both sides, but that doesn't mean there aren't good reasons for siding with one group over the other. And yes, the media plays terrible tricks with information. But that doesn't mean you can't, with a little work, sift through it to see what's real. In giving up too easily, you're opening the door for conspiracy theorists to undermine your good critical thinking skills.

## Use the Same Standards for Your Beliefs That You Apply to Others'

When we believe for bad reasons, we often have different standards for those beliefs than we do for others who hold contrary beliefs. We point out evidence that *confirms* our beliefs but look for evidence that *disconfirms* others' (confirmation bias). We consider the possibility that we are right to be more significant than the possibility that we are wrong (anchoring). We attribute others' beliefs to bad motives or conflicts of interest rather than bad evidence (*ad hominem*). We suggest that the fact that there's little evidence that we're wrong counts as evidence that we're right (argument from ignorance).

Believing responsibly, on the other hand, requires that we apply the same standards of good evidence to all beliefs, no matter who holds them. If a respected epidemiologist says that Covid-19 is life-threatening, we cannot simply reply that she is only saying that because she is a member of the medical establishment and then point to a different epidemiologist as evidence to the contrary. Use the same standard for your own beliefs that you hold others to.

## Get Independent Evidence from Diverse Sources

Conspiracy theorists often characterize their opponents as benefiting from the conspiracy in some way. Researchers get funding and cherished professional positions, executives get big bonuses, politicians get big dividends, and so on. If this is right, then it wouldn't be enough to ask them—the people who benefit—whether there is a conspiracy. They would obviously say no. But what about people who aren't positioned to benefit but who are positioned to know? If someone is not likely to benefit from the conspiracy and has access to the relevant information, then, barring secret threats (which did happen in the tobacco case), they could help confirm or disconfirm the conspiracy theory.

Consider yet again the case of Covid-19. While some epidemiologists, infectious disease doctors, and researchers had financial ties to big industries set to make a lot of money, not all did. Most hospital physicians, nurses, hospital administrators, and academic epidemiologists don't stand to benefit from the conspiracy. What were they saying? If everyone who had no obvious ties to the conspiracy had a different perspective on what was happening, then we would worry. But it turns out that the majority of independent experts held that Covid-19 was real, dangerous, and cause for political concern. Doctors who weren't epidemiologists nevertheless saw their ICUs fill up with patients with a strange respiratory disease. Nurses saw scores of people die because they couldn't breathe. No conspiracy theory about Covid-19 could escape the cold, hard truth that lots of people died very quickly.

The same strategy works for issues like climate change, whether HIV causes AIDS, whether GMOs are dangerous, and the like. As long as all the experts aren't paid off or threatened—which is exceedingly difficult given access to the internet—diverse, independent voices can be heard and can be helpful.

## Look for Consequences and Base Rates

In addition to independent expert voices, there are other pieces of evidence accessible to non-experts that are worth taking seriously. For example, you can look for whether events in the real world unfold as predicted by the conspiracy theorists. Consider the conspiracy theory that the MMR vaccine causes autism. There are lots of reasons to doubt this one. The originator, Andrew Wakefield, was not an expert in the field (he was a gastroenterologist, not an immunologist, geneticist, or developmental pediatrician). Wakefield's original research was retracted for falsified data, and no other study has replicated his supposed findings.

But even if you didn't know any of that, consider that most people alive today had the MMR vaccine, and yet the rate of people with autism remains low, about 1 percent. Further, some people who didn't get the MMR have autism. This shows that the base rate of people who get the vaccine but do not have autism is about 99 percent. Recall our discussion of "base rate neglect" from Chapter 8. Even without scientific training, you can see from the base rate of autism among the general, vaccinated population that there is not even a moderate correlation between the MMR vaccine and autism.

The same test exists for the dangers of Covid-19 and the effectiveness of vaccines. Ask anyone who works in hospitals if scores of people have been hospitalized with Covid-19. You'll find that many hospitals had to open whole new wings or whole floors just to accommodate the overflow of Covid-19 patients. And then ask them to compare the number of hospitalized Covid-19 patients who had the vaccine with the number of hospitalized Covid-19 patients who didn't get the vaccine. The number of unvaccinated hospitalizations vastly outstrips the number of vaccinated hospitalizations, across all demographics and health conditions. You don't need to be an expert to use these basic pieces of evidence to determine whether a theory about Covid-19 is a conspiracy theory.

As of the writing of this book, the pandemic continues. And many conspiracy theorists are concerned that mask mandates and lockdowns will become permanent—an overreach of governmental power aimed at eradicating individual freedom. They are saying things like: "If there's an omicron variant, you know there will be an omega variant. The pandemic will never end because it was never meant to end." This is clearly a slippery slope argument (see Chapter 10) designed to evade an empirical question: Will mandates last past the public health emergency? But there are already hopeful signs that such mandates are not permanent. Many countries and states in the United States have lifted mandates as Covid-19 numbers drop. Travel restrictions go away or come back as needed. This suggests that governments are responsive both to the data produced by hospitals and infection control centers and to their citizens' values and interests. Noticing these details and including them among your total evidence can help guard against the temptation to believe a conspiracy theory.

## The Bigger the Conspiracy, the Less Likely It Is True

While the tobacco industry conspiracy was huge, conspiracies are rarely that large. Or, at least the large ones are rarely discovered. If they aren't discoverable, there is little anyone can do about them (consider conspiracy theories about a New World Order or the Illuminati). In the case of the tobacco industry, experts in the field had a hard time figuring out how to get the real science into the hands of the public. Those are fights best left to the experts. Novices didn't have the real scientific evidence, and there was no way for them to get it. From a critical thinking perspective, the deceivers had done their work well. People were justified in believing the mainstream view even if that view were manufactured by a conspiracy and false.

The world is complicated, and there is no doubt that people with power use it poorly. The question is just how far their nefariousness can go. If a theory explaining some event requires gargantuan coordination efforts, it is probably not true. That doesn't mean that there is nothing to be concerned about—perhaps there are more localized collusions among certain parties. But applying this strategy allows you to spend your cognitive energy on more plausible explanations. And that brings us to the final strategy.

## Spend Time on What Matters; Suspend Belief about the Rest

Most of us believe way more than we actually have evidence for. That's because most of it doesn't matter that much. We grow up with false beliefs about Christopher Columbus, Abraham Lincoln, the Cold War, and so on. But nothing much hangs on them. Being a good critical thinker involves adjusting your degree of certainty about beliefs like that when you come across them. If someone were to ask, "Did George Washington really have wooden false teeth?" you might think: "Huh. Well, I remember hearing that when I was young, but I've never looked into it. I guess I'm not very certain that's true." Even though nothing really hangs on it, you are calibrating your belief-system to handle tougher cases when they come up. If someone asks, "Did your roommate really steal $20 from you?" you might be more prepared to say, "Well, my evidence isn't very strong at the moment. Maybe I will look into more before I accuse him."

The same goes for issues for which there are conspiracy theories. Most conspiracy theories are fun to think about but have little bearing on how we live our lives—Who really killed JFK? Did aliens crash in Roswell? Is the leader of the National Rifle Association really the target of a left-wing conspiracy to make citizens vulnerable to criminals? Some issues, however, are worth spending a little time with: Does HIV cause AIDS? Are humans the primary cause of climate change? Do vaccines cause autism? These issues affect people we know and love. Getting the real story about them affects how we live and how we vote. What's more, some issues associated with conspiracy theories have immediate and potentially devastating consequences: Is Covid-19 real, and will a vaccine help protect my family from medical bankruptcy or death? The more immediate and serious the impact a belief has, the more time and energy we should devote to having responsible beliefs about it. The less the immediacy and certainty a belief has for us, the more we should be willing to suspend judgment about it.

## Exercises

**A. Each of the following theories appeals to a conspiracy. Use the concepts and tools in this chapter and complete each of the following:**

1. **List the key features of conspiracy theories that each theory has.**
2. **Create your own conspiracy theory for that event. Explain your theory in three to four sentences.**
3. **Use the strategies explained in this chapter to give reasons for why you think the claim is a real conspiracy or a faulty conspiracy theory.**
   a. A conspiracy was behind the assassination of President Lincoln.
   b. A conspiracy was behind the assassination of President John F. Kennedy.
   c. A conspiracy explains why doctors continue to say that high-fat diets lead to heart disease.
   d. A conspiracy explains why the majority of scientists say that GMOs are safe.
   e. Conspirators hid the fact that General Motors's cars had faulty ignition systems despite several deaths.
   f. Psychiatrists have conspired to promote ECT (electroconvulsive therapy) as a treatment for depression despite evidence of its ineffectiveness.
   g. Climate scientists and governmental authorities have conspired to make the world believe that global warming is happening and that fossil fuels are the primary contributor.
   h. Corporate executives have conspired with governmental agencies to manufacture evidence that nuclear power is safe and environmentally friendly despite its obvious dangers.
   i. Government agents conspired to engineer the Watergate scandal in order to discredit the Democratic Party.
   j. Leftist politicians have conspired with social scientists to produce evidence that gun ownership is dangerous, flouting evidence to the contrary.

**B. Some people believe that the government's decision to put fluoride in the water was not motivated by concerns about oral health but instead was motivated by a conspiracy. Respond to the following prompts.**

1. Use the internet to find and explain this conspiracy. Make sure your responses include answers to these questions: What did the conspirators expect to gain? What did the population stand to lose?

What government agencies, experts, etc. had to be involved for this to be a successful conspiracy? What strategies/media/methods did the conspirators use to promote their theory throughout society?

2. Assuming this was no conspiracy, what might the government have done to combat this conspiracy?
3. How do you think about fluoride mandates? Do you have reasons to believe that there really is/was a conspiracy? Do you have reasons to believe there was no conspiracy at all and that people really do benefit from fluoride in the water? Explain in detail using the strategies from this chapter.

# References

Gorman, Jack, and Sarah Gorman (2017). *Denying to the Grave: Why We Ignore the Science That Will Save Us* (New York: Oxford University Press).

Sunstein, Cass R., and Adrian Vermeule (2008). Conspiracy Theories (January 15). Harvard Public Law Working Paper No. 08–03, University of Chicago, Public Law Working Paper No. 199, U of Chicago Law & Economics, Olin Working Paper No. 387. http://dx.doi.org/10.2139/ssrn.1084585.

# Answers to select "Getting familiar with…" exercises

## Chapter 1 – The basic tools of reasoning

### Getting familiar with… different types of claims.

1. Question
3. Command
5. Emotive Iteration
7. Emotive Iteration
9. Question (This one depends on context. Literally, it is a question. But, depending on who is saying it—and the tone with which it is said—it could be a command.)
11. Prescriptive Claim
13. Descriptive Claim
15. Question (If asked rhetorically, in an exasperated tone, this is an emotive iteration.)
17. Prescriptive Claim
19. Question

## Getting familiar with… operators.

a.

1. Conditional
3. Conjunction
5. Simple
7. Bi-conditional
9. Disjunction
11. Conditional
13. Disjunction
15. Negation

b.

1. Conditional
3. Bi-conditional
5. Conjunction

## Getting familiar with… quantifiers.

1. Some
3. None
5. Some
7. All
9. Some
11. All
13. None
15. All
17. Some
19. All

## Getting familiar with… evidence.

**a.**

1. Given the earth's speed and the time it takes to complete one rotation around the sun, then assuming the sun is in the center of the orbit, we can calculate the distance between the earth and the sun (indirect). Established scientists like Neil DeGrasse Tyson say that the Sun is about 92,960,000 miles from Earth (Indirect).
3. The people who program calculators believe that 2 + 2 = 4 (Indirect). I understand the relationship between 2 and 4 such that it is clear to me that 2 + 2 = 4 (Direct).
5. The only photo from the moon has shadows in two different directions, which wouldn't happen if the sun were the light source illuminating the picture; it must have been taken in a studio (Indirect). Scientists working for NASA have testified that all moon landing attempts were failures (Indirect).
7. I can tell the difference between different colors, and these words are black (Direct). Books are usually printed with black letters on white pages (Indirect).
9. I remember from Chemistry class that carbon atoms are larger than hydrogen atoms (Indirect). A chemist friend of mine says that hydrogen-1 atoms have a smaller atomic mass than carbon-12 atoms (Indirect).
11. I have suffered quite a bit (Direct). I have heard about the suffering of many people all over the world (Indirect).
13. Textual scholars reject that method as unreliable (Indirect). There are clear examples where that calculation leads to the wrong conclusion about the author of a text (Direct—counterexamples demonstrate directly that the method is unreliable).
15. I look older than my siblings, and people who look older usually are older (Indirect). My and my siblings' birth certificates tell me that I am older than they (Indirect).
17. Simpson had more motive and opportunity than anyone (Indirect). The murder weapon, style of killing, and time of death indicate that Simpson is likely the killer (Indirect).
19. Humans and chimpanzees are similar in genetic make-up (Indirect). Humans have physical features similar to chimpanzees (called homologies) (Indirect).

**b.**

1. Sense experience. (However, this phrase is sometimes used metaphorically to mean "angry," which would be an emotional experience.)
3. Sense experience
5. Sense experience
7. Sense experience
9. Emotional experience
11. At first, it is a sense experience, then, once processed, it becomes an emotional response as you remember what the smell reminds you of.
13. Sense experience. If I can feel such things at all, I physically feel my hand's position, though not through one of my primary five senses. This is most likely a combination of those senses.
15. Sense experience, most of the time. I can see and count three objects and then five objects and conclude that they represent eight objects. And I have been taught and remember that three of something and five of something are undoubtedly eight somethings. But actually "understanding" that it is true may be a different sort of experience altogether.
17. Sense experience. I feel the pressure, temperature, moisture, and the like. of the air change and I remember that those things are correlated with rain in the past.
19. Both sense and emotional experience. I may see something that inspires a memory of my deceased dog. The dog does not exist currently, yet I vividly remember its looks, actions, and the sound of its bark to be remarkably similar to what I just experienced. But that memory is vivid because it has many emotional features. I cannot remember my dog without feeling something about it.

## Getting familiar with… arguments.

1. Argument. Premises: The rug is stained. The rug was not stained last night. The dog is the only thing that has been in the room since last night. Conclusion: The dog stained the rug.
3. List
5. Narrative that includes information. We learn not only the order of events but also details about the events.
7. Argument. Premises: She is 21 years old (legal driving age). She

has no history of accident. She does not drink, which means she is not at risk for accidents due to alcohol. Conclusion: She is trustworthy to drive your vehicle.

9. Narrative
11. Narrative
13. Informational statement that contains a narrative. (The key is that the narrative doesn't tell us any details of the story; we don't know any details of the childhood home, the family lineage, etc. This suggests that it just meant to inform us about what sort of story he told.)
15. Narrative that contains an argument. Premises: [The victim was shot—enthymemic premise.] The bellhop had the gun that killed the victim. The bellhop is the only person with motive. There was no other evidence about who killed the victim. Conclusion: The bellhop killed the victim.
17. List that informs (This list is given in response to a question. The list serves as an answer to the question, so it is an informational statement.)
19. Argument. Premises: Edwin Hubble discovered evidence of a Big Bang event. Arno Penzias and Robert discovered more evidence of a Big Bang event. Conclusion: You should believe the Big Bang theory.

## Getting familiar with… identifying arguments.

1. **Premises**: The project has been unsuccessful. There is no hope that it will be successful. The money we are spending on it could be used better somewhere else. If these things are true, you should cut the program. **Conclusion**: <u>Therefore</u>, you should cut the program.
3. **Premises**: The first three experiments showed no positive results. The fourth experiment showed only slightly positive results. Experiments with drugs that do not yield overwhelmingly positive results suggests that those drugs are not effective. **Conclusion**: <u>We must conclude that</u> the drug is not effective for treating that illness.
5. **Premises**: Candidate Williams is caustic and mean. She is lazy and irresponsible. And she has no experience managing people. You should not vote for people with these qualities. **Conclusion**: You should not vote for candidate Williams. (No indicating words.)

7. **Premises**: There are many people who were concerned that Descartes had become a Protestant sympathizer. He threatened the standard educational practices in the Jesuit universities. Anyone who raises such concerns could be a target for assassination. **Conclusion**: Therefore, it isn't unreasonable to believe Descartes was poisoned.
9. **Premises**: All psychologists, poets, and novelists who have studied the intelligence of women recognize today that women represent the most inferior forms of human evolution and that they are closer to children and savages than to an adult, civilized man. Women excel in fickleness, inconstancy, absence of thought and logic, and incapacity to reason. [People who exhibit these traits are inferior to those who do not. Men do not excel in fickleness, inconstancy, absence of thought and logic, and incapacity to reason—enthymemic premises.] **Conclusion**: Women are inferior to men.

# Chapter 2 – Evaluating arguments

## Getting familiar with… extraneous material.

There are a number of ways to express the intended meaning of each these. Some of them could mean just about anything, and our answers here by no means exhaust the possibilities. But they give you a sense of possible interpretations. Experiment with others and talk them over with your instructor and peers.

1. The wind blew against the sea wall for a long time.
3. To succeed at any job well, you must be able to work with others who act differently than you.
5. Circumstances are unfortunate. We must all do things we do not like to keep things from getting worse.
7. Evaluate yourself or others in a way that helps you or them see their performance accurately.
9. I will not run for office if I don't believe I see what needs to be done to make people better off than they are and if I don't have the ability to do those things.
   (It is difficult to make this much more precise because it isn't clear what sorts of things could be done, what it would mean for someone to be "better off," or what it would mean to have the ability to do those things. Politicians are slippery.)

11. Please work hard and do your job well.
13. We need to design and create products that no one else has thought of.
15. We're trying out some new policies this year that we hope you'll like.
17. Don't be afraid to be creative. Experiment with new ways of doing things.
19. Don't waste time.

## Getting familiar with… implicit claims.

We have placed the implied claims in brackets.

1. Missing. God made dirt. [Anything God makes is not harmful.] Dirt doesn't hurt. [Therefore, you can eat(?) dirt.]
3. Disguised. You have to be registered to vote. You are not registered to vote. [Therefore, you should register to vote.]
5. Missing. Every religion is a story about salvation. [Buddhism is a religion.] So, Buddhism is a story about salvation.
7. Missing. [You should not put young children on trial.] That child is only four years old. Therefore, you should not put that child on trial.
9. Disguised. All liberals are elitist atheists. You're not an elitist atheist. [Therefore, you are not a liberal.]
11. Missing. You have to score at least a 90 to pass this exam. You only scored an 87. [Therefore, you did not pass this exam.]
13. Missing. It's not over until the music stops. The band plays on. [Therefore, it's not over.]
15. Missing. [If it is five o'clock somewhere, I am having a beer.] It's five o'clock somewhere. So, I'm having a beer.
17. Disguised premise. Missing conclusion. If Creationism were true, there wouldn't be any vestigial organs. The tailbone and appendix are vestigial organs. [There are vestigial organs. Therefore, Creationism isn't true.]
19. Missing. Most terrorists say they are members of Islam. [A religion is violent if its practitioners are violent.] Therefore, Islam is a violent religion.

## Getting familiar with … ambiguity and vagueness.

1. Syntactic ambiguity.
   **a.** The lab mice assaulted him.
   **b.** He was assaulted next to the lab mice.
3. Lexical ambiguity: prescription
   **a.** He gave her a medical prescription for a medication that alleviates pain.
   **b.** He gave her advice about how to cause pain.
5. Syntactic ambiguity.
   **a.** They were discussing cutting down the tree that is growing in her house.
   **b.** While they were in her house, they were discussing cutting down the tree.
7. Vague. It is unclear what counts as "unfair" in this context Some options:
   **a.** The test was more difficult than the student expected.
   **b.** The test did not give all students an equal chance at success.
   **c.** The test did not give students a reasonable chance at success.
9. Vague. It is unclear what counts as "nice" in this context. Some options:
   **a.** She is friendly.
   **b.** She is morally good.
   **c.** She is charitable.
   **d.** She is pleasant.
11. Syntactic ambiguity (but the syntactic ambiguity trades on a lexical ambiguity with the word "duck").
   **a.** He saw the duck that belongs to her.
   **b.** He saw her lower her head quickly.
13. Vague. It is unclear what counts as "terrible" in this context. Some options:
   **a.** Unsuccessful at his job.
   **b.** Supporting policies that harm citizens.
   **c.** Supporting policies with which the author disagrees.
   **d.** Not communicating well or much with citizens.
15. Vague. It is unclear what counts as "great" in this context. Some options:
   **a.** Locke was an intriguing writer.
   **b.** Locke defended many claims that turned out to be true.
   **c.** Locke argued for his views very ably.
   **d.** Locke was a well-known philosopher.

**e.** Locke was a well-respected philosopher.

17. Lexical ambiguity. "Match."

**a.** He could not find where the tennis match was being held.

**b.** He could not find the complement to his sock.

**c.** He could not find the wooden matchstick.

19. Syntactic ambiguity.

**a.** My uncle, the priest, got married to my father.

**b.** My uncle, the priest, performed the marriage ceremony for my father.

## Getting familiar with… validity.

1. "All monotheists believe in one god."
3. "Hence, they should act wickedly."
5. "You're not serious."
7. "Therefore, we either stay or we go."
9. "All chemists are scientists."

## Getting familiar with… argument strength.

1. c: somewhat unlikely. Given that you have only one past experience with the dog, and that the dog has a track record of being much calmer, you are unlikely to be bitten again. This conclusion would be highly unlikely if we had the premise that dogs that are castrated are much less likely to be aggressive.
3. b: somewhat likely. There is very little to connect the universe and watches, but they do share at least one trait that is common to both (complexity), which makes it slightly more likely that they also share other traits, such as "having a maker."
5. d: highly unlikely. Given only these premises, we have no idea whether Rajesh loves Neha. "Loves" is not a transitive relation. The evidence do not support the conclusion to any degree.
7. d: highly unlikely. The evidence suggests that it is highly likely that the next bean will be red. Therefore, it is unlikely that the conclusion is true.

9. b: somewhat likely. Every sporting match is different, so even these things might increase the likely that the Tigers will win, it is not clear how much (as many people who bet on such things find out the hard way).

# Chapter 3 – Thinking and reasoning with categories

## Answers to select "Getting familiar with…" exercises.

## Getting Familiar with… Categories

**A.**

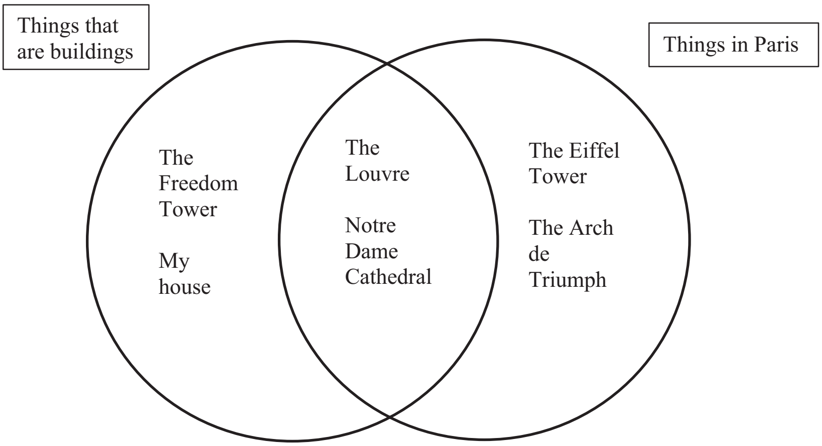
There may be a number of categories associated with each claim. We have focused on the categories you would use for expressing the claims in categorical logic. For example, in number one, you might include *things that are ancient*, *things that are Greek*, and *things that are philosophers*. Your instructor will indicate which answers are most fitting for the goals of your class.

1. Aristotle was an Ancient Greek philosopher who wrote many treatises.
   **Things that are Aristotle; things that are ancient Greek philosophers who wrote many treatises**
2. Rob has seen a few mailboxes painted like R2-D2, but most are blue.
   **Things that are mailboxes that Rob has seen; things that are mailboxes painted like R2-D2; things that are blue mailboxes**
   [Again, your instructor may allow a much more expansive list that includes *things that are Rob*, *things Rob has seen*; *things that are mailboxes*; *things that are painted mailboxes*, etc.]
3. Dinosaurs, like the Stegosaurus, roamed the Earth during the Jurassic Period.
   **Things that are dinosaurs; things that roamed the Earth during the Jurassic Period**
4. People who are not handicapped but who take handicapped persons' parking spots belong in jail.
   **Things that are people who are not handicapped but take handicapped persons' parking spots; people who belong in jail**

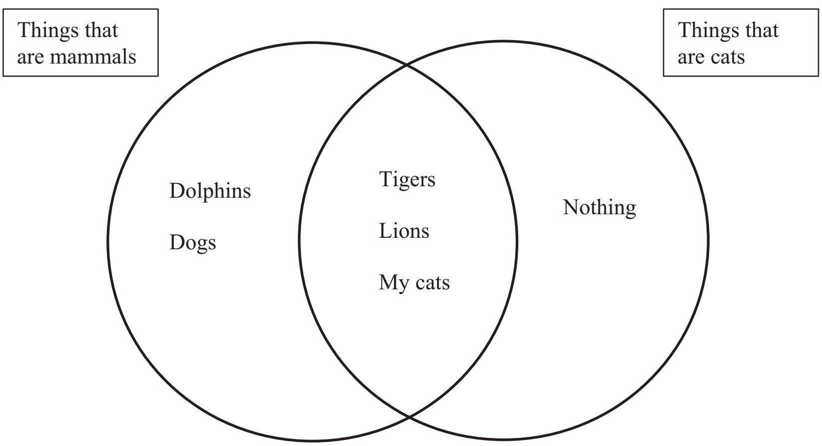
5. There are seven chimpanzees in that tree.
   **Things that are seven chimpanzees; things that are in that tree**

**B.**

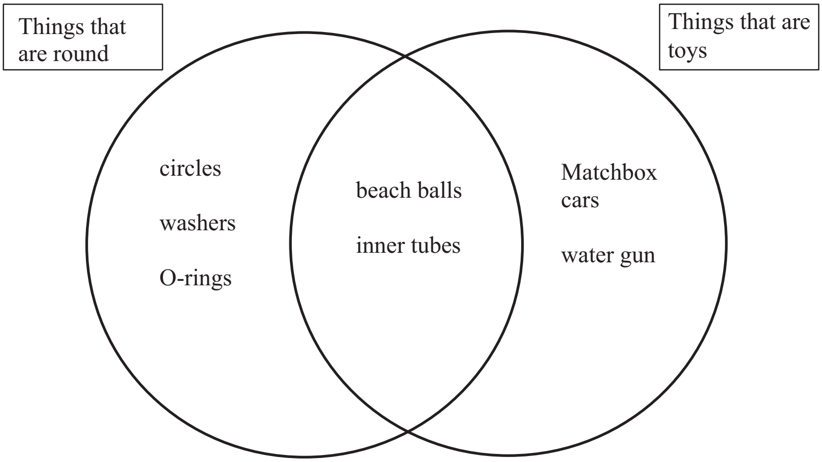
1.



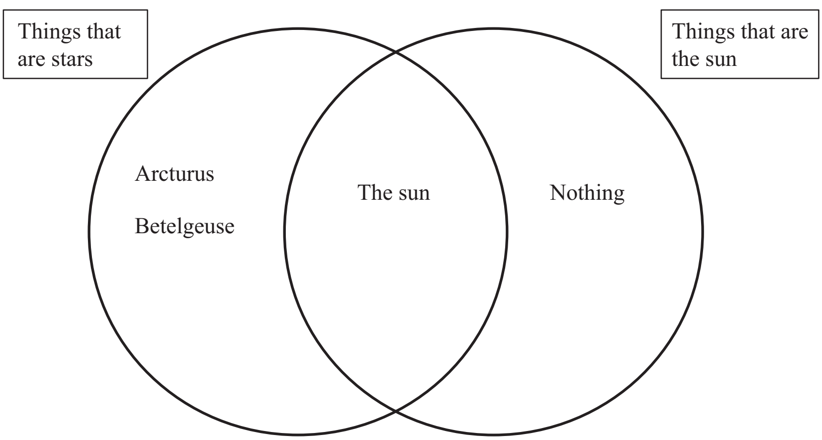

3.



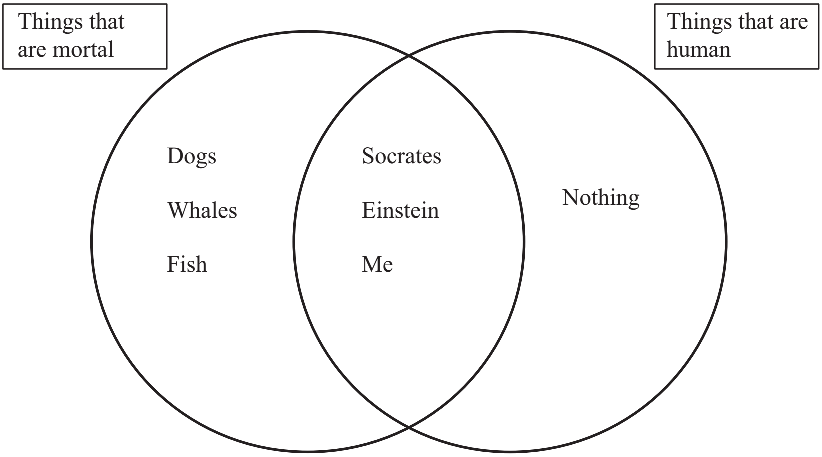
5.


Things that
are round
Things that are
toys
circles
washers
O-rings
beach balls
inner tubes
Matchbox
cars
water gun

7.

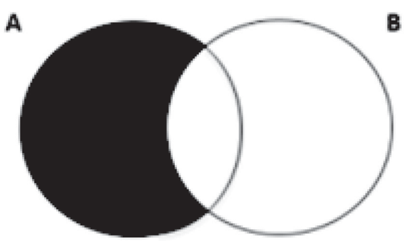

Things that
are stars
Things that are
the sun
Arcturus
Betelgeuse
The sun
Nothing

9.

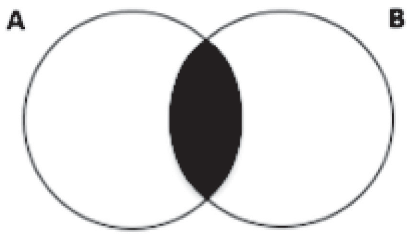



## Getting familiar with… standard-form categorical claims.

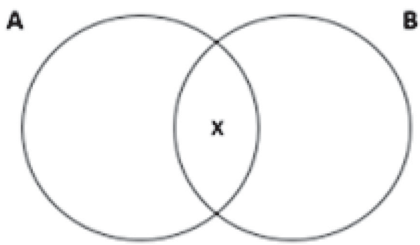
1.
A: Cats
B: Mammals



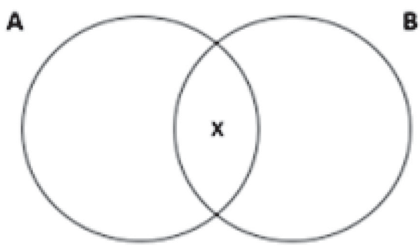
3.
A: Voters in the United States
B: People under eighteen years old



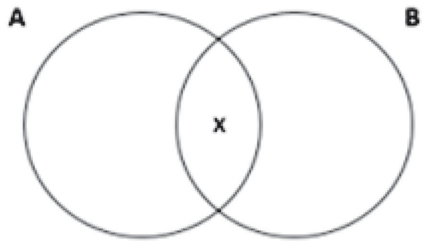

5.
A: Mormons
B: People that are rational



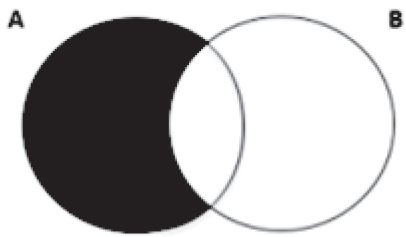

7.
A: People
B: People who like it hot



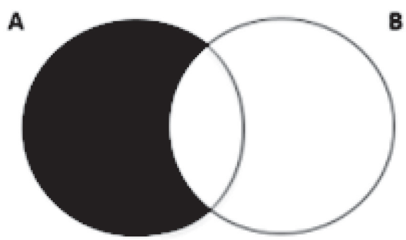
9.
A: Our students
B: People who are rational



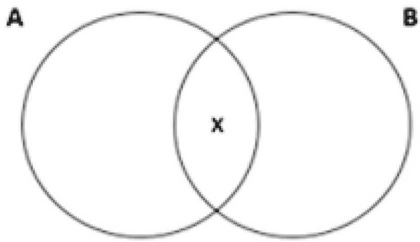

11.
A: Shelly and Zoe
B: People who are Hindu



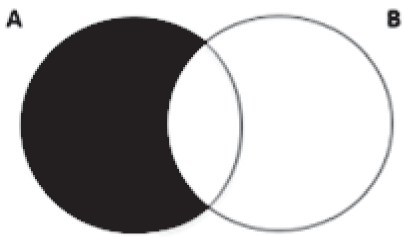

13.
A: Men
B: People who like Lady Gaga



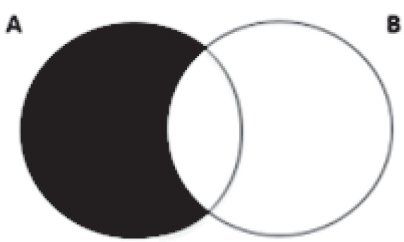
15.
A: Men
B: People who are brown-haired




17.
A: Items in this bin
B: Items that are on sale




19.
A: Dinosaurs
B: Animals that are extinct

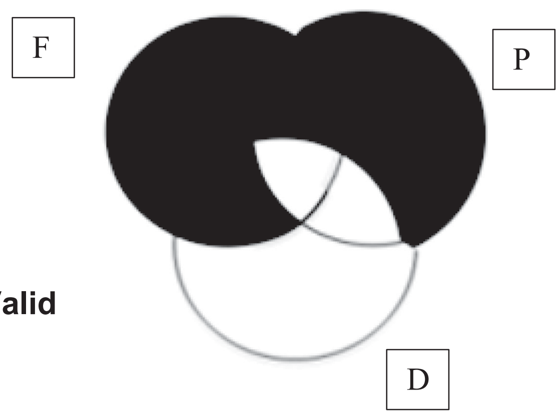


## Getting familiar with… the square of opposition.

1. True
3. False
5. True
7. False
9. False (unless you invoke the existential assumption; then it is true)
11. False
13. True
15. True
17. False
19. False

## Getting familiar with… testing categorical arguments with Venn diagrams.

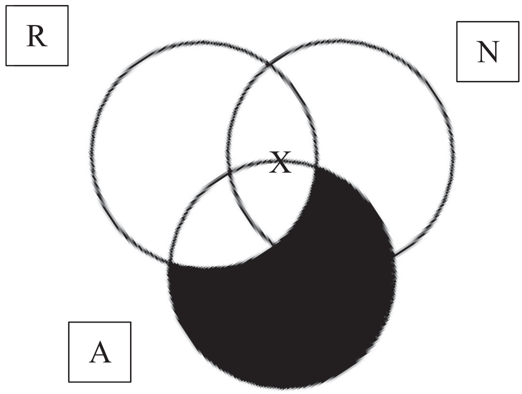
1. All frigs are pracks. All pracks are dredas. So, all frigs are dredas.




**Valid**

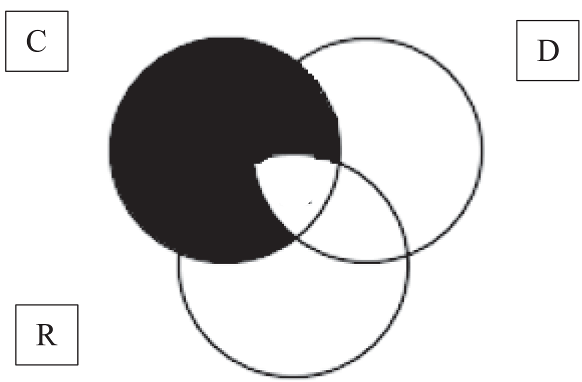
3. A few rock stars are really nice people. Alice Cooper is a rock star. Hence, Alice Cooper is a really nice person.

**Invalid**



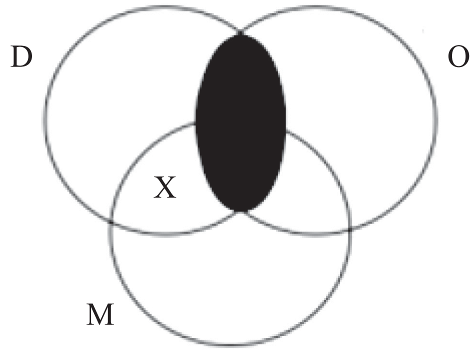

5. All CFCs (chlorofluorocarbons) deplete ozone molecules. CFCs are things that are produced by humans. Therefore, some things produced by humans deplete ozone molecules.

**Invalid**



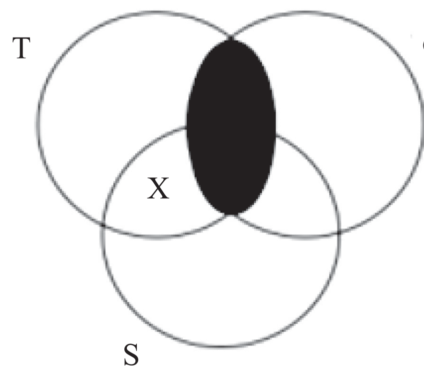
7. No drugs that can be used as medical treatment should be outlawed. Marijuana can be used as a medical treatment. Thus, marijuana should not be outlawed.

**Valid**




9. People who trust conspiracy theories are not good witnesses. A few clinically sane people trust conspiracy theories. So, some clinically sane people are not good witnesses.

**Valid**



# Chapter 4 – Basic propositional logic

## Getting familiar with … translation.

### A.

1. (C v S)
complex; disjunction

3. F
simple

5. ((B & D) v (P & S))
complex; disjunction

7. ~P
complex; negation

9. H
simple

11. G
simple

13. (F ⊃ (P v S))
complex; conditional

15. ((T v M) v Y)
complex; disjunction

17. (~S & (S ⊃ ~H))
complex; conjunction

19. ((A & T) ⊃ (D v C))

complex; conditional

## B.

1. If I throw the ball, then the window will break.
3. If it is the case that, if it is raining, the sidewalks are wet, and it is raining, then the sidewalks are wet.
5. If it is raining and it is not the case that I bring my umbrella, then I get wet.
7. If it isn't the case that if I don't pay for the ticket, I get kicked out, then I do not pay for the ticket.
9. He either went to the park or he went to the restaurant, and if he went to the park, then he is either on the swings or he is on the jungle gym.

# Getting familiar with … more difficult translations.

1. (T & D)
3. (P iff G)
5. ((L & N) & (A ⊃ F))
7. (~A ⊃ ~R)

If you interpret R as, "There is a real reason to care about morality," then translate it as ~R, as we have done: (~A ⊃ ~R). If you interpret R as "There is no real reason to care about morality," then translate it as R. We prefer the former as it allows for a more sophisticated analysis of an argument in which this claim may play a role.

9. (N & ~S)

This one is particularly tricky because of the word "sometimes." This is a quantifier, and we had a way of dealing with this in categorical logic, namely, translating it into an I-claim, "Some lies are things you should do." In propositional logic, you will need a whole new vocabulary to translate claims this like, "There is an x, and there is an F, such that x is a lie and F is a thing you should do, and x is an F, Fx." We will not cover anything that is complicated in this book, so we translate the claim containing it as a simple claim—S: "It is the case that both 'You shouldn't lie' and 'Sometimes, you should lie.'"

11. (~S v G) or (~G ⊃ ~S)
13. (~M & S)
15. (T & ~C)
17. (C & ~T)
19. (~H ⊃ ((~R v ~C) v ~M)))

This one is tricky because of the word "possible." There is another type of deductive logic that deals with "possibility" and "necessity," called *modal logic*. We will not cover modal logic in this book, so we just include "possibility" as part of the propositional claim.

# Chapter 5 – Truth tables

## Getting familiar with… constructing truth tables.

**For each of the following, construct the basic structure of a truth table. Ignore the operators for this set. (Save these; you will use them again in Getting familiar with … truth tables for operators.)**

### 1. (P v Q)

| (P | v | Q) |
|---|---|---|
| T | | T |
| T | | F |
| F | | T |
| F | | F |

### 3. ((A v B) & A)

| ((A | v | B) | & | A) |
|---|---|---|---|---|
| T | | T | | T |
| T | | F | | T |
| F | | T | | F |
| F | | F | | F |

## 5. ((A ⊃ B) v C)

| ((A | ⊃ | B) | v | C) |
|---|---|---|---|---|
| T | | T | | T |
| T | | T | | F |
| T | | F | | T |
| T | | F | | F |
| F | | T | | T |
| F | | T | | F |
| F | | F | | T |
| F | | F | | F |

## 7. (Q ⊃ ((R v P) & S))

| (Q | ⊃ | ((R | v | P) | & | S) |
|---|---|---|---|---|---|---|
| T | | T | | T | | T |
| T | | T | | T | | F |
| T | | T | | F | | T |
| T | | T | | F | | F |
| T | | F | | T | | T |
| T | | F | | T | | F |
| T | | F | | F | | T |
| T | | F | | F | | F |
| F | | T | | T | | T |
| F | | T | | T | | F |
| F | | T | | F | | T |
| F | | T | | F | | F |
| F | | F | | T | | T |
| F | | F | | T | | F |

| | | | |
|---|---|---|---|
| F | F | F | T |
| F | F | F | F |

### 9. (~ (C & F) v ~ (F & C))

| (~ | (C | & | F) | v | ~ | (F | & | C)) |
|---|---|---|---|---|---|---|---|---|
| | T | | T | | | T | | T |
| | T | | F | | | F | | T |
| | F | | T | | | T | | F |
| | F | | F | | | F | | F |

## Getting familiar with … truth tables for operators.

**Refer back to your answers to “Getting familiar with … constructing truth tables.” For each of those, construct a complete truth table, then construct one for each of the following. Start with the claims enclosed in the most number of parentheses, and move to the next most enclosed until you get to the main operator. Two examples have been provided.**

### 1. (P v Q)

| (P | v | Q) |
|---|---|---|
| T | T | T |
| T | T | F |
| F | T | T |
| F | F | F |

### 3. ((A v B) & A)

| ((A | v | B) | & | A) |
|---|---|---|---|---|
| T | T | T | T | T |
| T | T | F | T | T |
| F | T | T | F | F |
| F | F | F | F | F |

### 5. ((A ⊃ B) v C)

| ((A | ⊃ | B) | v | C) |
|---|---|---|---|---|
| T | T | T | T | T |
| T | T | T | T | F |
| T | F | F | T | T |
| T | F | F | F | F |
| F | T | T | T | T |
| F | T | T | T | F |
| F | T | F | T | T |
| F | T | F | T | F |

### 7. (Q ⊃ ((R v P) & S)) (Note that the major operator is a conjunction.)

| (Q | ⊃ | ((R | v | P) | & | S)) |
|---|---|---|---|---|---|---|
| T | T | T | T | T | T | T |
| T | T | T | T | T | F | F |
| T | T | T | T | F | T | T |
| T | T | T | T | F | F | F |
| T | T | F | T | T | T | T |

| | | | | | | |
|---|---|---|---|---|---|---|
| T | T | F | T | T | F | F |
| T | F | F | F | F | F | T |
| T | F | F | F | F | F | F |
| F | T | T | T | T | T | T |
| F | T | T | T | T | F | F |
| F | T | T | T | F | T | T |
| F | T | T | T | F | F | F |
| F | T | F | T | T | T | T |
| F | T | F | T | T | F | F |
| F | T | F | F | F | T | T |
| F | T | F | F | F | F | F |

## 9. (~ (C & F) v ~ (F & C)) (Note that the major operator is a disjunction.)

| (~ | C | & | F) | v | ~ | (F | & | C)) |
|---|---|---|---|---|---|---|---|---|
| F | T | F | T | F | F | T | T | T |
| F | T | F | F | T | T | F | F | T |
| T | F | T | T | T | T | T | F | F |
| T | F | F | F | T | T | F | F | F |

# Getting familiar with . . . truth tables for operators.

## 1. (A & ~ B)

| (A | & | ~ | B) | |
|---|---|---|---|---|
| T | F | F | T | |
| T | T | T | F | |
| F | F | F | T | ← |
| F | F | T | F | |

## 3. ~ (A ⊃ ~ B)

| ~ | (A | ⊃ | ~ | B) | |
|---|---|---|---|---|---|
| T | T | F | F | T | |
| F | T | T | T | F | |
| F | F | T | F | T | ← |
| F | F | T | T | F | |

## 5. ~ (~ W & ~ P)

| ~ | (~ | W | & | ~ | P) |
|---|---|---|---|---|---|
| T | F | T | F | F | T |
| T | F | T | F | T | F |
| T | T | F | F | F | T |
| F | T | F | T | T | F |

### 7. ~ (P & Q)

| ~ | (P | & | Q) |
|---|---|---|---|
| F | T | T | T |
| T | T | F | F |
| T | F | F | T |
| T | F | F | F |

### 9. (A v (B ⊃ C))

| (A | v | (B | ⊃ | C)) |
|---|---|---|---|---|
| T | T | T | T | T |
| T | T | T | F | F |
| T | T | F | T | T |
| T | T | F | T | F |
| F | T | T | T | T |
| F | F | T | F | F |
| F | T | F | T | T |
| F | T | F | T | F |

## Getting familiar with … using truth tables to test for validity.

**For each of the following arguments, construct its truth table and test it for validity.**

## 1. ((P ⊃ Q) & P) /.: Q

| ((P | ⊃ | Q) | & | P) | /.: | Q |
|---|---|---|---|---|---|---|
| T | T | T | T | T | | T |
| T | F | F | F | T | | F |
| F | T | T | F | F | | T |
| F | T | F | F | F | | F |

**Valid. There is no row where the premise is true and the conclusion is false.**

## 3. (M ≡ ~ N) ; ~ (N & ~ M) /.: (M ⊃ N)

| (M | ⊃ | ~ | N) | ; | ~ | (N | & | ~ | M) | /.: | (M | ⊃ | N) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| T | F | F | T | | T | T | F | F | T | | T | T | T | |
| T | T | T | F | | T | F | F | F | T | | T | F | F | ← |
| F | T | F | T | | F | T | T | T | F | | F | T | T | |
| F | F | T | F | | T | F | F | T | F | | F | T | F | |

**Invalid. In row 2, both premises are true, and the conclusion is false.**

## 5. (A ⊃ A) /.: A

| (A | ⊃ | A) | /.: | A | |
|---|---|---|---|---|---|
| T | T | T | | T | |
| F | T | F | | F | ← |

**Invalid. In row 2, the premise is true, but the conclusion is false. How could this be? It is obviously true that *if* A is true, *then* A is true. But *is* A really true? That's what the conclusion says. And that doesn't follow from the conditional.**

## 7. ~ R ; (S ⊃ R) /.: ~ S

| ~ | R | ; | (S | ⊃ | R) | /.: | ~ | S |
|---|---|---|---|---|---|---|---|---|
| F | T | | T | T | T | | F | T |
| F | T | | F | T | T | | T | F |
| T | F | | T | F | F | | F | T |
| T | F | | F | T | F | | T | F |

**Valid. There is no row where the premise is true and the conclusion is false.**

## 9. ((A & B) v (C v D)) ; ~ (C v D) /.: A

| ((A | & | B) | v | (C | v | D)) | ; | ~ | (C | v | D) | /.: | A |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| T | T | T | **T** | T | T | T | | **F** | T | T | T | | **T** |
| T | T | T | **T** | T | T | F | | **F** | T | T | F | | **T** |
| T | T | T | **T** | F | T | T | | **F** | F | T | T | | **T** |
| T | T | T | **T** | F | F | F | | **T** | F | F | F | | **T** |
| T | F | F | **T** | T | T | T | | **F** | T | T | T | | **T** |
| T | F | F | **T** | T | T | F | | **F** | T | T | F | | **T** |
| T | F | F | **T** | F | T | T | | **F** | F | T | T | | **T** |
| T | F | F | **F** | F | F | F | | **T** | F | F | F | | **T** |
| F | F | T | **T** | T | T | T | | **F** | T | T | T | | **F** |
| F | F | T | **T** | T | T | F | | **F** | T | T | F | | **F** |
| F | F | T | **T** | F | T | T | | **F** | F | T | T | | **F** |
| F | F | T | **F** | F | F | F | | **T** | F | F | F | | **F** |
| F | F | F | **T** | T | T | T | | **F** | T | T | T | | **F** |
| F | F | F | **T** | T | T | F | | **F** | T | T | F | | **F** |
| F | F | F | **T** | F | T | T | | **F** | F | T | T | | **F** |
| F | F | F | **F** | F | F | F | | **T** | F | F | F | | **F** |

**Valid. There is no row where both premises are true and the conclusion is false.**

## 11. (P ⊃ Q) /.: R

| (P | ⊃ | Q) | /.: | R | |
|---|---|---|---|---|---|
| T | T | T | | T | |
| T | T | T | | F | ← |
| T | F | F | | T | |
| T | F | F | | F | |
| F | T | T | | T | |
| F | T | T | | F | ← |
| F | T | F | | T | |
| F | T | F | | F | ← |

**Invalid. On at least one row, the premise is true and the conclusion is false.**

**• Note! There is an error in the text. Numbers 13 and 14 have no conclusion and, therefore, are not arguments. Thus, they cannot be tested for validity. Here, we have supplied conclusions to both, and we have provided the answer to number 13.**

## 13. ((M ≡ ~ N) & ~ (N & ~ M)) /.: ~(N v M)

| ((M | ≡ | ~ | N) | & | ~ | (N | & | ~ | M) | /.: | ~ | (N | v | M) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| T | F | F | T | F | T | T | F | F | T | | F | T | T | T | |
| T | T | T | F | **T** | T | F | F | F | T | | **F** | F | T | T | ← |
| F | T | F | T | F | F | T | T | T | F | | F | T | T | F | |
| F | F | T | F | F | T | F | F | T | F | | T | F | F | F | |

**Invalid. In row 2, the premise is true, and the conclusion is false.**

### 14. ((A ≡ ~B) v (B v A)) /.: (A & ~B)

Invalid. Let A be "false" and B be "true," and you will see that it is possible to construct a true premise and a false conclusion.

**Select Answers**

### 15. (P v ~Q) ; (R ⊃ ~Q) /.: (~P ⊃ R)

| (P | v | ~ | Q) | ; | (R | ⊃ | ~ | Q) | /.: | (~ | P | ⊃ | R) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| T | T | F | T | | T | F | F | T | | F | T | T | T | |
| T | T | F | T | | F | T | F | T | | F | T | T | F | |
| T | T | T | F | | T | T | T | F | | F | T | T | T | |
| T | T | T | F | | F | T | T | F | | F | T | T | F | |
| F | F | F | T | | T | F | F | T | | T | F | T | T | |
| F | F | F | T | | F | T | F | T | | T | F | F | F | |
| F | T | T | F | | T | T | T | F | | T | F | T | T | |
| F | T | T | F | | F | T | T | F | | T | F | F | F | ← |

**Invalid.**

### 17. (~ (Y & O) v W) /.: (Y ⊃ W)

| (~ | (Y | & | O) | v | W) | /.: | (Y | ⊃ | W) | |
|---|---|---|---|---|---|---|---|---|---|---|
| F | T | T | T | T | T | | T | T | T | |
| F | T | T | T | F | F | | T | F | F | |
| T | T | F | F | T | T | | T | T | T | |
| T | T | F | F | T | F | | T | F | F | ← |
| T | F | F | T | T | T | | F | T | T | |
| T | F | F | T | T | F | | F | T | F | |
| T | F | F | F | T | T | | F | T | T | |
| T | F | F | F | T | F | | F | T | F | |

**Invalid.**

## 19. (E v F) ; (E ⊃ F) ; (C & D) /.: (F ⊃ ~C)

| (E | v | F) | ; | (E | ⊃ | F) | ; | (C | & | D) | /.: | (F | ⊃ | ~ | C) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| T | **T** | T | | T | **T** | T | | T | **T** | T | | T | **F** | F | T | ← |
| T | T | T | | T | T | T | | T | F | F | | T | F | F | T | |
| T | T | T | | T | T | T | | F | F | T | | T | T | T | F | |
| T | T | T | | T | T | T | | F | F | F | | T | T | T | F | |
| T | T | F | | T | F | F | | T | T | T | | F | T | F | T | |
| T | T | F | | T | F | F | | T | F | F | | F | T | F | T | |
| T | T | F | | T | F | F | | F | F | T | | F | T | T | F | |
| T | T | F | | T | F | F | | F | F | F | | F | T | T | F | |
| F | **T** | T | | F | **T** | T | | T | **T** | T | | T | **F** | F | T | ← |
| F | T | T | | F | T | T | | T | F | F | | T | F | F | T | |
| F | T | T | | F | T | T | | F | F | T | | T | T | T | F | |
| F | T | T | | F | T | T | | F | F | F | | T | T | T | F | |
| F | F | F | | F | T | F | | T | T | T | | F | T | F | T | |
| F | F | F | | F | T | F | | T | F | F | | F | T | F | T | |
| F | F | F | | F | T | F | | F | F | T | | F | T | T | F | |
| F | F | F | | F | T | F | | F | F | F | | F | T | T | F | |

**Invalid.**
**Getting familiar with … using the short truth table method to test for validity**
**Test each of the following arguments for validity using the short truth table method.**

## 1. (P v ~Q) ; (R ⊃ ~Q) /.: (~P ⊃ R)

F T T F  F T T F  TF F F

**Invalid. In order to make the conclusion false, both P and R must be false. But we are free to set Q's value. If we set Q's value to F, all the premises are true and the conclusion is false.**

### 3. (~(Y & O) v W) /.: (Y ⊃ W)

T T F F T F     T F F

**Invalid. In order to make the conclusion false, Y must be true and W must be false. But W is the right disjunct of the premise, so in order for that disjunction to be true, the left disjunct must be true. We can do this if we set O's value to F.**

### 5. (E v F) ; (E ⊃ F) ; (C & D) /.: (F ⊃ ~C)

| (E | v | F) | ; | (E | ⊃ | F) | ; | (C | & | D) | /.: | (F | ⊃ | ~ | C) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| T | T | T | | T | T | T | | T | T | T | | T | F | F | T |
| F | T | T | | F | T | T | | T | T | T | | T | F | F | T |

**Invalid.**

### 7. (~(A & B) v C) /.: (A ≡ C)

| (~ | (A | & | B) | v | C) | /.: | (A | ≡ | C) |
|---|---|---|---|---|---|---|---|---|---|
| T | T | F | F | T | F | | T | F | F |

**Invalid.**

### 9. ((H & I) v L) ; (L & D) ; (D ⊃ ~R) /.: ~L

| ((H | & | I) | V | L) | ; | (L | & | D) | ; | (D | ⊃ | ~ | R) | /.: | ~ | L |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| T/F | T/F | T/F | T | T | | T | T | T | | T | T | T | F | | F | T |

**Invalid.**

### 11. (L⊃ (P & Q)) ; ~R ; (L & (P & O)) /.: P

| (L | ⊃ | (P | & | Q) | ; | ~ | R | ; | (L | & | (P | & | O)) | /.: | P |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| F | T | F | F | T/F | | T | F | | F | F | F | F | T/F | | F |

**Valid.**

## 13. ((Q v R) ⊃ S) /.: (Q ⊃ S)

| ((Q | v | R) | ⊃ | S) | /.: | (Q | ⊃ | S) |
|---|---|---|---|---|---|---|---|---|
| T | T | T/F | F | F | | T | F | F |

**Valid.**

## 15. ((K v L) ⊃ (M v N)) ; ((M v N) ⊃ O) /.: O

| ((K | v | L) | ⊃ | (M | v | N)) | ; | ((M | v | N) | ⊃ | O) | /.: | O |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| F | F | F | T | F | F | F | | F | F | F | T | F | | F |

**Invalid.**

## 17. ((~M & ~N) ⊃ (O ⊃ N)) ; (N ⊃ M) ; ~M /.: ~O

| ((~ | M | & | ~ | N) | ⊃ | (O | ⊃ | N)) | ; | (N | ⊃ | M) | ; | ~ | M | /.: | ~ | O |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| T | F | T | T | F | F | T | F | F | | F | T | F | | T | F | | F | T |

**Valid.**

## 19. (A ⊃ C) ; (B ⊃ D) ; (C ⊃ B) ; (S v ~D) ; S /.: ~A

| (A | ⊃ | C) | ; | (B | ⊃ | D) | ; | (S | v | ~ | D) | ; | S | /.: | ~ | A |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| T | T | T | | T/F | T | T/F | | T | T | T/F | T/F | | T | | F | T |

**Invalid.**

# Chapter 6 – Rules of deductive inference

## Getting familiar with … basic rules of inference.

**1.**

1. A

2. (A ⊃ B) /.: B

**3. B 1, 2 *modus ponens***

**3.**

1. (P & Q)

2. (R & S) /.: P

**3. P 1 simplification**

**5.**

1. ((R v S) & Q)

2. (~Q v S)

3. T /.: (Q & T)

**4. Q 1 simplification**

**5. (Q & T) 3, 4 conjunction**

**7.**

1. ((A ⊃ B) ⊃ (C v D))

2. ~ (C ⊃ D) /.: ~(A ⊃ B)

**3. ~(A ⊃ B) 1, 2 *modus tollens***

**9.**

1. ((P ⊃ Q) & (S ⊃ R))

2. (~ Q & ~ R) /.: (~P & ~S)

**3. (P ⊃ Q) 1 simplification**

**4. ~ Q 2 simplification**

**5. ~P 3, 4 *modus tollens***

**6. (S ⊃ R) 1 simplification**

**7. ~R 2 simplification**

**8. ~S 5,6 *modus tollens***

**9. (~P & ~S) 5, 8 conjunction**

**11.**

1. ((P &Q) & W)

2. R /.: W

**3. W 1 simplification**

**13.**

1. A

2. (B v C)

3. ((A & (B v C)) ⊃ D) /.: D

**4. (A & (B v C)) 1, 3 conjunction**

**5. D 3, 4 *modus ponens***

**15.**

1. ((P v Q) ⊃ (W & ~Y))

2. (~Q & W)

3. (X ⊃ Y)

4. (P v Q) /.: (~X & ~Q)

**5. (~W & ~Y) 1, 4 *modus ponens***

**6. ~Y 5 simplification**

**7. ~X 3, 6 *modus tollens***

**8. ~Q 2 simplification**

**9. (~X & ~Q) 7, 8 conjunction**

**17.**

1. ~P

2. (S ⊃ R)

3. (R ⊃ Q)

<u>4. (Q ⊃ P) /.: ~S</u>

**5. ~Q 1, 4 *modus tollens***

**6. ~R 3, 5 *modus tollens***

**7. ~S 2, 6 *modus tollens***

**19.**

1. ~(B v D)

2. (A ⊃ (B v D))

3. (H ⊃ ((E & F) & G))

<u>4. H /.: (~A & E)</u>

**5. ~A 1, 2 *modus tollens***

**6. ((E & F) & G) 3, 4 *modus ponens***

**7. (E & F) 6 simplification**

**8. E 7 simplification**

**9. (~A & E) 5, 8 conjunction**

**Getting familiar with… more rules of inference.**

**a.**

**1.**

1. ((A v B) ⊃ C)

2. (F & D)

<u>3. (C ⊃ (E v H)) /.: ((A v B) ⊃ (E v H))</u>

**4. ((A v B) ⊃ (E v H)) 1, 3 hypothetical syllogism**

**3.**

1. (~P v (D v Z))

2. (~(D v Z) v B)

<u>3. ~ B /.: ~P</u>

**4. ~(D v Z) 2, 3 hypothetical syllogism**

**5. ~P 1, 4 hypothetical syllogism**

**5.**

1. ((P v Q) v (~R v ~S))

2. ~(P v Q)

<u>3. ~~ S /.: ~R</u>

**4. (~R v ~S) 1, 2 hypothetical syllogism**

**5. ~R 3, 4 hypothetical syllogism**

**7.**

1. (((P v Q) & (R & S)) & (T v U))

<u>2. (A & B) /.: (B v P)</u>

**3. B 2 simplification**

**4. (B v P) 3 addition**

**9.**

1. A

2. ((A v B) ⊃ ~C)

<u>3. (~ C ⊃ F) /.: ((A v B) ⊃ F)</u>

**4. ((A v B) ⊃ F) 2, 3 hypothetical syllogism**

**b.**

**11.**

1. (~S ⊃ Q)

2. (R ⊃ ~T)

<u>3. (~S v R) /.: (Q v ~T)</u>

**4. (Q v ~T) 1-3 constructive dilemma**

**13.**

1. ((H ⊃ B) & (O ⊃ C))

2. (Q ⊃ (H v O))

<u>3. Q /.: (B v C)</u>

**4. (H v O) 2, 3 *modus ponens***

**5. (H ⊃ B) 1 simplification**

**6. (O ⊃ C) 1 simplification**

**7. (B v C) 4-6 constructive dilemma**

**15.**

1. (B ⊃ (A v C))

2. (B & ~A)    /.: C

**3. B    2 simplification**

**4. ~A    2 simplification**

**5. (A v C)    1, 3 *modus ponens***

**6. C    4, 5 disjunctive syllogism**

**17.**

1. ((A & B) ⊃ ~C)

2. (C v ~D)

3. (A ⊃ B)

4. (E & A)    /.: ~D

**5. A    4 simplification**

**6. B    3, 5 *modus ponens***

**7. (A & B) 5, 6 conjunction**

**8. ~C    1, 7 *modus ponens***

**9. ~D    2, 8 disjunctive syllogism**

**19.**

1. (F ⊃ (G ⊃ ~H))

2. ((F & ~W) ⊃ (G v T))

3. (F & ~T)

4. (W ⊃ T) /.: ~H

**5. F    3 simplification**

**6. ~T    3 simplification**

**7. ~W    4, 6 *modus tollens***

**8. (F & ~W)    5, 7 conjunction**

**9. (G v T)    2, 8 *modus ponens***

**10. G    6, 9 disjunctive syllogism**

**11. (G ⊃ ~H)    1, 5 *modus ponens***

**12. ~H    10, 11 *modus ponens***

**Getting familiar with… rules of replacement.**

**1.**

1. $( \sim (P \equiv R) \vee \sim (Q \;\&\; S))$

2. $\sim((P \equiv R) \;\&\; (Q \;\&\; S))$

**DeMorgan's Law**

**3.**

1. $\sim\sim (A \;\&\; B) \vee (Q \supset R)$

2. $(A \;\&\; B) \vee (Q \supset R)$

**Double Negation**

**5.**

1. $((P \;\&\; Q) \supset R)$

2. $\sim R \supset \sim(P \;\&\; Q)$

**Transposition**

**7.**

1. $(R \;\&\; Z)$

2. $(R \;\&\; Z) \vee (R \;\&\; Z)$

**Tautology**

**9.**

1. $(Q \vee (R \;\&\; S))$

2. $((Q \vee R) \;\&\; (Q \vee S))$

# Distribution

## Getting familiar with … proofs.

**1.**

1. ((A v B) ⊃ C)
2. (F & D)
3. A
4. (C ⊃ (E v H))  /.: ((A v B) ⊃ (E v H))

| | | |
|---|---|---|
| **5.** | **(A v B)** | **assumption for conditional proof** |
| **6.** | **C** | **1, 5 modus ponens** |
| **7.** | **(E v H)** | **4, 6 modus ponens** |
| **8.** | **((A v B) ⊃ (E v H))** | **5-8 conditional proof** |

**3.**

1. (~P v D)
2. (~D & B)
3. ((Z ⊃ P) & A)  /.: (~Z & A)

| | | |
|---|---|---|
| **4.** | **~(~Z & A)** | **assumption for indirect proof** |
| **5.** | **(~~Z v ~A)** | **4 DeMorgan's Law** |
| **6.** | **(Z v ~A)** | **5 double negation** |
| **7.** | **A** | **3 simplification** |
| **8.** | **~~A** | **7 double negation** |
| **9.** | **Z** | **6, 8 disjunctive syllogism** |
| **10.** | **(Z ⊃ P)** | **3 simplification** |
| **11.** | **P** | **9, 10 modus ponens** |
| **12.** | **~~P** | **11 double negation** |
| **13.** | **D** | **1, 12 disjunctive syllogism** |
| **14.** | **~D** | **2 simplification** |
| **15.** | **(D & ~D)** | **13, 14 conjunction** |
| **16.** | **(~Z & A)** | **4-15 indirect proof** |

**5.**

1. ((A v B) v (~C v ~D))
2. ~(A v B)
3. ~~ D /.: ~C

| | | |
|---|---|---|
| **4.** | **C** | **assumption for indirect proof** |
| **5.** | **(~C v ~D)** | **1, 2 disjunctive syllogism** |
| **6.** | **~~C** | **4 double negation** |
| **7.** | **~D** | **5, 6 disjunctive syllogism** |
| **8.** | **D** | **3 double negation** |
| **9.** | **(D & ~D)** | **7, 8 conjunction** |
| **10.** | **~C** | **4-9 indirect proof** |

**7.**

1. (((M v N) & (O & P)) & (Q v R))
2. (A & B) /.: (P & B)

| | | |
|---|---|---|
| 3. | ~(P & B) | assumption for indirect proof |
| 4. | (~P v ~B) | 3 DeMorgan's Law |
| 5. | B | 2 simplification |
| 6. | ~~B | 5 double negation |
| 7. | ~P | 4, 6 disjunctive syllogism |
| 8. | ((M v N) & (O & P)) | 1 simplification |
| 9. | (O & P) | 8 simplification |
| 10. | P | 9 simplification |
| 11. | (P & ~P) | 7, 10 conjunction |
| 12. | (P & B) | 3-11 indirect proof |

**9.**

1. A
2. ((A v B) ⊃ ~C)
3. (D ⊃ ~~ C) /.: ~D

| | | |
|---|---|---|
| **4.** | **D** | **assumption for indirect proof** |
| **5.** | **~~C** | **3, 4 modus ponens** |
| **6.** | **~(A v B)** | **2, 5 modus tollens** |
| **7.** | **(~A & ~B)** | **6 DeMorgan's Law** |
| **8.** | **~A** | **7 simplification** |
| **9.** | **(A & ~A)** | **1, 8 conjunction** |
| **10.** | **~D** | **4-9 indirect proof** |

**11.**

1. B
2. ((B v D) ⊃ ~H)
3. (H v F) /.: (C ⊃ F)

| | | |
|---|---|---|
| **4.** | **C** | **assumption for conditional proof** |
| **5.** | **(B v D)** | **1 addition** |
| **6.** | **~H** | **2, 5 modus ponens** |
| **7.** | **F** | **3, 6 disjunctive syllogism** |
| **8.** | **(C ⊃ F)** | **4-7 conditional proof** |

**13.**

1. ((M ⊃ O) v S)
2. ((~S & N) & M)
3. M
4. (P & ~O) /.: (S v B)

| | | |
|---|---|---|
| **5.** | **~(S v B)** | **assumption for indirect proof** |
| **6.** | **~O** | **4 simplification** |
| **7.** | **(~S & N)** | **2 simplification** |
| **8.** | **~S** | **7 simplification** |
| **9.** | **(M⊃ O)** | **1, 8 disjunctive syllogism** |
| **10.** | **O** | **3, 9 modus ponens** |
| **11.** | **(O & ~O)** | **6, 10 conjunction** |
| **12.** | **(S v B)** | **5-11 indirect proof** |

**15.**

1. (X v Y)
2. ((X & W) ⊃ (Z ⊃ Y))
3. (~Y & W)
4. Z /.: R

| | | |
|---|---|---|
| **5.** | **~R** | **assumption for indirect proof** |
| **6.** | **~Y** | **3 simplification** |
| **7.** | **X** | **1, 6 disjunctive syllogism** |
| **8.** | **W** | **3 simplification** |
| **9.** | **(X & W)** | **7, 8 conjunction** |
| **10.** | **(Z ⊃ Y)** | **2, 9 modus ponens** |
| **11.** | **Y** | **4, 10 modus ponens** |
| **12.** | **(Y & ~Y)** | **6, 11 conjunction** |
| **13.** | **R** | **5-12 indirect proof** |

**15. Alternative ending**

| | | |
|---|---|---|
| **11.** | **~Z** | **6, 10 modus tollens** |
| **12.** | **(Z & ~Z)** | **4, 11 conjunction** |
| **13.** | **R** | **5-12 conditional proof** |

**17.**

1. X
2. ((~S v Y) v Z)
3. (~Z & ~~S)   /.: (W ⊃ (Y v R))

| | | |
|---|---|---|
| **4.** | **W** | **assumption for conditional proof** |
| **5.** | **~Z** | **3 simplification** |
| **6.** | **(~S v Y)** | **2, 5 disjunctive syllogism** |
| **7.** | **~~S** | **3 simplification** |
| **8.** | **Y** | **6, 7 disjunctive syllogism** |
| **9.** | **(Y v R)** | **8 addition** |
| **10.** | **(W ⊃ (Y v R))** | **4-9 conditional proof** |

**19.**

1. (A ⊃ (~A v F))
2. ~ F   /.: ~A

| | | |
|---|---|---|
| **3.** | **A** | **assumption for indirect proof** |
| **4.** | **(~A v F)** | **1, 3 modus ponens** |
| **5.** | **~A** | **2, 4 disjunctive syllogism** |
| **6.** | **(A & ~A)** | **3, 5 conjunction** |
| **7.** | **~A** | **3-6 indirect proof** |

## Getting familiar with … formal fallacies.

**A.**

**1.**

1. He's the president of the company or I'm a monkey's uncle.
2. Here is the memo announcing that he is president.
3. So, I'm obviously not a monkey's uncle.

**Affirming the disjunct**

**3.**

1. It is either raining or storming.
2. It is certainly raining.
3. Thus, it is not storming.

**Affirming the disjunct**

**5.**

1. If it drops below 0$^o$ C, either the roads will become icy or the water line will freeze.

2. It is -5$^o$C (below 0$^o$).

3. So, either the roads will become icy or the water line will freeze.

4. The roads are icy.

5. Therefore, the water line is probably not frozen.

**Affirming the disjunct**

**b.**

**1. Affirming the disjunct**

1. Either the Bulls will win or the Suns will.

**2. The Bulls will win.**

**3. So, the Suns will not win.**

If you’re worried that this inference is a good one because only one team can win, remember that if only one team could win, then the teams are playing each other and the “or” is exclusive. But we cannot assume the “or” is exclusive unless it is explicitly stated. In this case, the team could be playing different teams or in different tournaments.

**3. Affirming the consequent**

1. If the road is wet, your tires won’t have as much traction.

**2. You won’t have as much traction.**

**3. Therefore, the road is wet.**

Why is this fallacious? Because the road’s being wet is one reason you won’t have good traction, but it is certainly not the only reason. There may be ice on the road, or your tires may be bald.

**5. Denying the antecedent**

1. If the bar is close, it will be safe to drive home.

**2. The bar is not close.**

**3. So, it won’t be safe to drive home.**

This is fallacious because, even though the bar’s proximity is one reason it will be safe to drive home, there may be others. For instance, the driver is not drunk, the roads are not slippery, it is not late at night, etc.

**7. Affirming the consequent**

1. We will win only if we strengthen our defense.

**2. We have strengthened our defense.**

**3. Therefore, we will win.**

Strengthening the defense may be a *necessary* condition for winning, but it is certainly not *sufficient*. You still have to play the game, your team members have to be in good shape, you have to outplay the other team, etc.

**9. Affirming the disjunct**

1. They will break up unless she is honest.

**2. She is honest.**

**3. Therefore, they will not break up.**

Notice how the inclusive "or" helps us here. They could break up for a number of reasons. If she is not honest, they will break up. That would be the valid conclusion of a disjunctive syllogism. But if she is honest, who knows what will happen? They may break up anyway, perhaps she was too honest; perhaps what she was honest about is a reason to break up. Maybe being honest increases the chances they will stay together, but it doesn't guarantee it.

# Chapter 7 – Probability and inductive reasoning

## "Getting familiar with ..." exercises.

**The following exercises are not in the book, but they may help you understand the material in this chapter better. We have included answers to the odd numbers below.**

**Getting familiar with… strong and weak quantifiers.**
**For each of the following claims, identify whether the quantifier is strong or weak.**

1. Many state senators were history majors.
2. Most philosophers who take the LSAT do well.
3. There are a few of us who support the president's initiative.

4. What I was saying is that the majority of students support the school’s new policy.
5. Many of the colleges that have tried this program report that it is successful.
6. We looked at a lot of studies, and a significant percentage of them conclude that people are biased when it comes to religious beliefs.
7. It is highly likely that this surgery will be successful.
8. Almost all the candidates for this job have degrees from Ivy League universities.
9. Although the evidence is incomplete, it is possible that there is life on other planets.
10. More often than not, people who get pregnant in high school do not complete a four-year college degree.

## Getting familiar with… probability and statistics.

**For each of the following claims, identify whether it is expressing a probability or a statistic.**

1. 7 out of 10 high school seniors said they have tried marijuana.
2. The risk that you will die in an automobile accident goes down significantly if you wear a seatbelt.
3. The chances of winning the lottery are slim to none.
4. Of those we surveyed, over half said they would vote in the next presidential election.
5. The percentage of deaths caused by police officers jumped dramatically last year.
6. Your portfolio is likely to grow a lot over the next year.
7. It rained 25 days out of 100 last year.
8. The likelihood that a student will get a job right after college has dropped every year for the past five years.
9. The likelihood that you will get a job when you finish college is not high.
10. 4 out of 5 doctors that we interviewed said they are concerned about the effectiveness of this year’s flu vaccine.

# Getting familiar with… types of probability.

## a. For each probability statement, identify whether it is referring to objective, epistemic, or subjective probabilities.

1. I can feel that it's about to rain.
2. The evidence tells us that Iran's new missile program will likely fail.
3. In a jar of 1,203 M&Ms, the probability of choosing a green one is 10%.
4. Twenty-five percent of cards in a deck are spades.
5. They are so incompatible; I know they'll break up within the week.
6. I'm going to win this next hand; I can feel it.
7. Given that there are 38 slots on a roulette wheel, and 18 of them are black, your chances of winning by betting black are about 47%.
8. All of the studies suggest that your chances of getting cancer are lower if you stop smoking.
9. My dog gets this look in her eye just before she bites, and she has it now, so she is probably about to bite.
10. The chances of rolling a prime number on a twenty-sided die are 8/20.

## b. For each probability statement, identify whether it is referring to a *dependent* or *independent* probability.

1. The probability of rolling an odd number on a twenty-sided die.
2. The probability of rolling an odd number on a twenty-sided die given that you just rolled an even number.
3. The probability that you rolled an odd number on a twenty-sided die given that the number you rolled is a prime number.
4. The probability of drawing an ace from a deck of 52 cards given that you just drew an ace you didn't replace.
5. The probability that you just drew an ace from a deck of 52 cards given that the card you drew was a spade.

## Getting familiar with… cost/benefit analyses.

**For each of the following, construct a cost/benefit analysis and identify the best decision. (Make up values where you need to.)**

1. You have to decide whether to start dating your best friend.
2. You have to decide whether to take a job in a country with an unstable political environment, though it pays better than any job in your home country.
3. You have to decide whether to sell a new product that causes blindness in 1% of users.
4. You have to decide whether to join a Mars exploration team knowing that you will never be able to return to Earth.
5. You have to decide between looking for work after college or taking a year off after college to backpack the Appalachian Trail (which takes between 4 and 7 months).

## Getting familiar with… strong and weak quantifiers.

**For each of the following claims, identify whether the quantifier is strong or weak.**

1. Many state senators were history majors.
**Many – weak**
3. There are a few of us who support the president’s initiative.
**A few – weak**
5. Many of the colleges that have tried this program report that it is successful.
**Many – weak**
7. It is highly likely that this surgery will be successful.
**Highly likely – strong**
9. Although the evidence is incomplete, it is possible that there is life on other planets.
**It is possible - weak**

## Getting familiar with… probability and statistics.

**For each of the following claims, identify whether it is expressing a probability or a statistic.**

1. 7 out of 10 high school seniors said they have tried marijuana.
**Statistic**
3. The chances of winning the lottery are slim to none.
**Probability**
5. The percentage of deaths caused by police officers jumped dramatically last year.
**Statistic**
7. It rained 25 days out of 100 last year.
**Statistic**
9. The likelihood that you will get a job when you finish college is not high.
**Probability**

## Getting familiar with… types of probability.

### a. For each probability statement, identify whether it is referring to objective, epistemic, or subjective probabilities.

1. I can feel that it's about to rain.
**Subjective**
3. In a jar of 1,203 M&Ms, the probability of choosing a green one is 10%.
**Objective**
5. They are so incompatible; I know they'll break up within the week.
**Subjective**
7. Given that there are 38 slots on a roulette wheel, and 18 of them are black, your chances of winning by betting black are about 47%.
**Objective**
9. My dog gets this look in her eye just before she bites, and she has it now, so she is probably about to bite.
**Epistemic**

### b. For each probability statement, identify whether it is referring to a *dependent* or *independent* probability.

1. The probability of rolling an odd number on a twenty-sided die.
**Independent**
3. The probability that you rolled an odd number on a twenty-sided die given that the number you rolled is a prime number.
**Dependent**
5. The probability that you just drew an ace from a deck of 52 cards given that the card you drew was a spade.
**Dependent**

## Getting familiar with… cost/benefit analyses.

**For each of the following, construct a cost/benefit analysis and identify the best decision. (Make up values where you need to.)**

1. You have to decide whether to start dating your best friend.

**Let's assume that one possible outcome of dating your best friend is long-term happiness. Another possibility is that you lose the friendship. How valuable are these possibilities and what are their chances?**

**Long-term happiness might be really important to you since it affects the rest of your life on this planet, so let's set its value at (+100)**

**Long-term happiness. = V(+100)**

**Losing the friendship is bad, but you know how the world works. Keeping any friend for the rest of your life is rare. And if you don't marry your best friend, you will likely choose a spouse anyway, and that relationship will take precedence over your friendship.**

**Losing the friendship. = V(-75)**

**What are the probabilities that either of these will happen if you date? Long-term happiness is rare no matter who gets married, so we have to set that one low: P(.2). And you still might keep the friendship, so we'll set that one at 50/50: P(.5).**

**What about not marrying your friend? Again, long-term happiness is rare no matter what you do, so let's keep it at P(.3). And unfortunately, even if you don't get married, you might still lose the friendship. So, let's set that one low, but significant: P(.3).**

**Calculating, we have:**

**Marry your best friend: ((P(.2) x V(+100)) + (P(.5) x V(-75))) = -17.5**

**Do not marry your best friend: ((P(.3) x V(+100)) + ((P(.3) x V(-75))) = +7.5**

**If our numbers are accurate for your values, your life will be less bad if you don't marry your best friend.**

3. You have to decide whether to sell a new product that causes blindness in 1% of users.

**The most common value associated with new products is profit. But profit can be affected by a number of different variables, not least of which is public image. So, here, you might measure your company's potential profits against the potential negative image that would come with the news that your product causes blindness. The overall value would be whether the company grows.**

**In this case, let's say the growth is moderate with no change in company image.**

**Company grows: (+10)**

**On the other hand, a bad image could cost the company for a long time.**

**Company shrinks: (-30)**

**Selling the new product and growing: P(.6) (There is a good chance of monetary growth, but also a good chance of a poor public image.)**

**Selling the new product and shrinking: P(.4)**

**Not selling the new product and growing: P(.7) (If the company was already doing okay, it will likely continue doing okay, though some stockholders may find that not selling the product distasteful.)**

**Not selling the new product and shrinking: P(.3) (The company invested money in the new product, so they might be set back, but not likely.)**

**Selling the new product: ((P(.6) x V(+10)) + (P(.4) x V(-30))) = -6**

**Not selling the new product: ((P(.7) x V(+10)) + (P(.3) x V(-30))) = -2**

**If these numbers reliably track your values and the probabilities, not selling the product is slightly less bad than selling it. Ah well, that's the nature of business.**

5. You have to decide between looking for work after college or taking a year after college to backpack the Appalachian Trail (which takes between 4 and 7 months).

**"Gap" years are usually the years between high school and college when you're not working. But some college students take a year or so after college to do something momentous: backpack across Europe, work for the Peace Corps, or hike the Appalachian Trail. If you take a year off, you will lost whatever money and experience you might have obtained working, and on the trail you will also risk some bodily injury. On the other hand, hiking the Appalachian Trail is a monumental achievement, and one you are unlikely to have the opportunity to attain (it takes about 6 months). Plus, there are no guarantees you will get a job right after college. Some people are out of work for 6 months to a year.**

**In order to assign values, let's assume you really want to hike the Trail and you're not terribly concerned about the money you will miss.**

**Having meaningful experiences: (+50)**

**Being financially stable: V(+25)**

**Hiking and Meaningful Experiences: P(.7)**

**Hiking and Financially Stable: P(.3)**

**Looking for a Job and Meaningful Experiences: P(.4)**

**Looking for a Job and Financially Stable: P(.6)**

**Taking a year off: ((P(.7) x V(+50)) + (P(.3) x V(+25))) = +42.5**

**Not taking a year off: ((P(.4) x V(+50)) + (P(.6) x V(+25))) = +35**

**Notice there aren't any negatives in this calculation. We've figured those into the values up front. Meaningful experiences come with some risk (risk of injury, risk of financial hardship). And being financially stable usually comes with a lot of drudgery. Both numbers would be higher if not for these negatives. But here we are assuming the positives outweigh the negatives in both cases. From this calculation, taking the year off is the better option for you.**

# Chapter 8 – Generalization, Analogy, and Causation

## Getting familiar with … inductive generalization

### A. Complete each of the following inductive generalizations by supplying the conclusion.

**1.**

1. Almost all politicians lie.
2. Blake is a politician.
3. Hence, **Blake very likely lies.**

**3.**

1. You haven't liked anything you've tried at that restaurant.
2. Therefore, this time **you probably won't like anything you've tried.**

**5.**

1. In the first experiment, sugar turned black when heated.
2. In experiments two through fifty, sugar turned black when heated.
3. Therefore, probably **the next bit of sugar we heat will turn black.**

**7.**

1. Every time you have pulled the lever on the slot machine, you've lost.
2. So, **the next time you pull the lever you are likely to lose.**

**9.**

1. Every girl I met at the bar last night snubbed me.
2. Every girl I met at the bar so far tonight has snubbed me.
3. Therefore, **the next girl I meet will snub me.**

**B. For each of the following examples, explain a way the method of data collecting could undermine the strength of an inductive generalization. There is more than one problem with some examples.**

1. Marvin county schools offered any child who is interested the opportunity to change schools to a school with a new curriculum in order to test the effectiveness of the new curriculum.

   **It is possible that only children who are already motivated to succeed academically will participate. This means the sample will likely be biased by those who choose to participate. Because these are high-achieving students, the program will look like a success even if it doesn't actually work. (Note. This is a common type of bias called "self-selection bias." Self-selection bias occurs when the sample selects itself, very likely resulting in a non-random distribution.)**

3. To find out what typical Americans think of the current political climate, 785 college students were polled from a variety of campuses all over the United States.

   **The sample is biased by the demographic. It is not obvious that the political views of college students represent the political views of "typical Americans."**

   **This sampling method's validity is also suspicious. What do the surveyors mean by "current political climate"? Is there something specific they want to know? And what do the surveyors mean by what people "think" about that climate? Do they want specific criticisms or compliments?**

5. To find out how well Georgians think the Georgia governor is doing in office, researchers polled 90% of the population of the largely Republican Rabun County.

   **This sample could be biased by the distribution of political parties. If Rabun County's demographic were representative of the distribution of Georgia's political parties, then the**

**polling results might be unbiased. But if Georgia as a whole is not largely Republican, the sample is very likely biased.**

7. Tameeka says, "I've known two people who have visited Europe, and they both say that Europeans hate Americans. It seems that people outside the U.S. do not like us."

**This sample is not proportionate. Two people's experiences with Europeans is not enough to draw a conclusion about what all Europeans think of American.**

**Also, the survey is invalid. We don't know what it was about those Europeans that led them to think Europeans hate Americans. Were they treated poorly? Did those Europeans say they do not like Americans or American tourists or American politics or American education, etc.? Is it possible that those two people were acting in an obnoxious way, which made the Europeans they encountered more hostile than they might have been?**

9. A survey question asks, "Given the numerous gun-related accidents and homicides, and the recent horrifying school shootings, are you in favor of more gun regulation?"

**This sampling method is invalid. It frames the question (framing bias) in a leading way. The answers are more likely to reflect the respondents' emotional reactions to accidents, homicides, and "horrifying" school shootings than to the effectiveness of gun regulation.**

## Getting familiar with … errors in statistics and probability

**For each of the following, explain which probability error has been committed.**

1. "Every time I take this new VitaMix cold medicine, my cold goes away. Therefore, I know it works."

**This person is committing the base rate fallacy. Colds go away on their own. Even if this person took no medication, the results would be the same. So, why think VitaMix played some causal role in its going away? To know whether VitaMix**

**helped in this respect, we would need to compare it to cases with different outcomes. For instance, did the cold go away more quickly than normal? To answer this, we would need to know the base rate duration of colds, and then we would need to compare this to many people who took VitaMix at a particular point during their cold (if some took it at the beginning and some took it near the end, our results will not be informative).**

3. "Every time I leave the house without an umbrella, it rains. Why me!?"

(This is also an example of something called a "hedonic asymmetry." We pay more attention to events that cause emotional response—positive or negative—than to events that don't. So, even though the number of times it rains when you don't take an umbrella may be roughly equal to the times it rains when you do, you tend to remember the times you don't more vividly because they cause a strong emotional response.)

**This person is committing the base rate fallacy by ignoring the number of times she left the house when it wasn't raining and the number of times she left with her umbrella and it was raining. Because of the hedonic asymmetry, she focuses on those times when forgetting her umbrella stands out in her memory, namely, when it rains. Without comparing the number of times she remembered her umbrella and it rained and the number of times she didn't take her umbrella and it didn't rain, we have no idea whether it only rains when she goes out without an umbrella.**

5. After watching Kareem win three tennis sets in a row, the recruiter is sure that Kareem will be a good fit for his all-star team.

**This is an instance of the regression fallacy. By definition, few people are exceptional and few people are deplorable. People who excel in one case often do more poorly in subsequent cases. People who are deplorable in one case often do better in subsequent cases. Therefore, three exceptional plays in a row may indicate an exceptional tennis player, or they may indicate a lucky streak. One cannot reliably conclude from these three wins that Kareem will continue to win.**

7. After acing her first exam, Simone was shocked to discover that she only got an 85 on the second. She concludes that she must be getting dumber.

**Regression fallacy**

9. "Ever since I bought this mosquito repellent, I haven't been bitten by one mosquito. It must really work."

**We often reason this way, and it isn't obviously erroneous. The goal of this example is to get you think about a way in which the inference doesn't work. Notice how this could be an example of the base rate fallacy. If the person had been bitten regularly by mosquitoes and then, after using mosquito repellent, stopped getting bitten, then the repellent likely works. But if he was only bitten infrequently, then noticing he hasn't been bitten after buying the repellent may not indicate anything about the repellent's effectiveness. Alternatively, imagine he was getting bitten regularly in the Everglades National Park, buys the repellent, and then immediately flies back to his home state of New York. The drop in mosquito bites is a function of the base rate of getting bitten in New York as opposed to the base rate of getting bitten in the Everglades.**

## Getting familiar with … arguments from analogy

**1.**

1. Bear paw prints have five toe marks, five claw marks, and an oblong-shaped pad mark.
2. This paw print has five toe marks, five claw marks, and an oblong-shaped pad mark.
3. Thus, **this paw print was likely made by a bear.**

**3.**

1. The jeans I'm wearing are Gap brand, they are "classic fit," they were made in Indonesia, and they fit great.

2. This pair of jeans are Gap brand, "classic fit," and were made in Indonesia.
3. Therefore, **they probably fit great.**

**5.**

1. At the first crime scene, the door was kicked in and a playing card was left on the victim.
2. At this crime scene, the door was kicked in and there is a playing card on the victim.
3. Therefore, **the person who committed this crime is likely the same person who committed the last crime.**

**7.** Everything I have read about this pickup truck tells me it is reliable and comfortable. There is a red one at the dealer. I want it because **it will likely be reliable and comfortable.**

**9.** This plant looks just like the edible plant in this guidebook. Therefore, **this plant is probably the same type of plant that is mentioned in the guidebook.**

## Getting familiar with … causal arguments

### A. Complete each of the following arguments by supplying a causal claim for the conclusion.

**1.**

1. I have released this pen 750 times.
2. Every time, it has fallen to the floor.
3. Thus, **something causes this pen to fall to the floor.**

**3.**

1. In the past, when I thought about raising my arm, it raised.
2. So, **thinking about raising my arm probably causes my arm to raise.**

**5.**

1. The label says gingko biloba increases energy.
2. I have taken gingko biloba every day for two months.

3. I notice no increase in energy.

4. Thus, **gingko biloba probably does not increase energy.**

## B. Explain whether each of the following is a causal argument or an explanation.

1. The window is broken, and there is a baseball in the pile of glass. Therefore, the baseball probably broke the window.

**This one is a bit subtle, and it depends on understanding what question is at stake. We have a conclusion indicating word (therefore), which suggests it is an argument. But here is a way to think through it:**

**One question might be, "What happened in this room?" or "What was that noise?" An *explanation* would be that a baseball broke a window. Another question might be, "What broke the window?" or "Did that baseball break the window?" An *argument* would involve citing evidence of a baseball's proximity to the broken glass. In this case, its location (in the pile of glass) is evidence that the baseball was the cause.**

**This could be an argument or an explanation depending on what question is being asked. But notice that the second question already assumes the glass is broken, yet the author mentions that the glass is broken as if it were new information. This suggests that the most likely interpretation is that this is an explanation.**

3. The sun rises every morning because the Earth rotates on its axis once every twenty-four hours. As it turns toward the sun, we experience what we colloquially call "the sun's rising."

**This is an explanation. None of the claims are intended the increase the likelihood of any of the others. The author is telling us what we are experiencing when we say "the sun is rising."**

5. He ran off the road because the cold medicine made him drowsy. Running off the road caused him to hit the lamppost. The lamppost caused the head trauma. Thus, driving while on cold medicine can lead to serious injuries.

**This is an explanation. It is an answer to question like, “What happened?” or “How did he get those injuries?” None of the claims are intended the increase the likelihood of any of the others. The author is telling us how this man sustained his injuries.**

## C. Explain the mistaken identification of causation in each of the following examples. Give an explanation of what might really be happening.

1. “I flipped five tails in a row. That’s highly improbable! The universe must be telling me I need to go to Vegas.”

**Mistaking coincidence for causation. Five heads are improbable, but they do happen naturally from time to time. What is probably happening is that the person is committing the base rate fallacy. He is assuming that a run of five heads is so rare that it must be miraculous. But this ignores the rare base rate, and assumes there are no times, outside of the causal hand of fate or destiny or the gods, that such things happen.**

3. “There is a strong positive correlation between being poor and being obese. This tells us that poverty causes obesity.”

**Mistaking correlation for causation. Although the results are correlated, it is unclear what the cause of this correlation might be. Perhaps there is a third event that serves as a common cause to both. Perhaps obesity causes poverty. Perhaps this is only one experiment and the results are purely coincidental, not to be reproduced in subsequent trials.**

5. “I see the same woman in the elevator every morning. And we take the same bus into town. Fate must be trying to put us together.”

**Mistaking coincidence for causation. Even though “every morning” is mentioned, this is not a mistake in temporal order. The events occur at the same time. And given that our arguer seems astute enough not to think that arriving at the station causes the woman to show up, it is not likely to be mistaking**

**correlation for causation; he or she is thinking in terms of a common cause.**

**But the common cause cited is "fate" (a remnant of the ancient Greek belief in the Fates (*morai*), which directed the destinies of both gods and humans). Is this the most plausible common cause? The mistake is likely a simple misassignment of the cause (see also false cause fallacy, Chapter 10). The coincidence does not allow us to draw a strong inference about the common cause. It could be that both people live in the same building and have jobs during normal business hours. These are coincidences. It could be that she is stalking our arguer (which is a bit creepy), which is not mere coincidence, but neither is it a happy conclusion. The author seems arbitrarily to choose fate as the cause, but this is unjustified by the evidence.**

# Chapter 9 – Scientific experiments and inference to the best explanation

## Getting familiar with … confirmation and disconfirmation

### A. For each of the following observations and causal claims, construct a simple experimental model.

**[There are many possible tests in each case. These are just suggestions.]**

1. "I have allergic reactions. Shellfish probably causes them."

**O: I have allergic reactions.**
**H: Shellfish causes allergic reactions.**
**I: Eating only shellfish will cause allergic reactions while eating anything else won't.**
**If shellfish causes my allergic reactions, then eating only shellfish will cause allergic reactions while eating anything else won't.**
**[Notice that our test implication includes a contrast class (eating anything else won't). This helps prevent confirmation bias. Even if shellfish causes allergic reactions, that doesn't mean nothing else does. So even if you experience an allergic reaction while eating seafood, something else may be giving you the**

**allergic reaction. You can't be sure it's the shellfish. We include a contrast class in each of our experiments.]**

3. "Many people have allergic reactions. I bet they are all caused by eating shellfish."

**O: Many people have allergic reactions.**
**H: Shellfish causes allergic reactions.**
**I: Most people who eat shellfish will have allergic reactions while most people who don't have any allergic reactions.**
**If shellfish causes allergic reactions, then most people who eat shellfish will have allergic reactions while most people who don't have any allergic reactions.**

5. "I cannot sleep at night. I probably drink too much tea."

**O: I cannot sleep at night.**
**H: Drinking too much tea prevents me from sleeping at night.**
**I: I will not be able to sleep on the nights I drink tea, and I will be able to sleep on nights I drink anything else or nothing at all.**
**If drinking too much tea prevents me from sleeping at night, then I will not be able to sleep on the nights I drink tea, and I will be able to sleep on nights I drink anything else or nothing at all.**

## B. State two initial conditions and at least one auxiliary hypothesis that might affect the results of experiments on these hypotheses.

**[There are many possible tests in each case. These are just suggestions.]**

1. Ethanol makes gasoline less efficient.

**$IC_1$: The same type of combustion is used throughout the experiment.**
**$IC_2$: Each sample is burned for the same amount of time.**
**AH: Our test for efficiency is reliable.**

3. Eating a lot of cheese and beer raises bad cholesterol levels.

**$IC_1$: The same cheese and beer is used throughout the experiment.**

**$IC_2$: The test subjects were not eating cheese or drinking beer outside of the experiment.**
**AH: Food is the primary cause of cholesterol levels.**

5. Changing time zones causes jet lag.

**$IC_1$: The same number of time zones are crossed in each test.**
**$IC_2$: The speed of the travel in each experiment is comparable (car travel is compared with car travel; air travel is compared with air travel).**
**AH: Jet lag is measurable.**

## C. Short answer.

1. Explain the limitations of simple models of confirmation and disconfirmation.

**The simple models are subject to various biases, such as hidden variables and vagueness. The more precise the test implication, the more reliable the experiment will be.**

3. Come up with two examples of an observation and a hypothesis. Construct a simple experimental model for each.

**3.a.**
**Observation: Cats knead on soft blankets.**
**Hypothesis: Kneading simulates the movement kittens use to get milk from their mothers' teats.**
**I: Bottle-fed kittens will not kneed on soft blankets when they are adults, whereas naturally fed kittens will.**
**If kneading simulates the movement kittens use to get milk from their mothers' teats, then bottle-fed kittens will not kneed on soft blankets when they are adults, whereas naturally fed kittens will.**
**3.b.**
**Observation: My vehicle is not getting the same fuel efficiency (miles per gallon) as it used to.**
**Hypothesis: Inexpensive gasoline is less fuel efficient than expensive gasoline.**
**I: Using expensive gasoline will increase fuel efficiency, whereas using inexpensive gasoline will decrease fuel efficiency.**

**If inexpensive gasoline is less fuel efficient than expensive gasoline, then using expensive gasoline will increase fuel efficiency, whereas using inexpensive gasoline will decrease fuel efficiency.**

5. Based on your understanding of this chapter and the last, why are experiments so important for causal arguments?

**Experiments are important for identifying the actual cause of event, as opposed to mere correlations, coincidences, and temporal orderings. They introduce control conditions that help us rule out other potential causes and determine the extent to which a hypothesized cause is actually responsible for an observation.**

## Getting familiar with … formal experiments

### A. For each of the following causal claims, explain how you would set up a randomized experimental study. (i) Identify some relevant controls for your test group; (ii) explain a specific test implication; (iii) explain how you would conduct the experiment.

1. Eating a bag of potato chips every day leads to weight gain.

**(i) I would choose test subjects that are within the same age range, and who have a variety lifestyles, gender, and past medical histories.**
**(ii) This causal claim is confirmed if the experimental group gains at least three pounds after consuming 8 ounces of potato chips a day for thirty-five days.**
**(iii) I would randomly distribute the test subjects in a control group, in which subjects abstained from eating potato chips but otherwise lived normally for thirty-five days, and an experimental (or test) group, which subjects lived normally except they eat eight ounces of potato chips each day for thirty-five days. I would have research assistants weigh each test subject prior to the experiment**

**and after each seven-day period. I would have research assistants collect the data and present it blindly so that I wouldn't know which results were from the control group and which were from the experimental group.**

3. Taking large doses of vitamin C reduces the duration of a cold.

(i) **I would make sure all participants are adults, have a cold (and not something else) that started roughly around the same time, and have no allergic reactions to vitamin C.**

(ii) **This causal claim is confirmed if taking 1,000 mg of vitamin C per day during a cold reduces the cold's duration by at least 25%.**

(iii) **I could randomly distribute test subjects into a control group, which takes only pain- and sinus pressure–relieving medications with no vitamin C, and an experimental group, which, in addition to normal pain- and sinus-relieving medications, takes 1,000 mg of vitamin C per day. I would then have research assistants monitor the duration of each test subject's cold and compile the data for each group. I would have research assistants present the data blindly so that I wouldn't know which results were from the control group and which were from the experimental group.**

5. Drinking protein shakes after weight lifting increases strength.

(i) **I would select a sample of men and women between the ages of twenty and forty who consistently but relatively recently (within the first two years) began weight lifting, both men and women, who weight lift between three and five times per week.**

(ii) **The causal claim is confirmed if the experimental group experiences 25% more strength (or more) in bench press and dead lift than the control group after weightlifting for three months.**

(iii) **I would split the test subjects into a control group that drinks 15 oz. of water before and after weight lifting, and an experimental group that drinks 15 grams of whey protein before and after weight lifting. I would have each participant track the weights he or she uses for bench press and dead lift. Also, at the end of each week, lab assistants will have subjects demonstrate a "max lift" for both exercises and track the weights. At the end of three months, the increases between the two groups will be compared.**

## B. For each of the following causal claims, explain how you would set up a prospective study. (i) Identify some relevant controls for your test group. (ii) Explain a specific test implication. (iii) Explain how you would conduct the experiment.

1. Smoking marijuana causes short-term memory loss.

**(i) I would select a group of men and women between the ages of eighteen and thirty-five, some of whom have recently started smoking at least one marijuana cigarette at least twice a week (the experimental group) and some of whom never smoke marijuana (the control group). I would control for other drug use and health conditions (especially head trauma).**

**(ii) The causal claim is confirmed if the experimental group has significantly lower short-term memory retrieval than the control group.**

**(iii) Once a week for six weeks, I would assign each group a set of short-term memory exercises. After six weeks, lab assistants would display the results in a blinded chart to see if the experimental group had significantly worse short-term memory retrieval.**

3. Chevy trucks are safer in accidents than other models.

**(i) I would select a sample of Chevy truck drivers (the experimental group) and a group of those who drive other makes of truck (the control group). I would control for past accident history, types of driving (city or highway), and amount of driving time.**

**(ii) The causal claim is confirmed if subjects in the experimental group experience fewer injuries in accidents over a five-year period than those in the control group.**

**(iii) I would have participants self-report any accidents they have, describing the accidents, including the driving conditions and the nature of the damage, and including any documents from insurance companies, law enforcement, and medical facilities. After five years, I would compare the data from the two groups.**

5. Cigars are much less harmful than cigarettes.

**(i) I would select a sample of men and women between the ages of twenty and forty, some of whom smoke cigarettes (no more than one pack per day) and some of whom smoke cigars (no more than one per day). I would control for the use of other substances (alcohol, hookah, chewing tobacco, prescription medication), medical history, and lifestyle.**

**(ii) The causal claim will be confirmed if cigar smokers experience at least 25% fewer smoking-related illnesses over a ten-year period (including shortness of breath, emphysema, bronchitis, lung cancer, mouth cancer, and heart disease).**

**(iii) Subjects would be asked to complete a self-assessment report of their daily tobacco use as well as their lifestyles and health problems once a month for ten years. Each participant would get a physical each year of the study. At the end of ten years, I would compare the illness rates between the two groups.**

## C. For each of the following observations, explain how you would set up a retrospective study to discover a relevant cause. (i) Identify some relevant controls for your test group; (ii) explain how you would conduct the experiment.

1. My allergy attacks have increased.

**(i) I would select a group of people who are similar to you (in age and gender) whose allergy attacks have increased over the past two years. I would control for obvious factors that were not like you own, such as recently moving to a new geographic region, recently getting a pet, and changing prescription medications.**

**(ii) The hypothesis that X is the cause will be confirmed if more than 65% of test subjects experienced the same change over the past two years.**

**(iii) I would have you and the participants list all major changes to their lives and compare the lists. If there is a single change running through more than 65% of them, the hypothesis will be that this explains the increased allergies. If there is not a single**

**change, further investigation into similarities and differences should be conducted.**

3. An overall sense of well-being.

**(i) I would select a group of people who are similar to you (in age and gender) who have recently experienced an overall sense of well-being. I would control for short-term factors that merely relieve certain sorts of anxiety, such as getting a job and falling in love.**
**(ii) The hypothesis that X is the cause will be confirmed if more than 65% of test subjects recently made a similar lifestyle change.**
**(iii) I would ask participants about their lifestyle and eating behaviors, looking for patterns of eating a certain type of food (e.g., raw vegan or pescatarian) and specific behaviors (e.g., yoga for stress relief, picking up a sport or hobby). If there is a single change running through more than 65% of them, the hypothesis will be that this explains the overall sense of well-being. If there is not a single change, further investigation into similarities and differences should be conducted.**

5. More white people are employed at company X than Black people.

**(i) I would select a sample of the notes from past hiring decisions kept on file by Human Resources, including the number of applicants, the races of the applicants, the experience and education of each applicant, and the reasons given for the decisions made.**
**(ii) The hypothesis that X is the cause will be confirmed if more than 75% of the hires are either explicitly or implicitly explained by X.**
**(iii) I would look at the racial distribution of the applicants. If only 10% of the employees are Black and only 10% of the applicants are Black, there are no obvious racial concerns. If only 10% of the employees are Black and 50% of the applicants were Black, then I would look at education and experience, and then the hiring notes. If at least 75% of applicants were clearly chosen on the basis of their qualifications and education, the explanation for the observation may simply be chance. If at least 75% of applicants were clearly chosen for a biased reason (a cultural name, gender, prejudicial comments), the explanation for the observation may be a type of prejudice.**

## Getting familiar with … informal experiments

### A. For each of the following informal experiments, explain which of Mill's Methods is being used.

1. You get sick after eating lobster for the first time and conclude that it probably was the lobster.

   **Method of Agreement. Eating lobster co-occurs with (or agrees) with getting sick. This is likely a hasty generalization. More testing would be needed to rule out other causes.**

3. Susan has to weigh her cat at the vet, but the cat won't sit still on the scale by herself. So, the nurse records Susan's weight first, which is 120 pounds. Then she has Susan and her cat step on the scale, notes that the scale now reads 130 pounds, and records the cat's weight as ten pounds. Which of Mill's methods did the nurse utilize?

   **Method of Residues. The cat's weight are the pounds left over after subtracting Susan's weight. It is the residue left after the experiment.**

5. Zoe sneezed every time she went into the basement. Her parents tried to figure out what was causing it by vacuuming, dusting, and scrubbing the floors, in various combinations, and having her go in the basement afterward. Zoe still sneezed, no matter if the basement was: vacuumed, but not dusted or scrubbed; dusted, but not vacuumed or scrubbed; scrubbed but not vacuumed or dusted; vacuumed and dusted, but not scrubbed; vacuumed and scrubbed, but not dusted; dusted and scrubbed, but not vacuumed; vacuumed, dusted, *and* scrubbed. One thing that stayed the same throughout the vacuuming, dusting, and scrubbing events, however, was that the fabric softener sheets (which gave off a strong lilac smell) were present every time Zoe went into the basement. Zoe's parents then removed the fabric softener sheets and sent Zoe into the basement. Finally, she stopped sneezing! They put the fabric softener sheets back, and guess what happened? She sneezed again. They have since stopped using the fabric softener sheets and Zoe no longer sneezes when she goes into the basement. So, from this whole ordeal, Zoe and her parents reasoned that the fabric softener sheets were what caused the sneezing.

**Joint Method of Agreement and Difference. There are four possible causes: a substance that vacuuming could eliminate, a substance dusting could eliminate, a substance scrubbing could eliminate, and the scent of the dryer sheets. After showing that sneezing does not "agree" with any of the first three or combinations thereof, the only remaining factor that co-occurs with the sneezing is the scent of the dryer sheets.**

## B. Set up one of Mill's Methods to identify the cause of each of the following observations.

1. "I suddenly feel sick after eating at that restaurant. How could I tell if it was something I ate?"

    **Method of Difference. Compare all you ate with what others ate. Of those who didn't eat what you ate, did any get sick? If not, then the cause of your sick feelings may be what you ate.**

3. "There are at least four reasons for my headaches: stress, allergies, head injury, and brain tumors. How can I tell which one?"

    **Method of Residues. Since brain tumors are the most difficult to get rid of, try to subtract stress, allergies, and head injuries from your life. After subtracting each, consider whether you still have a headache. If not, the item most recently removed might be the cause of your headaches.**

5. "When I visit some people, I get really hungry, when I visit others I don't. What might cause that?"

    **Method of Agreement. Compare what is in each person's house (objects, scents, colors). If those where you are hungry have similar scents or colors or something else, that may be what triggers your hungry feeling.**

# Getting familiar with … inference to the best explanation

## A. For each of the following, identify both the explanation and the observation being explained.

1. Flowers are able to reproduce because bees transfer pollen from flower to flower as they gather pollen for honey.

    **Observation: Flowers reproduce with one another without moving or touching.**
    **Explanation: Bees move pollen from one flower to another, thereby facilitating reproduction. Therefore, the bees' transferring pollen explains how flowers can reproduce without moving or touching.**

3. Of course your eyes no longer itch. Benadryl stops allergic reactions.

    **Observation: My eyes were itching, but now they are not.**
    **Explanation: Itching eyes are caused by allergic reactions. Benadryl stops allergic reactions, and you took Benadryl. So, taking Benadryl explains why your eyes no longer itch.**

5. The car is out of gas. That's why it won't start.

    **Observation: The car won't start.**
    **Explanation: The car is out of gas. Cars need gas to start. Thus, the car's not having gas explains why the car won't start.**

## B. Using the theoretical virtues, construct one plausible and one implausible explanation for each of the following observations.

1. I don't have my wallet.

    **Plausible: You often leave your wallet lying around. And I remember your putting it on the table while we were at dinner. You probably left it on the table.**
    **This explanation is plausible because it is simple (it explains with a minimum number of assumptions and objects); it is conservative, appealing to your typical behavior with your**

**wallet; it is fecund, because we can go back to the table and check; it is independently testable if there are others who know your behavior with your wallet; and it has explanatory power because it fully explains why you don't have your wallet.**

**Implausible: Zeus is angry with you because last week you were mean to that guy with one eye. Zeus is hiding your wallet to punish you.**

**This explanation is implausible because it lacks simplicity (because it seems unnecessary to invoke Zeus to explain a missing wallet); it is not conservative (it appeals to Zeus, whom very few people believe exists); it lacks fecundity because it does not help us learn more about what makes Zeus angry or how to stop it; it is not independently testable since we cannot tell whether Zeus is really angry by any other means and whether he was involved in any other punishing events.**

3. I feel strange after drinking that glass of milk.

**Plausible: You are developing lactose intolerance.**

**This is plausible because it is conservative (lactose intolerance is a common condition); it is simple (it appeals to only one condition); it is independently testable because we could conduct experiments to see if you really are lactose intolerant; while it does not have a broad explanatory scope (it doesn't explain many strange feelings), it does explain this case specifically, so it has explanatory depth.**

**Implausible (suggestion 1): The milk was bad.**

**This has all the virtues of lactose intolerance but it is less plausible because it is not conservative (few people can drink bad milk without realizing it is bad).**

**Implausible (suggestion 2): The milk was poisoned.**

**This is implausible because it is not simple (it requires motive and poison, which are not already included in the description of the case—this may be different in, say, a crime novel); it lacks conservativeness because few people are poisoned.**

5. My boyfriend just freaked out when I asked him about his sister.

**Plausible: He has a bad relationship with his sister.**

**This is plausible because bad sibling relationships are common (conservative); it is independently testable and fecund; and it has some explanatory scope because it might explain many of his reactions related to his sister.**

**Implausible: He has a sexual relationship with his sister.**

**This is implausible because incestuous relationships are rare (not conservative; it is not simple (there would have to be a complex set of social factors for this to happen); it is unlikely to be independently testable if he or his sister is unwilling to talk about it.**

## C. In each of the following there is an observation and two possible explanations. Using at least one theoretical virtue, identify the best of the two explanations.

**1. Observation: This shrimp tastes funny.**

Explanation A: The shrimp is bad.
Explanation B: It is not shrimp.

**Explanation A is more plausible because, even though there are shrimp substitutes, few are convincing (so it isn't conservative). Also, there would have to be a reason someone would substitute something else for shrimp (this is possible—the restaurant ran out of actual shrimp—but rare; mostly someone would just say they are out of shrimp). And shrimp goes bad fairly easily (conservative).**

**3. Observation: This guitar string keeps going out of tune.**

Explanation A: The string is old.
Explanation B: Someone keeps turning the tuner when I'm not looking.

**Explanation A is more plausible because even though B is possible (especially with a prankster bandmate), it is less conservative and more complex than the common occurrence that old strings regularly go out of tune.**

**5. Observation: An oil spill in Prince William Sound, Alaska**

Explanation A: Members of Green Peace bombed the tanker.
Explanation B: The tanker hit a reef due to the negligence of an overworked crew.

**Both events are rare, so it is difficult to say without more information which is more plausible. We might know that Green Peace is particularly concerned to protect the environment, and that causing an oil spill would have to be a by-product of some other goal, and therefore, a mistake on their part. Bombing a tanker and making a mistake is less likely than just bombing the**

**tanker. Also, there is some evidence that blue-collar employees like tanker pilots are often overworked, so this explanation has some plausibility on grounds of conservatism. Both have roughly equal explanatory scope and depth. Explanation B is simpler than A because no people other than the ship's crew are needed for B.**

## D. In each of the following there is an observation and two more complicated possible explanations. Using at least two theoretical virtues, identify the best of the two explanations.

**1. Observation: "That landscape is represented perfectly on this photo paper! How is that?"**

Explanation A: A small demon lives inside cameras and each has the unique ability to paint pictures very quickly and very accurately.

Explanation B: Thin papers, treated with chemicals to make them sensitive to the light of the three primary colors (yellow, red, blue), are exposed to the light reflected from a scene (such as a landscape). This produces a reverse image of the scene called a "negative." A chemical reaction with silver halide causes the negative to transfer (by a process called "diffusion") into a positive image, or, the image you wanted to capture.

**Explanation A is vastly simpler than B, but it is also vastly less conservative (we don't generally believe demons exist, or, at least, if we do, we don't think they're employed by artists). Explanation B is more plausible because of its scope and fecundity—we can explain more and do more with the information in B than with the information in A.**

**3. Observation: "Hey, these two pieces of steel get warm when you rub them together quickly. Why is that?"**

Explanation A: There is a liquid-like substance called "caloric" that is warm. When an object has more caloric it is warmer than when it has less. Caloric flows from warmer objects to cooler just as smoke dissipates into a room. When you rub two pieces of steel together, the caloric from your body flows into the steel.

Explanation B: Objects are made of molecules. Heat is a function of the speed at which molecules in an object are moving. If the molecules move faster, the object becomes warmer; if the molecules slow down, the object becomes cooler. Rubbing two metal pieces together quickly speeds up the molecules in the metal, thereby making it warmer.

**Both explanations are consistent with our experience of heat, and both explain heat widely and in depth. Explanation B is simpler in that it relies only on the physical elements we already believe make up objects and does not require the extra substance "caloric." The important factors will be independent testability and fecundity after we construct some experiments.**

# Chapter 10 – Informal fallacies

## Getting familiar with … informal fallacies

### A. Short answer

1. Without looking back at the text, define the term "fallacy."

   **An error in reasoning whereby one draws a conclusion from a premise or a set of premises when that conclusion does not follow.**

3. Denying the antecedent is a distortion of which valid form of inference?

   ***modus tollens***

5. Is it possible for the conclusion of a fallacious argument to be true? Explain why or why not.

   **Yes. An argument is fallacious when the premises do not support the conclusion strongly or validly because of an error on the**

**part of the arguer. There are no other constraints on what counts as a fallacious argument. It could have true premises and a true conclusion, false premises and a false conclusion, true premises and a false conclusion, false premises and a true conclusion, or a mix of true and false premises and either a true or false conclusion.**

### B. Use the fallacies we have discussed so far to identify the fallacy committed in each of the following arguments.

1. "What an idiot! Mark never reads and he plays video games all day long. He is not qualified to advise the state's finance committee."

    ***ad hominem*, abusive**

3. "People who use heavy hallucinogens almost always started with marijuana, so marijuana is a gateway drug to heavy hallucinogens. And that's the main reason to ban marijuana."

    **slippery slope**

5. Your English professor says, "Of course God exists. There's undeniable evidence for His existence."

    **appeal to inappropriate authority (*ad verecundiam*)**

7. "It's obvious: violence in heavy metal music makes kids want to go out and commit violent acts in the real world."

    **false cause**

9. "Every swan I've ever seen has been white—in books, on TV, in the movies, on the Internet—so all swans are white."

    **hasty generalization**

11. The *National Enquirer* newspaper prints: "Monkey-boy is his own father!"

    **appeal to inappropriate authority (*ad verecundiam*)**

13. "You'll support what we're saying here, right? You wouldn't want your windows broken, would you?"

    **appeal to force (*ad baculum*)**

15. "You can't really expect me to believe that stealing is wrong. Everyone does it."

    **appeal to the people (*ad populum*)**

# Glossary

**Abductive Argument:** See Inference to the Best Explanation.

**Addition:** a valid **rule of inference** that states that, for any claim you know (or assume) to be true, you may legitimately disjoin any other claim to it by a rule called *addition* without altering the truth value of the original disjunctive claim (not to be confused with conjunction).

**Alternative Facts:** a false claim that is justified by commitment to the idea that reality is whatever you want it to be, or whatever people in power say it is.

**Ambiguity**: the property of a claim that allows it to express more than one clear meaning.

**Lexical Ambiguity**: a claim in which one or more words in the claim has multiple clear meanings. For example, the word *bank* in the claim, "I went to the bank."

**Syntactic Ambiguity**: a claim that is worded in such a way that it has more than one clear meaning. For example, "I cancelled my travel plans to play golf."

**Ampliative**: an inference in which there is more information in the conclusion than is available in the premises. This typically occurs in an inductive argument. See also **Non-ampliative**.

**Antecedent**: the part of a conditional claim on which the consequent is conditional. It typically follows the "if" and precedes the "then."

**Argument**: one or more claims, called a premise (or premises), intended to support the truth of a claim, called the conclusion.

**Argument from Analogy**: an inductive argument in which a conclusion is drawn from similarities in the features of two objects or events.

**Artificial Language**: a language created for a specific purpose, for instance a computer language. Artificial languages typically lack the semantic ambiguity and vagueness inherent in natural languages.

**Asymmetric Relationship**: a one-directional relationship. For example, between a mother and a child, a leader and a follower.

**Belief**: a mental attitude toward a claim.

**Bias**: a systemic inaccuracy in data due to the characteristics of the process employed in the creation, collection, manipulation, and presentation of data, or due to faulty sample design of the estimating technique.

**Cultural Bias**: the phenomenon of interpreting and judging phenomena by standards inherent to one's own culture. For example, wording questions on a test or survey so that only native speakers or members of a certain economic class can respond accurately.

**Bi-conditional**: a claim using the "if and only if" (or ≡) operator in propositional logic. For example: "Knives are placed in this drawer if and only if they are sharpened."

**Big Four Graduate School Entrance Exams**: Graduate Record Examinations (GRE), Law School Admission Test (LSAT), Graduate Management Admission Test (GMAT), and Medical College Admission Test (MCAT).

**Cascade Logic:** a key feature of conspiracy theories that starts with raising suspicion based on common sense. If one piece of common sense holds, then another closely related suspicion is raised. The collection of suspicion, reinforced by multiple voices, suddenly makes a very implausible claim seem likely to be true.

**Category**: a class, group, or set containing things (members, instances, individuals, elements) that share some feature or characteristic in common. For example, the category of cats, or of dogs, or of things that are red, or of things that are located in Paris.

**Causal Argument**: an inductive argument whose premises are intended to support a causal claim.

**Causal Claim**: a claim that expresses a causal relationship between two events.

**Claim (Proposition)**: a declarative statement, assertion, proposition, or judgment, that expresses something about the world (a state of affairs), and is either true or false.

**Clickbait:** a phrase or sentence, often used as a title or caption to online media, that is deliberately designed to encourage readers to click on an article or website.

**Cogency**: synonymous with a good inductive argument, the quality of an inductive argument whereby it is strong and all of the premises are true.

**Complementary term:** in categorical logic, the complementary term is the term that names every member that is not in the original category or the "non" of the term.

**Complex Argument**: an argument with more than one conclusion.

**Complex Claim:** one or more claims to which an operator has been applied; example: P is a simple claim, ~P is a complex claim.

**Conclusion**: a claim in need of support by evidence.

**Conditional Claim**: an "if … then" hypothetical claim—with the "if" claim known as the antecedent and the "then" claim known as the consequent—whose truth value is determined by the "⊃" operator.

**Confirmation**: evidence that a causal claim is true.

**Conjunct**: a claim that is part of a conjunction.

**Conjunction**: a claim whose truth value is determined by the "and" (or &) operator.

**Consequent**: in a conditional claim, the claim that follows the "then."

**Conspiracy:** an action committed by a small group of people in secret to achieve a shared goal.

**Conspiracy Theory:** a *weak* or *faulty* explanation of an event that involves a secret plan by a powerful group.

**Constructive Dilemma:** a valid rule of inference that states that, if you know two conditionals are true, then the disjunction of their antecedents logically implies the disjunction of their consequents; example: If you know "If A then B" and you know "If P then Q," and you know "Either A or P," then you can conclude, "Either B or Q."

**Contradictory Claims**: in categorical logic, corresponding A-claims and O-claims, as well as corresponding E-claims and I-claims are contradictory claims, meaning that they have opposite truth values. If an A-claim is true, then an O-claim is false, and vice versa, while if an E-claim is true, then an I-claim is false, and vice versa. But unlike contrary claims, both claims cannot be false; and unlike subcontraries, both cannot be true. If one is false, the other must be true.

**Contraposition (see Transposition)**

**Contrary Claims**: in categorical logic, A-claims and E-claims that correspond with one another (have the exact same subject and predicate) are called contrary claims, meaning they are never both true at the same time. Contrary claims are never both true. Contrary claims can both be false. If one contrary claim is false, it is undetermined whether the other is true or false.

**Conversion:** the process of taking one of the standard-form categorical claims and switching the subject and the predicate; example: All As are Bs becomes All Bs are As; note that conversion is not "truth-preserving" for all categorical forms: It doesn't follow from "All cats are mammals" that "All mammals are cats."

**Copula**: a word used to link subject and predicate.

**Correlation**: a patterned statistical relationship between two or more events.

**Positive Correlation**: a correlation whereby the frequency of one event increases as the frequency of another event increases.

**Negative Correlation**: a correlation whereby the frequency of one event decreases as the frequency of another event increases.

**Correspondence Theory of Truth**: the belief that a claim is true if and only if it accurately expresses some state of affairs, that is, it corresponds to some feature of reality.

**CRAAP Test:** an acronym that stands for currency, relevance, authority, accuracy, and purpose. This test is a heuristic that can be helpful in distinguishing fake from real news.

**Currency:** refers to how recent a study is, where timelier (i.e., more recent) findings are valued as more likely to be accurate or reliable. There are exceptions to this heuristic, such as with historical findings.

**Relevance:** refers to the degree of importance, significance, or other significant relation to the topic under investigation.

**Authority:** refers to the author of a study, article, or other piece of information and whether they have the credentials to be drawing the conclusions they do or making the assertions they do.

**Accuracy:** the information is confirmed by reputable sources or supported by independent evidence.

**Purpose:** refers to the reason why the information was either published or presented in the way that it was.

**Critical Thinking**: the conscious, deliberate process of evaluating arguments in order to make reasonable decisions regarding what to believe about ourselves and the world as we perceive it.

**Deductive Argument**: an argument whereby the conclusion follows from the premise(s) with necessity so that, if all of the premises are true, then the conclusion cannot be false.

**Definition**: a claim that is composed of a *definiens* (a claim or term that defines) and a *definiendum* (a term that needs defining). For example, "A vixen (*definiendum*) is a female fox (*definiens*)."

**DeMorgan's Law:** a valid rule of replacement identified by logician Augusts DeMorgan which states that, if it is true that P is false and Q is also false, then the disjunction of P and Q cannot be true, since neither conjunct is true.

**Descriptive Claim**: a claim that expresses the way the world is or was or could be or could have been, as in a report or explanation.

**Destructive Dilemma:** a valid rule of inference that states that, if you know two conditionals are true, and you know that at least one of the consequents of those conditionals is false (you know its negation), then you know at least one of the antecedents of those conditionals is false (you know its negation); example: If you know "If A then B" and "If P then Q," and you know "Either not-B or not-Q," then you can derive, "Either not-A or not-P."

**Diminishing Marginal Value (Diminishing Marginal Utility)**: the phenomenon that occurs whereby, as the quantity of a valued thing increases, its value to you decreases.

**Direct Evidence**: evidence that a claim is true or false that you as a critical thinker have immediate access to, for instance, seeing that something is red or round or recognizing that a particular claim follows from a mathematical theorem. (See also **Evidence** and **Indirect Evidence**)

**Disconfirmation**: evidence that a causal claim is false.

**Disguised Claim**: a claim disguised as a question.

**Disinformation:** information that is both false and intentionally distracting; it turns people away from the truth and toward false claims or irrelevant information

**Disjunct**: a claim that is part of a disjunction.

**Disjunction**: a claim whose truth value is determined by the "or" (or v) operator.

**Disjunctive Syllogism:** a valid deductive argumentative form in which one of the disjuncts of a disjunctive claim is derived from the negation of one of the other disjuncts; for example, if you know "A or B," and you know "not-A," then you can conclude "B."

**Distributed Term**: in categorical logic, the term that refers to all members of a class.

**Double negation:** a valid rule of replacement that states that any claim, P, is truth-functionally equivalent to the complex claim ~~P (not-not P).

**Enthymeme**: an argument in which a premise or conclusion is implied instead of explicitly stated.

**Evidence**: a reason or set of reasons to believe that a claim is true or false. (See also **Direct Evidence** and **Indirect Evidence**)

**Exclusive *Or***: a disjunction that is treated as if both disjuncts could not be true at the same time.

**Existential Assumption**: in categorical logic, the assumption that the quantifier "some" refers to at least one thing in existence.

**Expected Value**: the outcome, output, or consequence that is expected as a result of a decision.

**Experiment**: a method of testing causal claims by holding certain features of an event fixed (the controls), observing any changes that might result from another feature of the event (the variable), and reasoning inductively from the results to a conclusion about the cause. (See **Study** for different types of experiments.)

**Explanation**: a claim that is composed of an *explanans* (claims that explain) and an *explanandum* (a claim that needs explaining). For example, "Objects fall to the ground (*explanandum*) because gravity affects all objects on the planet (*explanans*)."

**Extraneous Material**: words or phrases in a passage that do not do rational work in an argument.

**Fake News:** intentional disinformation or misinformation. (See also **Disinformation** and **Misinformation**)

**Fallacy**: an error in reasoning, whether intentional or unintentional.

**Formal Fallacy**: a mistake in the form of an argument whereby one of the rules associated with that particular argument form has been violated, and a conclusion has been drawn inappropriately; a mistake in the argument's structure or form, not its content.

**Affirming the Consequent**: a formal fallacy where one inappropriately draws a conclusion to the antecedent of a conditional claim, given premises that include the affirmation of the conditional claim as one premise and the affirmation of the consequent of that conditional claim as another premise.

**Affirming the Disjunct**: a formal fallacy where a disjunction is given, one of the disjuncts is affirmed, and then one inappropriately draws a conclusion to the truth or falsity of the other disjunct.

**Denying the Antecedent**: a formal fallacy where one inappropriately draws a conclusion to the negation of the consequent of a conditional claim, given premises that include the affirmation of the conditional claim as one premise and the denial/negation of the antecedent of that conditional claim as another premise.

**Informal Fallacy**: a mistake in the content of the claims of an argument—that is, mistakes in either the meanings of the terms involved (e.g., ambiguity, vagueness, presumption) or the relevance of the premises to the conclusion—and a conclusion has been drawn inappropriately; a mistake in the argument's content, not its structure or form.

**Ad hominem, Abusive Fallacy (Appeal to the Person)**: an informal fallacy in which an attack is made on the person, instead of the person's reasoning.

**Ad hominem, Circumstantial Fallacy**: an informal fallacy in which an attack is made on the person's circumstances, instead of the person's reasoning.

**Ad ignorantiam Fallacy (Appeal to Ignorance)**: an informal fallacy that occurs when one concludes some claim is true based upon a lack of evidence against, or for, a claim.

**Ad misericordiam Fallacy (Appeal to Pity/Misery)**: an informal fallacy that occurs when one concludes some claim is true based upon a feeling of pity or similar emotion.

**Ad populum Fallacy (Appeal to the People)**: an informal fallacy that occurs when one concludes that some claim is true based upon a premise that everyone or a majority of people think the claim is true.

**Ad baculum Fallacy (Appeal to Force/Threat)**: an informal fallacy that occurs when one concludes some claim is true based upon a perceived harm or threat.

**Ad vericundium Fallacy (Appeal to Inappropriate Authority)**: an informal fallacy that occurs when one concludes some claim is true based upon an unqualified, illegitimate, or inappropriate authority figure's endorsement of the claim.

**Appeal to Snobbery Fallacy**: an informal fallacy that occurs when one concludes that some claim is true based upon a premise that a select group of people think the claim is true.

**Circular Argument (Begging the Question) Fallacy**: an informal fallacy that occurs when one assumes the conclusion in the premise(s) of the argument.

**Composition Fallacy**: an informal fallacy that occurs when one draws an inappropriate conclusion about the whole from premises having to do with the facts or features of some part of the whole.

**Division Fallacy**: an informal fallacy that occurs when one draws an inappropriate conclusion about some part of the whole from premises having to do with the facts or features of the whole itself.

**False Analogy**: an informal fallacy applied to an analogical argument in which either there are not enough comparisons to make a strong inference or the comparisons are not sufficiently relevant to make a strong inference.

**False Cause**: an informal fallacy that occurs when one incorrectly thinks that an event, condition, or thing A causes another event, condition, or thing B, when in fact there is not this causal connection.

**False Dilemma**: an informal fallacy that occurs when someone concludes something based upon premises that include only two options, when, in fact, there are three or more options.

**Gambler's Fallacy**: an informal fallacy that occurs when we use evidence of past, independent events to draw probabilistic conclusions about future events (e.g., "I've lost 7 games in a row. Surely I must win the next one!).

**Hasty Generalization**: an informal fallacy whereby one inappropriately draws a conclusion about an entire population based upon premises having to do with a sample of the population.

**Loaded Question**: an informal fallacy whereby one assumes a certain conclusion in the very question itself.

**Red Herring**: an informal fallacy whereby someone uses claims and arguments that have nothing to do with the issue at hand in order to get someone to draw a conclusion that they believe to be true. So, the claims and arguments are the "red herrings" they use to throw you off the "trail" of reasoning that would lead to another, probably more appropriate, conclusion altogether.

**Slippery Slope**: an informal fallacy that occurs when one inappropriately concludes that some further chain of events, ideas, or beliefs will follow from some initial event, idea, or belief and, thus, we should reject the initial event, idea, or belief. It is as if there is an unavoidable slippery slope that one is on, and there is no way to avoid sliding down it.

**Straw Person**: an informal fallacy in which argument in which an arguer responds to a different, superficially similar argument (X*) than the original one presented (X), though he treats it (X*) as the one presented (X).

**Tu quoque (you, too)**: an informal fallacy in which an attack is made on the person claiming that the person is a hypocrite, instead of the person's reasoning.

**Formal Language**: a language that a human creates for a particular purpose, such as a computer languages (PASCAL, C++) or symbolic logic.

**Four Moves and a Habit Strategy:** a strategy for identifying and combating misinformation and other fake news. This strategy includes processes like checking sources for previous work, going upstream, reading laterally, and circling back. The habit part of the strategy refers to the critical thinker checking their emotions as they evaluate and process information.

**Hypothesis**: a claim that counts as a reason to expect some observation. (See also **Auxiliary Hypothesis**)

**Hypothetical Syllogism:** a valid rule of inference that states that, for any two conditionals, if the antecedent of one is the consequent of the other, then you can derive a conditional, where antecedent of the first conditional entails the consequent of the second conditional; If you know "If A then B," and if you know "If B then C," then you can derive, "If A then C."

**Inclusive *Or***: A disjunction which is treated as if both disjuncts could be true at the same time.

**Indicating Words and Phrases**: words and/or phrases that indicate a premise or a conclusion in an argument. Common **conclusion-indicating**

**words and phrases** include: Hence; Thus; Therefore; So; So that; This shows us that; We may conclude/deduce/infer that; Entails; Implies; Consequently; It follows that; It must be the case that. Common **premise-indicating words and phrases** include: Because; Since; For; For the reason that; As; Due to the fact that; Given that; In that; It may be concluded from.

**Indirect Evidence**: mediating evidence that a claim is true or false; information that aims to connect information you would normally get from direct evidence with your belief. (See also **Evidence** and **Direct Evidence**)

**Inductive Argument**: an argument whereby the conclusion follows from the premise or premises with some degree of probability less than 1. Probability is measured on a decimal scale between 0 and 1, where 50 percent probability is P(0.5), 90 percent probability is P(0.9), and 100 percent probability is P(1).

**Inductive Generalization (Enumerative Induction)**: an inference from a sample of some population or a set of past events to every member of that population or future events.

**Inference to the Best Explanation** (also **Abductive Argument**): a prudential argument that concludes one explanation is better than another by contrasting their theoretical virtues, namely, Independent Testability, Simplicity, Conservatism, Fecundity, Explanatory Scope, and Explanatory Depth.

**Independent Testability:** a test that increases or decreases the likelihood that your hypothesis is true; it is independent because it doesn't depend on the truth of the hypothesis.

**Simplicity:** an explanatory virtue that says that, for any two hypotheses that purport to explain the same observation, the explanation that invokes the fewer number of laws or entities or explanatory principles is more likely to be true.

**Conservatism:** an explanatory virtue in which an explanation of a phenomenon is viewed as being strong evidence if accepting the new explanation will not require us to change a substantial number of our previous beliefs.

**Fecundity:** an explanatory virtue according to which, a hypothesis provides new opportunities for research, it is considered an explanation of a hypothesis is considered stronger evidence if it provides new opportunities for research.

**Explanatory Scope:** the breadth of an explanation, that is, the number of observations it can successfully explain; in abductive arguments, an explanation that explains more observations is preferable to an explanation that explains fewer observations.

**Explanatory Depth:** the complexity of an explanation; explanations that include greater or fewer details about observation; in abductive arguments, an explanation that explains an observation more thoroughly is preferable to one that explains more superficially.

**Initial Conditions**: in the context of a scientific experiment, the conditions under which an experiment takes place (including facts about the test subjects, laboratory conditions, and experimental tools, such as slide stain solution), any of which may affect experimental results.

**Lexical Definition:** the meaning of a term that is widely accepted by the majority of speakers in that language; also known as a "dictionary definition."

**Major Operator**: the dominant logical operator in a complex claim.

**Margin of Error**: an estimate of the possible variation within the population, given that the sample is representative. Margins of error measure sampling error, that is, the possibility of error in the statistical calculation, which is based on something called the confidence interval.

**Member (of a Category)**: an instance, individual, or element that is part of a class, category, group, or set. For example, Garfield the cat is a member of the cat class.

**Mental Attitude**: a feeling about the world that helps to inform our reaction to it.

**Middle Term**: the term that is the subject or predicate in both of the premises of the syllogism, but not in the conclusion. For example, B is the middle term in the following syllogism: All A are B. All B are C. Therefore, All A are C.

**Mill's Methods**: informal experiments devised by philosopher John Stuart Mill (1806–1873), namely, Method of Agreement, Method of Difference, Joint Method of Agreement and Difference, Method of Residues, and Method of Concomitant Variation.

**Method of Agreement**: According to Mill himself in *A System of Logic* (ASL, 1843): "If two or more instances of the phenomenon under investigation have only one circumstance in common, the circumstance in which alone all the instances agree, is the cause (or effect) of the given phenomenon" (ASL, p. 454).

**Method of Difference**: "If an instance in which the phenomenon under investigation occurs, and an instance in which it does not occur, have every circumstance save one in common, that one occurring only in the former; the circumstance in which alone the two instances differ, is the effect, or cause, or a necessary part of the cause, of the phenomenon" (ASL, p. 455).

**Joint Method of Agreement and Difference**: "If two or more instances in which the phenomenon occurs have only one circumstance in common, while two or more instances in which it does not occur have nothing in common save the absence of that circumstance; the circumstance in which alone the two sets of instances differ, is the effect, or cause, or a necessary part of the cause, of the phenomenon" (ASL, p. 463).

**Method of Residues**: "Remove from any phenomenon such part as is known by previous inductions to be the effect of certain antecedents, and the residue of the phenomenon is the effect of the remaining antecedents" (ASL, p. 465).

**Method of Concomitant Variation**: "Whatever phenomenon varies in any manner whenever another phenomenon varies in some particular manner, is either a cause or an effect of that phenomenon, or is connected with it through some fact of causation" (ASL, p. 470).

**Misappropriation:** (see **Photo and Video Manipulation**)

**Misinformation:** information that "misleads" audiences from a more accurate view of the world; it is not, strictly speaking, false, but it often encourages false beliefs; an example is "click bait" article titles.

***Modus Ponens*****:** a valid form of deductive argument in which the consequent of a conditional claim can be derived from the antecedent; if you know "If A, then B," and you also know "A," then, by *modus ponens*, you can conclude, "B."

***Modus Tollens*****:** a valid form of deductive argument in which the negation of the antecedent of a conditional claim can be derived by demonstrating the negation of the consequent of the conditional claim; if you know "if A, then B," and you also know "not-B," then, by *modus tollens*, you can conclude, "not-A."

**Natural Language**: a language spoken by some group of people that has developed over time (e.g., English, French, Swahili).

**Necessary Condition**: for some state of affairs S, a condition that must be satisfied in order for S to obtain. For example, a cloud is a necessary condition for rain, being 35 years of age is a necessary condition for becoming President of the United States, taking Philosophy 101 at University X is a necessary condition for taking Philosophy 102 at University X.

**Negation**: a negated claim.

**Non-Ampliative**: an inference in which there is no more information in the conclusion than is available in the premises. See **Ampliative**.

**Normative Reasons:** claims about what should (morally or legally or socially) be done, or what one ought to do.

**Obversion**: the process of taking one of the standard-form categorical claims, changing it from the affirmative to the negative (A-claim becomes E-claim and vice versa, and I-claim becomes O-claim and vice versa), and replacing the predicate term with its complementary term (the term that names every member that is not in the original category, or the "non" of the term).

**Old School Strategy:** the classic strategy for determining which of several competing claims are justified that involves various search strategies, identifying reputable sources, and comparing and contrasting reasons for accepting a belief; often useful when trying to distinguish real news from fake or misleading news.

**Operator**: a modifier of claims that allows us to express more complicated states of affairs. The basic operators discussed in this book are: and (& or •), or (v), not (~ or ¬), if… then (⊃ or →), if and only if (≡ or ↔).

**Outlier**: a data point that does not conform to the statistical pattern (correlation line) in a correlation.

**Parody:** a form of comedy that makes fun of some subject matter by imitating that subject matter; can be used as a form of fake news. (See **Fake News**)

**Photo and Video Manipulation:** the alteration of a photo or video to create a false narrative.

**Misappropriation:** When an image is used out of context to make it easier to spread a false story, regardless of whether the user meant the story to be false or not.

**Post-truth (or post-fact):** the view that society has come to value appeals to emotion over objective reality or facts, and therefore, that emotions are more important than objective reality or facts.

**Practical Reason**: a reason to believe based on what is better or best for you, more useful to you, or more helpful to you.

**Predicate**: with respect to categorical logic, the category or member of a category in a standard-form categorical claim that is related to the subject through a quantifier (all, no, some) and a copula (is, is not).

**Premise**: a claim that supports the conclusion.

**Premise-Circularity**: an argument in which a premise explicitly restates the conclusion.

**Prescriptive (Normative) Claim**: a claim that expresses that the world ought to be or should be some way.

**Principle of Charity**: a principle which states that one should always begin an argument by giving a person the benefit of the doubt.

**Probability**: a function of the evidence we have for that claim given everything else we know about the claim. Probability measurements are expressed as chances—in this case, 1 in 2, or ½—or as percentages—50%, as we just noted—or as decimals—the decimal of 50% is 0.5, so we write this: P(0.5).

**Conditional Probability**: a probability that is conditional on the condition of other probabilities.

**Dependent Probability**: a probability that depends on another probability.

**Epistemic Probability**: a measure of the likelihood of an event given our current evidence.

**Independent Probability**: a probability that is not affected by the probability of another event.

**Objective Probability**: the likelihood of a specific occurrence, based on repeated random experiments and measurements (subject to verification by independent experts), instead of on subjective evaluations.

**Subjective Probability (Credence)**: the numeric measure of chance that reflects the degree of a personal belief in the likelihood of an occurrence.

**Problem of Induction:** a philosophical objection to inductive reasoning in which it is argued that the evidence about the past or a sample of population does not count as sufficient evidence for claims about the future state or about the whole population.

**Proof**: in propositional logic, the demonstration or “showing your work” utilizing rules of inference and/or replacement associated with how a conclusion has been deduced from premises given.

**Conditional Proof:** a strategy for proving the truth of a conditional from a set of premises that may or may not include a conditional, so long as the consequent of the conditional is true (e.g., if we know B is true, then the following conditional is true, regardless of whether A is true: if A, then B).

**Indirect Proof**: a strategy for disproving some claim, P, by demonstrating that assuming the truth of P leads to a contradiction.

**Proposition**: See **Claim**.

**Propositional Logic**: the logic of claims or propositions.

**Prudential Argument**: An argument whose conclusion expresses a practical or useful thing to do or believe rather than what is true or false; prudential arguments can be helpful when there is a great deal of uncertainty about what's true or false.

**Quantifier**: an indicator of how many of something is referred to in a claim, and there are three basic quantifiers: all, some, and none.

**Random Sampling**: a sampling that takes information from all relevant portions of the population. If a sample is not random, it is biased.

**Reiteration:** A valid rule of replacement that states that, from any claim, P, we can derive (or conclude) P at any point in an argument without loss of truth value.

**Rule-Circularity**: an argument that uses the rule of inference that it attempts to prove.

**Rules of Inference**: in propositional logic, valid deductive inferences in a proof, including Simplification, Conjunction, *modus ponens*, *modus tollens*, Disjunctive Syllogism, Addition, Hypothetical Syllogism, and Constructive and Destructive Dilemmas.

**Rules of Replacement**: in propositional logic, the legitimate equivalency moves in the reasoning process of a proof, including Reiteration, Double Negation, Transposition, DeMorgan's Law, Commutativity, Associativity, Distribution, Conditional Exchange, Material Equivalence, Exportation, and Tautology.

**Self-Selection Bias**: inferences about whole populations drawn from self-selected samples.

**Simple Argument**: an argument with only one conclusion.

**Simple Model of Confirmation**: a classic set of experimental models for testing hypotheses.

**Simplification:** a valid rule of inference that says, from any conjunction, such as (P & Q), we are permitted to derive (or conclude) any of the conjuncts; for example, from (P & Q), we can conclude P by simplification, or we can conclude Q by simplification.

**Soundness**: synonymous with a good deductive argument, the quality of a deductive argument whereby it is valid and all of the premises are true.

**Square of Opposition**: in categorical logic, a diagram showing all of the possible truth values, logical relationships, and legitimate inferences that can be made between the four standard-form categorical claims: A-Claim, E-Claim, I-Claim, and O-Claim.

**Standard Argument Form**: a form whereby the premises of an argument are numbered, then listed one on top of the other with a line below the final premise—called the derivation line—and the conclusion placed below the line.

**Standard-Form Categorical Claim**: a claim in categorical logic whereby one category or member of a category is or is not predicated of another category or member of a category, taking one of four forms: A-Claim, E-Claim, I-Claim, or O-Claim.

**A-Claim**: the standard-form categorical claim that communicates, "All As are Bs."

**E-Claim**: the standard-form categorical claim that communicates, "No As are Bs."

**I-Claim**: the standard-form categorical claim that communicates, "Some As are Bs."

**O-Claim**: the standard-form categorical claim that communicates, "Some As are not Bs."

**State of Affairs**: the way the world is or was or could be or could have been or is not.

**Strong (Inductive Strength)**: the quality of an inductive argument whereby the conclusion does in fact follow from the premise(s) with a high degree of probability.

**Study (see also Experiment)**: a method of testing causal claims by holding certain features of an event fixed (the controls), observing any changes that might result from another feature of the event (the variable), and reasoning inductively from the results to a conclusion about the cause.

**Randomized Experimental Study**: a study that allows the greatest reliability and validity of statistical estimates of treatment effects. In the statistical theory of design of experiments, randomization involves randomly allocating the experimental units across the treatment groups. For example, if an experiment compares a new drug against a standard drug, then the patients should be allocated to either the new drug or to the standard drug control using randomization.

**Prospective Study:** a study that follows over time a group of similar individuals who differ with respect to certain factors under study, to determine how these factors affect rates of a certain outcome. For example, one might follow a cohort of middle-aged truck drivers who vary in terms of smoking habits, to test the hypothesis that the twenty-year incidence rate of lung cancer will be highest among heavy smokers, followed by moderate smokers, and then nonsmokers.

**Retrospective Study:** a study in which a search is made for a relationship between one (usually current) phenomenon or condition and another that occurred in the past.

**Subalternation** and **Superalternation**: in categorical logic, A- and I-claims and E- and O-claims are in a relationship of superalternation and subalternation. This means that if an A-claim is true, then the corresponding I-claim is true as well.

**Subcontrary Claims**: in categorical logic, I-claims and O-claims that correspond with one another are called subcontrary claims, and they are never both false.

**Subject**: with respect to categorical logic, the category or member of a category in a standard-form categorical claim that is related to the predicate through a quantifier (all, no, some) and a copula (is, is not).

**Sufficient Condition**: for some state of affairs S is a condition that, if satisfied, guarantees that S obtains. For example, jumping in a pool is sufficient for getting wet, being human is a sufficient condition for being a mammal, and being a single male is a sufficient condition for being a bachelor.

**Syllogism**: in categorical logic, an argument made up of exactly one conclusion that is a standard-form categorical claim and two premises that are standard-form categorical claims.

**Symmetric Relationship**: a relationship that holds in both directions. “Is a sister of” and “is married to” are symmetrical relationships.

**Technical Definition (also Term of Art):** a definition formulated by experts or professionals of a given field to serve a very specific function, usually a more precise meaning; it usually differs in important ways from the term's **lexical definition**.

**Test Implication**: an experimental result we would expect to be true independently of our observation.

**Theoretical Virtues**: the features of an explanation that help us determine which is more plausible, namely, Independent Testability, Simplicity, Conservatism, Fecundity, Explanatory Scope, and Explanatory Depth.

**Theory:** an explanation of some state of the world.

**Transposition (Contraposition):** a valid rule of replacement that states that, for any conditional, if you know the negation of its consequent, you can derive the negation of its antecedent. In other words, any conditional is truth-functionally equivalent to a conditional in which its antecedent and consequent are flipped and negated. For example: If this is true: $(P \supset Q)$, then this is true $(\sim Q \supset \sim P)$, and vice versa.

**Truth Table**: a tool for expressing all the possible truth values of a claim, whether simple or complex.

**Truth Table Method**: one method of testing arguments in propositional logic for validity utilizing truth tables.

**Long Truth Table Method**: the method of testing arguments in propositional logic for validity utilizing all logically possible truth tables associated with the claims of the argument.

**Short Truth Table Method**: the method of testing arguments in propositional logic for validity by forcing the conclusion to be false and attempting to make all of the premises true.

**Truth Value**: the quality of a claim whereby it is true or false.

**Underdetermination**: the phenomenon that occurs when the results of an experiment are ambiguous between two explanations such that we discover two hypotheses, both of which cannot be true, but which are both sufficient to explain the same test implication.

**Undetermined**: in categorical logic, a case in which one is not able to say, for sure, whether a standard-form categorical claim is true or false.

**Vagueness**: the quality of a word whereby it has a clear meaning, but not precisely defined truth conditions.

**Validity**: the quality of a deductive argument whereby it is not possible for the premises to be true and the conclusion false.

**Valid Scientific Instrument**: an instrument that yields the relevant information we are looking for, that is, it measures what it claims to measure.

**Variable**: a placeholder for a term. In logic, the placeholder could be for a category, proposition, subject, or predicate.

**Venn Diagram**: named after John Venn (1834–1923), a visual representation of a standard-form categorical claim using two intersecting circles to represent the two terms of the claim.

**Venn Diagram Method**: named after John Venn (1834–1923), a visual representation of whether a syllogism is valid or not using three intersecting circles to represent the three terms of the syllogism.

**Well-formed Formula**: a sentence of propositional logic that is not ambiguous.

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