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For All X

Midwest Collaboration

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Adam Edwards compiled this edition and wrote original material for it. He takes full responsibility for any mistakes remaining in this version of the text.

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“When you come to any passage you don’t understand, *read it again*: if you *still* don’t understand it, *read it again*: if you fail, even after *three* readings, very likely your brain is getting a little tired. In that case, put the book away, and take to other occupations, and next day, when you come to it fresh, you will very likely find that it is *quite* easy.”
– Charles Dodgson (Lewis Carroll) *Symbolic Logic* (**Dodgson1896**)

“Few persons care to study logic, because everybody conceives himself to be proficient enough in the art of reasoning already. But I observe that this satisfaction is limited to one’s own ratiocination and does not extend to that of other men. We come to the full possession of our power of drawing inferences the last of all our faculties, for it is not so much a natural gift as a long and difficult art.”
– Charles Sanders Peirce “The Fixation of Belief”, in *Popular Science Monthly*, Vol. 12 (November 1877)”

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Basic Concepts

What Is Logic?

Introduction

Logic is a part of the study of human reasoning—the ability we have to think abstractly, solve problems, explain the things that we know, and infer new knowledge on the basis of evidence. Traditionally, logic has focused on the last of these items, the ability to make inferences on the basis of evidence. This is an activity you engage in every day. Consider, for example, the game of Clue. (For those of you who have never played, Clue is a murder mystery game where players have to decide who committed the murder, what weapon they used, and where they were.) A player in the game might decide that the murder weapon was the candlestick by ruling out the other weapons in the game: the knife, the revolver, the rope, the lead pipe, and the wrench. This evidence lets the player know something they did not know previously, namely, the identity of the murderer.

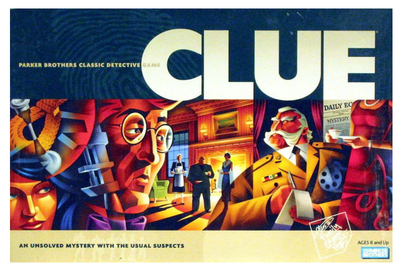

Figure 1: The boardgame Clue.

In logic, we use the word "argument" to refer to the attempt to show that certain evidence supports a conclusion. This is very different from the sort of argument you might have when you are mad at someone, which could involve a lot of yelling. We are going to use the word "argument" a lot in this book, so you need to get used to thinking of it as a name for an abstract and rational process, and not a word that describes what happens when people disagree.

A logical argument is structured to give someone a reason to believe some conclusion. Here is the argument about a game of Clue written out in a way that shows its structure.

(A1) In a game of Clue, the possible murder weapons are the knife, the candlestick, the revolver, the rope, the lead pipe, and the wrench.
(A2) The murder weapon was not the knife.
(A3) The murder weapon was also not the revolver, the rope, the lead pipe, or the wrench.
(A4) $\therefore$ Therefore, the murder weapon was the candlestick.

In the argument above, statements P_1–P_3 are the evidence. We call these the PREMISES. The word "therefore" indicates that the final statement, marked with a C, is the CONCLUSION of the argument. If you believe the premises, then the argument provides you with a reason to believe the conclusion. You might use reasoning like this purely in your own head, without talking with anyone else. You might wonder what the murder weapon is, and then mentally rule out each item, leaving only the candlestick. On the other hand, you might use reasoning like this while talking to someone else, to convince them that the murder weapon is the candlestick. (Perhaps you are playing as a team.) Either way the structure of the reasoning is the same.

We can define LOGIC then more precisely as the part of the study of reasoning that focuses on argument. In more casual situations, we will follow ordinary practice and use the word "logic" to either refer to the business of studying human reason or the thing being studied, that is, human reasoning itself. While logic focuses on argument, other disciplines, like decision theory and cognitive science, deal with other aspects of human reasoning, like abstract thinking and problem solving more generally. Logic, as the study of argument, has been pursued for thousands of years by people from civilizations all over the globe. The initial motivation for studying logic is generally practical. Given that we use arguments and make inferences all the time, it only makes sense that we would want to learn to do these things better. Once people begin to study logic, however, they quickly realize that it is a fascinating topic in its own right. Thus the study of logic quickly moves from being a practical business to a theoretical endeavor people pursue for its own sake.

In order to study reasoning, we have to apply our ability to reason to our reason itself. This reasoning about reasoning is called METAREASONING. It is part of a more general set of processes called METACOGNITION, which is just any kind of thinking about thinking. When we are pursing logic as a practical discipline, one important part of metacognition will be awareness of your own thinking, especially its weakness and biases, as it is occurring. More theoretical metacognition will be about attempting to understand the structure of thought itself.

Whether we are pursuing logical for practical or theoretical reasons, our focus is on argument. The key to studying argument is to set aside the subject being argued about and to focus on the *way* it is argued *for*. The section opened with an example that was about a game of Clue. However, the kind of reasoning used in that example was just the process of elimination. Process of elimination can be applied to any subject. Suppose a group of friends is deciding which restaurant to eat at, and there are six restaurants in town. If you could rule out five of the possibilities, you would use an argument just like the one above to decide where to eat. Because logic sets aside what an argument is about, and just looks at how it works rationally, logic is said to have CONTENT NEUTRALITY. If we say an argument is good, then the same kind of argument applied to a different topic will also be good. If we say an argument is good for solving murders, we will also say that the same kind of argument is good for deciding where to eat, what kind of disease is destroying your crops, or who to vote for.

When logic is studied for theoretical reasons, it typically is pursued as FORMAL LOGIC. In formal logic we get content neutrality by replacing parts of the argument we are studying with abstract symbols. For instance, we could turn the argument above into a formal argument like this:

(B1) There are six possibilities: A, B, C, D, E, and F.
(B2) A is false.
(B3) B, D, E, and F are also false.
(B4) .·. .·. The correct answer is C.

Here we have replaced the concrete possibilities in the first argument with abstract letters that could stand for anything. We have also replaced the English word "therefore" with the symbol ".·.," which means therefore. This lets us see the formal structure of the argument, which is why it works in any domain you can think of. In fact, we can think of formal logic as the method for studying argument that uses abstract notation to identify the formal structure of argument. Formal logic is closely allied with mathematics, and studying formal logic often has the sort of puzzle-solving character one associates with mathematics. You will see this when we get to Part **??**, which covers formal logic.

When logic is studied for practical reasons, it is typically called critical thinking. We will define CRITICAL THINKING narrowly as the use of metareasoning to improve our reasoning in practical situations. Sometimes we will use the term "critical thinking" more broadly to refer to the results of this effort at self-improvement. You are "thinking critically" when you reason in a way that has been sharpened by reflection and metareasoning. A CRITICAL THINKER someone who has both sharpened their reasoning abilities using metareasoning and deploys those sharpened abilities in real world situations.

Critical thinking is generally pursued as INFORMAL LOGIC, rather than formal logic. This means that we will keep arguments in ordinary language and draw extensively on your knowledge of the world to evaluate them. In contrast to the clarity and rigor of formal logic, informal logic is suffused with ambiguity and vagueness. There are problems with multiple correct answers, or where reasonable people can disagree with what the correct answer is. This is because you will be dealing with reasoning in the real world, which is messy.

You can think of the difference between formal logic and informal logic as the difference between a laboratory science and a field science. If you are studying, say, mice, you could discover things about them by running experiments in a lab, or you can go out into the field where mice live and observe them in their natural habitat. Informal logic is the field science for arguments: you go out and study arguments in their natural habitats, like newspapers, courtrooms, and scientific journal articles. Like studying mice scurrying around a meadow, the process takes patience, and often doesn't yield clear answers but it lets you see how things work in the real world. Formal logic takes arguments out of their natural habitat and performs experiments on them to see what they are capable of. The arguments here are like lab mice. They are pumped full of chemicals and asked to perform strange tasks, as it were. They live lives very different than their wild cousins. Some of the arguments will wind up looking like the "ob/ob mouse", a genetically engineered obese mouse scientists use to study type II diabetes (See Figure 2). These arguments will be huge, awkward, and completely unable to survive in the wild. But they will tell us a lot about the limits of logic as a process.

Figure 2: The ob/ob mouse (left), a laboratory mouse which has been genetically engineered to be obese, and an ordinary mouse (right). Photo from **WikimediaCommons2006**.

Our main goal in studying arguments is to separate the good ones from the bad ones. The argument about Clue we saw earlier is a good one, based on the process of elimination. It is good because it leads to truth. If I've got all the premises right, the conclusion will also be right. The textbook *Logic: Techniques of Formal Reasoning* (**Kalish1980**) had a nice way of capturing the meaning of logic: "logic is the study of virtue in argument." This textbook will accept this definition, with the caveat that an argument is virtuous if it helps us get to the truth.

Logic is different from RHETORIC, which is the study of effective persuasion. Rhetoric does not look at virtue in argument. It only looks at the power of arguments, regardless of whether they lead to truth. An advertisement might convince you to buy a new truck by having a gravelly voiced announcer tell you it is "ram tough" and showing you a picture of the truck on top of a mountain, where it no doubt actually had to be airlifted. This sort of persuasion is often more effective at getting people to believe things than logical argument, but it has nothing to do with whether the truck is really the right thing to buy. In this textbook we will only be interested in rhetoric to the extent that we need to learn to defend ourselves against the misleading rhetoric of others. This will not, however, be anything close to a full treatment of the study of rhetoric.

Statement, Argument, Premise, Conclusion

So far we have defined logic as the study of argument and outlined its relationship to related fields. To go any further, we are going to need a more precise definition of what exactly an argument is. We have said that an argument is not simply two people disagreeing; it is an attempt to prove something using evidence. More specifically, an argument is composed of statements. In logic, we define a STATEMENT as a unit of language that can be true or false. That means that statements are TRUTH EVALUABLE . All of the items below are statements.

(A) *Tyrannosaurus rex* went extinct 65 million years ago.

(B) *Tyrannosaurus rex* went extinct last week.

(C) On this exact spot, 100 million years ago, a *T. rex* laid a clutch of eggs.

(D) Abraham Lincoln is the king of Jupiter.

(E) Murder is wrong.

(F) Abortion is murder.

(G) Abortion is a woman's right.

(H) Lady Gaga is pretty.

(I) Murder is the unjustified killing of a person.

(J) The slithy toves did gyre and gimble in the wabe.

(K) The murder of logician Richard Montague was never solved.

Because a statement is something that can be true *or* false, statements include truths like (A) and falsehoods like (B). A statement can also be something that that must either be true or false, but we don't know which, like (C). A statement can be something that is completely silly, like (D). Statements in logic include statements about morality, like (E), and things that in other contexts might be called "opinions," like (F) and (G). People disagree strongly about whether (F) or (G) are true, but it is definitely possible for one of them to be true. The same is true about (H), although it is a less important issue than (F) and (G). A statement in logic can also simply give a definition, like (I). This sort of statement announces that we plan to use words a certain way, which is different from statements that describe the world, like (A), or statements about morality, like (F). Statements can include nonsense words like (J), because we don't really need to know what the statement is about to see that it is the sort of thing that can be true or false. All of this relates back to the content neutrality of logic. The statements we study can be about dinosaurs, abortion, Lady Gaga, and even the history of logic itself, as in statement (K), which is true.

We are treating statements primarily as units of language or strings of symbols, and most of the time the statements you will be working with will just be words printed on a page. However, it is important to remember that statements are also what philosophers call "speech acts." They are actions people take when they speak (or write). If someone makes a statement they are typically telling other people that they believe the statement to be true, and will back it up with evidence if asked to. When people make statements, they always do it in a context—they make statements at a place and a time with an audience. Often the context statements are made in will be important for us, so when we give examples, statements, or arguments we will sometimes include a description of the context. When we do that, we will give the context in *italics*. See Figure 3 for examples. For the most part, the context for a statement or argument will be important in the chapters on critical thinking, when we are pursing the study of logic for practical reasons. In the chapters on formal logic, context is less important, and we will be more likely to skip it.

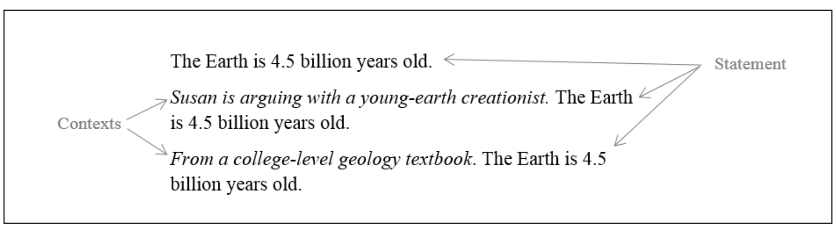

Figure 3: A statement in different contexts, or no context.

"Statements" in this text will *not* include questions, commands, exclamations, or sentence fragments. Someone who asks a *question* like "Does the grass need to be mowed?" is typically not claiming that anything is true or false. *Questions* do not count as statements, but *answers* usually will. "What is this course about?" is not a statement. An answer to that question such as "No one knows what this course is about," is a statement.

For the same reason *commands* do not count as statements for us. If someone bellows "Mow the grass, now!" they are not saying whether the grass has been mowed or not. You might infer that they believe the lawn has not been mowed, but then again maybe they think the lawn is fine and just want to see you exercise.

An exclamation like "Ouch!" is also neither true nor false. On its own, it is not a statement. We will treat "Ouch, I hurt my toe!" as meaning the same thing as "I hurt my toe." The "ouch" does not add anything that could be true or false.

Finally, a lot of possible strings of words will fail to qualify as statements simply because they don't form a complete sentence. In your composition classes, these were probably referred to as sentence fragments. This includes strings of words that are parts of sentences, such as noun phrases like "The tall man with the hat" and verb phrases, like "ran down the hall." Phrases like these are missing something they need to make a claim about the world. The class of sentence fragments also includes completely random combinations of words, like "The up if blender route," which don't even have the form of a statement about the world.

Other logic textbooks describe the components of argument as "propositions," or "assertions," and we will use these terms sometimes as well. There is actually a great deal of disagreement about what the differences between all of these things are and which term is best used to describe parts of arguments. However, none of that makes a difference for this textbook. Some textbooks will also use the term "sentence" here. We will not use the word "sentence" to mean the same thing as "statement." Instead, we will use "sentence" the way it is used in ordinary grammar, to refer generally to statements, questions, and commands.

Sometimes the outward form of a speech act does not match how it is actually being used. A rhetorical question, for instance, has the outward form of a question, but is really a statement or a command. If someone says "don't you think the lawn needs to be mowed?" they may actually mean a statement like "the lawn needs to be mowed" or a command like "mow the lawn, now." Similarly one might disguise a command as a statement. "You will respect my authority" *is* either true or false—either you will or you will not. But the speaker may intend this as an order—"Respect me!"—rather than a prediction of how you will behave.

When we study argument, we need to express things as statements, because arguments are composed of statements. Thus if we encounter a rhetorical question while examining an argument, we need to convert it into a statement. "Don't you think the lawn needs to be mowed" will become "the lawn needs to be mowed." Similarly, commands will become should statements. "Mow the lawn, now!" will need to be transformed into "You should mow the lawn."

The latter kind of change will be important in critical thinking, because critical thinking often studies arguments whose goal is to an get audience to do something. These are called PRACTICAL ARGUMENTS. Most advertising and political speech consists of practical arguments, and these are crucial topics for critical thinking.

Once we have a collection of statements, we can use them to build arguments. An ARGUMENT is a connected series of statements designed to convince an audience of another statement. Here an audience might be a literal audience sitting in front of you at some public speaking engagement. Or it might be the readers of a book or article. The audience might even be yourself as you reason your way through a problem. Let's start with an example of an argument given to an external audience. This passage is from an essay by Peter Singer called "Famine, Affluence, and Morality" in which he tries to convince people in rich nations that they need to do more to help people in poor nations who are experiencing famine.

> *A contemporary philosopher writing in an academic journal.* If it is in our power to prevent something bad from happening, without thereby sacrificing anything of comparable moral importance, we ought, morally, to do so. Famine is something bad, and it can be prevented without sacrificing anything of comparable moral importance. So, we ought to prevent famine. **Singer1972**

Singer wants his readers to work to prevent famine. This is represented by the last statement of the passage, "we ought to prevent famine," which is called the conclusion of the passage. The CONCLUSION of an argument is the statement that the argument is trying to convince the audience of. The statements that do the convincing are called the PREMISES. In this case, the argument has three premises: (1) "If it is in our power to prevent something bad from happening, without thereby sacrificing anything of comparable moral importance, we ought, morally, to do so"; (2) "Famine is something bad"; and (3) "it can be prevented without sacrificing anything of comparable moral importance."

Now let's look at an example of internal reasoning.

> *Jack arrives at the track, in bad weather.* There is no one here. I guess the race is not happening.

In the passage above, the words in *italics* explain the context for the reasoning, and the words in regular type represent what Jack is actually thinking to himself. (We will talk more about his way of representing reasoning in section **??**, below.) This passage again has a premise and a conclusion. The premise is that no one is at the track, and the conclusion is that the race was canceled. The context gives another reason why Jack might believe the race has been canceled, the weather is bad. You could view this as another premise—it is very likely a reason Jack has come to believe that the race is canceled. In general, when you are looking at people's internal reasoning, it is often hard to determine what is actually working as a premise and what is just working in the background of their unconscious.

When people give arguments to each other, they typically use words like "therefore" and "because." These are meant to signal to the audience that what is coming is either a premise or a conclusion in an argument. Words and phrases like "because" signal that a premise is coming, so we call these PREMISE INDICATORS. Similarly, words and phrases like "therefore" signal a conclusion and are called CONCLUSION INDICATORS. The argument from Peter Singer (on page 16) uses the conclusion indicator word, "so." Table 2 is an incomplete list of indicator words and phrases in English.

Table 2: Premise and Conclusion Indicators.

Premise Indicators:	because, as, for, since, given that, for the reason that
Conclusion Indicators:	therefore, thus, hence, so, consequently, it follows that, in conclusion, as a result, then, must, accordingly, this implies that, this entails that, we may infer that

The two passages we have looked at in this section so far have been simply presented as quotations. But often it is extremely useful to rewrite arguments in a way that makes their logical structure clear. One way to do this is to use something called "canonical form." An argument written in CANONICAL FORM has each premise numbered and written on a separate line. Indicator words and other unnecessary material should be removed from the premises. Although you can shorten the premises and conclusion, you need to be sure to keep them all complete sentences with the same meaning, so that they can be true or false. The argument from Peter Singer, above, looks like this in canonical form:

(C1) If we can stop something bad from happening, without sacrificing anything of comparable moral importance, we ought to do so.
(C2) Famine is something bad.
(C3) Famine can be prevented without sacrificing anything of comparable moral importance.
(C4) $\therefore$ We ought to prevent famine.

Each statement has been written on its own line and given a number. The statements have been paraphrased slightly, for brevity, and the indicator word "so" has been removed. Also notice that the "it" in the third premise has been replaced by the word "famine," so that statements reads naturally on its own.

Similarly, we can rewrite the argument Jack gives at the racetrack, on page 16, like this:

Notice that we did not include anything from the part of the passage

(D1) There is no one at the race track.
(D2) ∴ The race is not happening.

in italics. The italics represent the context, not the argument itself. Also, notice that the "I guess" has been removed. When we write things out in canonical form, we write the content of the statements, ignore information about the speaker's mental state, like "I believe" or "I guess."

One of the first things you have to learn to do in logic is to identify arguments and rewrite them in canonical form. This is a foundational skill for everything else we will be doing in this text, so we are going to run through a few examples now, and there will be more in the exercises. The passage below is paraphrased from the ancient Greek philosopher Aristotle.

> *An ancient philosopher, writing for his students* Again, our observations of the stars make it evident that the earth is round. For quite a small change of position to south or north causes a manifest alteration in the stars which are overhead. (**Aristotle:heavens**, 298a2-10)

The first thing we need to do to put this argument in canonical form is to identify the conclusion. The indicator words are the best way to do this. The phrase "make it evident that" is a conclusion indicator phrase. He is saying that everything else is *evidence* for what follows. So we know that the conclusion is that the earth is round. "For" is a premise indicator word—it is sort of a weaker version of "because." Thus the premise is that the stars in the sky change if you move north or south. In canonical form, Aristotle's argument that the earth is round looks like this.

(E1) There are different stars overhead in the northern and southern parts of the earth.
(E2) ∴ The earth is spherical in shape.

That one is fairly simple, because it just has one premise. Here's another example of an argument, this time from the book of Ecclesiastes in the Bible. The speaker in this part of the bible is generally referred to as The Preacher, or in Hebrew, Koheleth. In this verse, Koheleth uses both a premise indicator and a conclusion indicator to let you know he is giving reasons for enjoying life.

> *The words of the Preacher, son of David, King of Jerusalem* There is something else meaningless that occurs on earth: the righteous who get what the wicked deserve, and the wicked who get what the righteous deserve. . . . So I commend the enjoyment of life, because there is nothing better for a person under the sun than to eat and drink and be glad. (Ecclesiastes 8:14-15, New International Version)

Koheleth begins by pointing out that good things happen to bad people and bad things happen to good people. This is his first premise. (Most Bible teachers provide some context here by pointing that that the ways of God are mysterious and this is an important theme in Ecclesiastes.) Then Koheleth gives his conclusion, that we should enjoy life, which he marks with the word "so." Finally he gives an extra premise, marked with a "because," that there is nothing better for a person than to eat and drink and be glad. In canonical form, the argument would look like this.

(F1) Good things happen to bad people and bad things happen to good people.

(F2) There is nothing better for people than to eat, to drink and to enjoy life.

(F3) $\therefore$ You should enjoy life.

Notice that in the original passages, Aristotle put the conclusion in the first sentence, while Koheleth put it in the middle of the passage, between two premises. In ordinary English, people can put the conclusion of their argument where ever they want. However, when we write the argument in canonical form, the conclusion goes last.

Unfortunately, indicator words aren't a perfect guide to when people are giving an argument. Look at this passage from a newspaper:

> *From the general news section of a national newspaper* The new budget underscores the consistent and paramount importance of tax cuts in the Bush philosophy. His first term cuts affected more money than any other initiative undertaken in his presidency, including the costs thus far of the war in Iraq. All told, including tax incentives for health care programs and the extension of other tax breaks that are likely to be taken up by Congress, the White House budget calls for nearly $300 billion in tax cuts over the next five years, and $1.5 trillion over the next 10 years. (**Toner2006**)

Although there are no indicator words, this is in fact an argument. The writer wants you to believe something about George Bush: tax cuts are his number one priority. The next two sentences in the paragraph give you reasons to believe this. You can write the argument in canonical form like this.

The ultimate test of whether something is an argument is simply whether some of the statements provide reason to believe another one of the statements. If some statements support others, you are looking at an argument. The speakers in these two cases use indicator phrases to let you know they are trying to give an argument.

A final bit of terminology for this section. An INFERENCE is the act of coming to believe a conclusion on the basis of some set of premises. When Jack in the example above saw that no one was at the track, and came to

(G1) Bush's first term cuts affected more money than any other initiative undertaken in his presidency, including the costs thus far of the war in Iraq.

(G2) The White House budget calls for nearly $300 billion in tax cuts over the next five years, and $1.5 trillion over the next 10 years.

(G3) $\therefore$ Tax cuts are of consistent and paramount importance of in the Bush philosophy.

believe that the race was not on, he was making an inference. We also use the term inference to refer to the connection between the premises and the conclusion of an argument. If your mind moves from premises to conclusion, you make an inference, and the premises and the conclusion are said to be linked by an inference. In that way inferences are like argument glue: they hold the premises and conclusion together.

Arguments and Nonarguments

We just saw that arguments are made of statements. However, there are lots of other things you can do with statements. Part of learning what an argument is involves learning what an argument is not, so in this section and the next we are going to look at some other things you can do with statements besides make arguments.

The list below of kinds of nonarguments is not meant to be exhaustive: there are all sorts of things you can do with statements that are not discussed. Nor are the items on this list meant to be exclusive. One passage may function as both, for instance, a narrative and a statement of belief. Right now we are looking at real world reasoning, so you should expect a lot of ambiguity and imperfection.

Simple Statements of Belief

An argument is an attempt to persuade an audience to believe something, using reasons. Often, though, when people try to persuade others to believe something, they skip the reasons, and give a SIMPLE STATEMENT OF BELIEF. This is a kind of nonargumentative passage where the speaker simply asserts what they believe without giving reasons. Sometimes simple statements of belief are prefaced with the words "I believe," and sometimes they are not. A simple statements of belief can be a profoundly inspiring way to change people's hearts and minds. Consider this passage from Dr. Martin Luther King's Nobel acceptance speech.

> I believe that even amid today's mortar bursts and whining bullets, there is still hope for a brighter tomorrow. I believe that wounded justice, lying prostrate on the blood-flowing streets of our nations, can be lifted from

> this dust of shame to reign supreme among the children of men. I have the audacity to believe that peoples everywhere can have three meals a day for their bodies, education and culture for their minds, and dignity, equality and freedom for their spirits. (**King2001**)

This actually is a part of a longer passage that consists almost entirely of statements that begin with some variation of "I believe."It is incredibly powerful oration, because the audience, feeling the power of King's beliefs, comes to share in those beliefs. The language King uses to describe how he believes is important, too. He says his belief in freedom and equality requires audacity, making the audience feel his courage and want to share in this courage by believing the same things.

These statements are moving, but they do not form an argument. None of these statements provide evidence for any of the other statements. In fact, they all say roughly the same thing, that good will triumph over evil. So the study of this kind of speech belongs to the discipline of rhetoric, not of logic.

Expository Passages

Perhaps the most basic use of a statement is to convey information. Often if we have a lot of information to convey, we will sometimes organize our statements around a theme or a topic. Information organized in this fashion can often appear like an argument, because all of the statements in the passage relate back to some central statement. However, unless the other statements are given as reasons to believe the central statement, the passage you are looking at is not an argument. Consider this passage:

> *From a college psychology textbook.* Eysenck advocated three major behavior techniques that have been used successfully to treat a variety of phobias. These techniques are modeling, flooding, and systematic desensitization. In **modeling** phobic people watch nonphobics cope successfully with dreaded objects or situations.In **flooding** clients are exposed to dreaded objects or situations for prolonged periods of time in order to extinguish their fear. In contrast to flooding, **systematic desensitization** involves gradual, client-controlled exposure to the anxiety eliciting object or situation. (Adapted from Ryckman **Ryckman2007**)

We call this kind of passage an expository passage. In an EXPOSITORY PASSAGE, statements are organized around a central theme or topic statement. The topic statement might look like a conclusion, but the other statements are not meant to be evidence for the topic statement. Instead, they elaborate on the topic statement by providing more details or giving examples. In the passage above, the topic statement is "Eysenck advocated three major behavioral techniques . . . ." The statements describing these techniques elaborate on the topic statement, but they are not evidence for it. Although the audience may not have known this fact about Eysenk before reading the passage, they will typically accept the truth of this statement instantly, based on the textbook's authority. Subsequent statements in the passage merely provide detail.

Deciding whether a passage is an argument or an expository passage is complicated by the fact that sometimes people argue by example:

Steve:	Kenyans are better distance runners than everyone else.
Monica:	Oh come on, that sounds like an exaggeration of a stereotype that isn't even true.
Steve:	What about Dennis Kimetto, the Kenyan who set the world record for running the marathon? And you know who the previous record holder was: Emmanuel Mutai, also Kenyan.

Here Steve has made a general statement about all Kenyans. Monica clearly doubts this claim, so Steve backs it up with some examples that seem to match his generalization. This isn't a very strong way to argue: moving from two examples to statement about all Kenyans is probably going to be a kind of bad argument known as a hasty generalization. (This mistake is covered in the complete version of this text in the chapter on induction Chapter **??** on induction.) The point here however, is that Steve is just offering it as an argument.

The key to telling the difference between expository passages and arguments by example is whether there is a conclusion that they audience needs to be convinced of. In the passage from the psychology textbook, "Eysenck advocated three major behavioral techniques" doesn't really work as a conclusion for an argument. The audience, students in an introductory psychology course, aren't likely to challenge this assertion, the way Monica challenges Steve's overgeneralizing claim.

Context is very important here, too. The Internet is a place where people argue in the ordinary sense of exchanging angry words and insults. In that context, people are likely to actually give some arguments in the logical sense of giving reasons to believe a conclusion.

Narratives

Statements can also be organized into descriptions of events and actions, as in this snippet from book V of *Harry Potter.*

> But she [Hermione] broke off; the morning post was arriving and, as usual, the *Daily Prophet* was soaring toward her in the beak of a screech owl, which landed perilously close to the sugar bowl and held out a leg. Hermione pushed a Knut into its leather pouch, took the newspaper, and scanned the front page critically as the owl took off again. (**Rowling2003**)

We will use the term NARRATIVE loosely to refer to any passage that gives a sequence of events or actions. A narrative can be fictional or nonfictional. It can be told in regular temporal sequence or it can jump around, forcing the audience to try to reconstruct a temporal sequence. A narrative can describe a short sequence of actions, like Hermione taking a newspaper from an owl, or a grand sweep of events, like this passage about the rise and fall of an empire in the ancient near east:

> The Guti were finally expelled from Mesopotamia by the Sumerians of Erech (*c.* 2100), but it was left to the kings of Ur's famous third dynasty to re-establish the Sargonoid frontiers and write the final chapter of the Sumerian History. The dynasty lasted through the twenty first century at the close of which the armies of Ur were overthrown by the Elamites and Amorites (**McEvedy1967**).

This passage does not feature individual people performing specific actions, but it is still united by character and action. Instead of Hermione at breakfast, we have the Sumarians in Mesopotamia. Instead of retrieving a message from an owl, the conquer the Guti, but then are conquered by the Elamites and Amorites. The important thing is that the statements in a narrative are not related as premises and conclusion. Instead, they are all events which are united common characters acting in specific times and places.

Key Terms

1. **Argument**
2. **Canonical form**
3. **Conclusion**
4. **Conclusion indicator**
5. **Content neutrality**
6. **Critical thinker**
7. **Critical thinking**
8. **Explanation**
9. **Expository passage**
10. **Formal logic**
11. **Inference**
12. **Informal logic**
13. **Logic**
14. **Metacognition**
15. **Metareasoning**
16. **Narrative**
17. **Practical argument**
18. **Premise**
19. **Premise indicator**
20. **Reason**
21. **Rhetoric**
22. **Simple statement of belief**
23. **Statement**
24. **Target proposition**

The Basics of Evaluating Argument

Two Ways an Argument Can Go Wrong

Arguments are supposed to lead us to the truth but they don't always succeed. There are two ways that arguments can fail to lead us to true conclusions. First, they can simply start off with false premises. Consider the following argument:

(H1) It is raining heavily.
(H2) If it is raining heavily, then you should take an umbrella.
(H3) $\therefore$ So, you should take an umbrella.

If premise (1) is false—if it is sunny outside—then the argument gives you no reason to carry an umbrella. The argument has failed its job. Premise (2) could also be false: Even if it is raining outside, you might not need an umbrella. You might wear a rain poncho or keep to covered walkways and still avoid getting soaked. Again, the argument fails because a premise is false. An argument with false premises can not lead us to a true conclusion.

Even if an argument has all true premises, there is still a second way it can fail. Consider another example:

(I1) You are reading this book.
(I2) Most people who read this book are logic students.
(I3) $\therefore$ You are a logic student.

This is not a terrible argument. The premises are true. Most people who read this book *are* logic students. Yet, it is possible for someone besides a logic student to read this book. If your friend who is not currently in a logic class read this book, they would not immediately become a logic student. So the premises of this argument, even though they are true, do not guarantee the truth of the conclusion. The evidential support between premises and conclusion is not a guarantee. This criterion is about the *structure* of the argument, and how the premises and the conclusion are related to one another. There are better and worse ways that the premises of an argument can supply evidential support to its conclusion. Compare the example above with this one:

(J1) You are reading this book.
(J2) At least one person reading this book is a professional surfer.
(J3) ∴ You are a professional surfer.

This argument should strike you as substantially worse than the previous one, even if you really are a professional surfer! Suppose the premises are both true. It still would seem pretty unlikely that the premises are very good reason to think that the conclusion is true. Just because there's at least one professional surfer who read this book, it doesn't follow that that person is you. Even though both of these arguments fail to guarantee their conclusions, one does seem better than the other. We'll be discussing why some arguments that fail this second citerion may still be worthwhile arguments.

To sum up, for any argument there are two ways that it could fail. First, one or more of the premises might be false. Second, the premises might fail to support the conclusion. Even if the premises were true, the form of the argument might be weak, meaning that there is little to no evidential support from premises to conclusion.

Validity and Soundness

In logic, we are mostly concerned with evaluating the quality of inferences, not the truth of the premises. The truth of various premises will be a matter of whatever specific topic we are arguing about and since logic is content neutral we will also remain neutral.

The strongest possible evidential support would be for the premises to somehow force the conclusion to be true. This kind of inference is called VALID. Lets make this notion a bit more precise:

An argument is valid if and only if it is impossible for the premises to be true and the conclusion false.

The important thing to see is that the definition is about what *would* happen if the premises were true. It doesn't state that the premises actually *are* true. This is why our definition is about what is possible or impossible. The argument is valid if, when you imagine the premises are true, you are somehow forced into imagining that the conclusion is also true. Consider the argument in Figure **??**

The American pop star Lady Gaga is not from Mars. (She's from New York City.) Nevertheless, if you grant that she is from Mars, you *also* have to grant that she is from the fourth planet from our sun, because Mars simply is the fourth planet form our sun. Therefore this argument is valid.

(K1) Lady Gaga is from Mars.

(K2) ∴ Lady Gaga is from the fourth planet from our sun.

This way of understanding validity is based on what you can imagine, but not everyone is convinced that the imagination is a reliable tool in logic. That is why definitions like **??** and **??** talk about what is necessary or impossible. If the premises are true, the conclusion necessarily must be true. Alternately, it is impossible for the premises to be true and the conclusion false. The idea here is that instead of talking about the imagination, we will just talk about what can or cannot happen at the same time. The fundamental notion of validity remains the same, however: the truth of the premises would simply guarantee the truth of conclusion.

So, assessing validity means wondering about whether the conclusion would be true *if* the premises were true. This means that valid arguments can have false conclusions. This is important to keep in mind because people naturally tend to think that any argument must be good if they agree with the conclusion. And the more passionately people believe in the conclusion, the more likely we are to think that any argument for it must be brilliant. Conversely, if the conclusion is something we don't believe in, we naturally tend to think the argument is poor. And the more we don't like the conclusion, the less likely we are to like the argument.

But this is not the correct way to evaluate inferences at all. The quality of the inference is entirely independent of the truth of the conclusion. You can have great arguments for false conclusions and horrible arguments for true conclusions. We have trouble seeing this because of biases built deep in the way we think called "cognitive biases." A COGNITIVE BIAS is a habit of reasoning that can be dysfunctional in certain circumstances. Generally these biases developed for a reason, so they serve us well in many or most circumstances. But cognitive biases also systematically distort our reasoning in other circumstances, so we must be on guard against them.

There is a particular cognitive bias that makes it hard for us to recognize when a poor argument is being given for a conclusion we agree with. It is called "confirmation bias" and it is in many ways the mother of all cognitive biases. CONFIRMATION BIAS is the tendency to discount or ignore evidence and arguments that contradict one's current beliefs. It really pervades all of our thinking, right down to our perceptions.

Because of confirmation bias, we need to train ourselves to recognize valid arguments for conclusions we think are false. Remember, an argument is valid if it is impossible for the premises to be true and the conclusion false. This means that you can have valid arguments with false conclusions, they just have to also have false premises. Consider the example in Figure **??**

(L1) Oranges are either fruits or musical instruments.
(L2) Oranges are not fruits.
(L3) ∴ Oranges are musical instruments.

The conclusion of this argument is ridiculous. Nevertheless, it follows validly from the premises. This is a valid argument. *If* both premises were true, *then* the conclusion would necessarily be true.

This shows that a valid argument does not need to have true premises or a true conclusion. Conversely, having true premises and a true conclusion is not enough to make an argument valid. Consider the example in Figure **??**

(M1) London is in England.
(M2) Beijing is in China.
(M3) ∴ Paris is in France.

The premises and conclusion of this argument are, as a matter of fact, all true. This is a terrible argument, however, because the premises have nothing to do with the conclusion. Imagine what would happen if Paris declared independence from the rest of France. Then the conclusion would be false, even though the premises would both still be true. Thus, it is *logically possible* for the premises of this argument to be true and the conclusion false. The argument is not valid. If an argument is not valid, it is called INVALID. As we shall see, this term is a little misleading, because less than perfect arguments can be very useful. But before we do that, we need to look more at the concept of validity.

In general, then, the *actual* truth or falsity of the premises, if known, do not tell you whether or not an inference is valid. There is one exception: when the premises are true and the conclusion is false, the inference cannot be valid, because valid reasoning can only yield a true conclusion when beginning from true premises.

Figure **??** has another invalid argument:

(N1) All dogs are mammals.
(N2) All dogs are animals.
(N3) ∴ All animals are mammals.

In this case, we can see that the argument is invalid by looking at the truth of the premises and conclusion. We know the premises are true. We know that the conclusion is false. This is the one circumstance that a valid argument is supposed to make impossible.

Some invalid arguments are hard to detect because they resemble valid arguments. Consider the one in Figure **??**

(O1) An economic stimulus package will allow the U.S. to avoid a depression.
(O2) There is no economic stimulus package
(O3) ∴ [.3] The U.S. will go into a depression.

This reasoning is not valid since the premises do not *definitively* support the conclusion. To see this, assume that the premises are true and then ask, "Is it possible that the conclusion could be false in such a situation?". There is no inconsistency in taking the premises to be true without taking the conclusion to be true. The first premise says that the stimulus package will allow the U.S. to avoid a depression, but it does not say that a stimulus package is the *only* way to avoid a depression. Thus, the mere fact that there is no stimulus package does not necessarily mean that a depression will occur.

When an argument resembles a good argument but is actually a bad one, we say it is a .FALLACY. Fallacies are similar to cognitive biases, in that they are ways our reasoning can go wrong. Fallacies, however, are always mistakes you can explicitly lay out as arguments in canonical form, as above.

Here is another, trickier, example. I will give it first in ordinary language.

> *A pundit is speaking on a cable news show* If the U.S. economy were in recession and inflation were running at more than 4%, then the value of the U.S. dollar would be falling against other major currencies. But this is not happening — the dollar continues to be strong. So, the U.S. is not in recession.

The conclusion is "The U.S. economy is not in recession." If we put the argument in canonical form, it looks like figure **??**

(P1) If the U.S. were in a recession with more than 4% inflation, then the dollar would be falling.
(P2) The dollar is not falling.
(P3) ∴ The U.S. is not in a recession.

The conclusion does not follow necessarily from the premises. It does follow necessarily from the premises that (i) the U.S. economy is not in recession or (ii) inflation is running at more than 4%, but they do not guarantee (i) in particular, which is the conclusion. For all the premises say, it is possible that the U.S. economy is in recession but inflation is less than 4%. So, the inference does not *necessarily* establish that the U.S. is not in recession. A parallel inference would be "Jack needs eggs and milk to make an omelet. He can't make an omelet. So, he doesn't have eggs.".

If an argument is not only valid, but also has true premises, we call it SOUND. "Sound" is the highest compliment you can pay an argument. If logic is the study of virtue in argument, sound arguments are the most virtuous. We said in Section I that there were two ways an argument could go wrong, either by having false premises or weak inferences. Sound arguments have true premises and undeniable inferences. If someone gives a sound argument in a conversation, you have to believe the conclusion, or else you are irrational.

Valid, but not sound	**Valid and sound**

The argument on the left in Figure **??** is valid, but not sound. The argument on the right is both valid and sound.

Both arguments have the exact same form. They say that a thing belongs to a general category and everything in that category has a certain property, so the thing has that property. Because the form is the same, it is the same valid inference each time. The difference in the arguments is not the validity of the inference, but the truth of the second premise. People are not carrots, therefore the argument on the left is not sound. People are mortal, so the argument on the right is sound.

Often it is easy to tell the difference between validity and soundness if you are using completely silly examples. Things become more complicated with false premises that you might be tempted to believe, as in the argument in Figure **??**.

(S1) Every Irishman drinks Guinness.
(S2) Smith is an Irishman.
(S3) $\therefore$ Smith drinks Guinness.

You might have a general sense that the argument in Figure **??** is bad—you shouldn't assume that someone drinks Guinness just because they are Irish. But the argument is completely valid (at least when it is expressed this way.) The inference here is the same as it was in the previous two arguments. The problem is the first premise. Not all Irishmen drink Guinness, but if they did, and Smith was an Irishman, he would drink Guinness.

The important thing to remember is that validity is not about the actual truth or falsity of the statements in the argument. Instead, it is about the way the premises and conclusion are put together. It is really about the *form* of the argument. A valid argument has perfect logical form. The premises and conclusion have been put together so that the truth of the premises is incompatible with the falsity of the conclusion.

A general trick for determining whether an argument is valid is to try to come up with just one way in which the premises could be true but the conclusion false. If you can think of one (just one! anything at all! but no violating the laws of physics!), the reasoning is *invalid.*

Strong, Cogent, Deductive, Inductive

We have just seen that sound arguments are the very best arguments. Unfortunately, sound arguments are really hard to come by, and when you do find them, they often only prove things that were already quite obvious, like that Socrates (a dead man) is mortal. Fortunately, arguments can still be worthwhile, even if they are not sound. Consider this one:

(T1) In January 1997, it rained in San Diego.
(T2) In January 1998, it rained in San Diego.
(T3) In January 1999, it rained in San Diego.
(T4) ∴ It rains every January in San Diego.

This argument is not valid, because the conclusion could be false even though the premises are true. It is possible, although unlikely, that it will fail to rain next January in San Diego. Moreover, we know that the weather can be fickle. No amount of evidence should convince us that it rains there *every* January. Who is to say that some year will not be a freakish year in which there is no rain in January in San Diego? Even a single counterexample is enough to make the conclusion of the argument false.

Still, this argument is pretty good. Certainly, the argument could be made stronger by adding additional premises: In January 2000, it rained in San Diego. In January 2001... and so on. Regardless of how many premises we add, however, the argument will still not be deductively valid. Instead of being valid, this argument is strong. An argument is STRONG if the premises would make the conclusion more likely, were they true. In a strong argument, the premises don't guarantee the truth of the conclusion, but they do make it a good bet. If an argument is strong, and it has true premises, we say that it is COGENT Cogency is the equivalent of soundness in strong arguments. If an inference is neither valid, nor strong, we say it is WEAK. In a weak argument, the premises would not even make the conclusion likely, even if they were true.

You may have noticed that the word "likely" is a little vague. How likely do the premises have to make the conclusion before we can count the argument as strong? The answer is a very unsatisfying "it depends." It depends on what is at stake in the decision to believe the conclusion. What happens if you are wrong? What happens if you are right? The phrase "make the conclusion a good bet" is really quite apt. Whether something is a good bet depends a lot on how much money is at stake and how much you are willing to lose. Sometimes people feel comfortable taking a bet that has a 50% chance of doubling their money, sometimes they don't.

The vagueness of the word "likely" brings out an interesting feature of strong arguments: some strong arguments are stronger than others. The argument about rain in San Diego, above, has three premises referring to three previous Januaries. The argument is pretty strong, but it can become stronger if we go back farther into the past, and find more years where it rains in January. The more evidence we have, the better a bet the conclusion is. Validity is not like this. Validity is a black-or-white matter. You either have it, and you're perfect, or you don't, and you're nothing. There is no point in adding premises to an argument that is already valid.

Arguments that are valid, or at least try to be, are called DEDUCTIVE , and people who attempt to argue using valid arguments are said to be arguing *deductively.* The notion of validity we are using here is, in fact, sometimes called *deductive validity.* Deductive argument is difficult, because, as we said, in the real world sound arguments are hard to come by, and people don't always recognize them as sound when they find them. Arguments that purport to merely be strong rather than valid are called INDUCTIVE. The most common kind of inductive argument includes arguments like the one above about rain in San Diego, which generalize from many cases to a conclusion about all cases.

Deduction is possible in only a few contexts. You need to have clear, fixed meanings for all of your terms and rules that are universal and have no exceptions. One can find situations like this if you are dealing with things like legal codes, mathematical systems or logical puzzles. One can also create, as it were, a context where deduction is possible by imagining a universal, exceptionless rule, even if you know that no such rule exists in reality. In the example above about rain in San Diego, we can change the argument from inductive to deductive by adding a universal, exceptionless premise like "It always rains in January in San Diego." This premise is unlikely to be true, but it can make the inference valid. (For more about trade offs between the validity of the inference and the truth of the premise, see the chapter on incomplete arguments in the complete version of this text.

Here is an example in which the context is an artificial code — the tax code:

> *From a the legal code posted on a government website* A tax credit for energy-efficient home improvement is available at 30% of the cost, up to $1,500 total, in 2009 & 2010, ONLY for existing homes, NOT new construction, that are your "principal residence" for Windows and Doors (including sliding glass doors, garage doors, storm doors and storm windows), Insulation, Roofs (Metal and Asphalt), HVAC: Central Air Conditioners, Air Source Heat Pumps, Furnaces and Boilers, Water Heaters: Gas, Oil, & Propane Water Heaters, Electric Heat Pump Water Heaters, Biomass Stoves.

This rule describes the conditions under which a person can or cannot take a certain tax credit. Such a rule can be used to reach a valid conclusion that the tax credit can or cannot be taken.

As another example of an inference in an artificial situation with limited and clearly defined options, consider a Sudoku puzzle. The rules of Sudoku are that each cell contains a single number from 1 to 9, and each row, each column and each 9-cell square contain one occurrence of each number from 1 to 9. Consider the following partially completed board:

5	3			7				
6			1	9	5			
	9	8					6	
8				6				3
4			8		3			1
7				2				6
	6					2	8	
			4	1	9			5
				8			7	9

The following inference shows that, in the first column, a 9 must be entered below the 7:

> The 9 in the first column must go in one of the open cells in the column. It cannot go in the third cell in the column, because there is already a 9 in that 9-cell square. It cannot go in the eighth or ninth cell because each of these rows already contains a 9, and a row cannot contain two occurrences of the same number. Therefore, since there must be a 9 somewhere in this column, it must be entered in the seventh cell, below the 7.

The reasoning in this inference is valid: if the premises are true, then the conclusion must be true. Logic puzzles of all sorts operate by artificially restricting the available options in various ways. This then means that each conclusion arrived at (assuming the reasoning is correct) is necessarily true.

One can also create a context where deduction is possible by imagining a rule that holds without exception. This can be done with respect to any subject matter at all. Speakers often exaggerate the connecting premise in order to ensure that the justificatory or explanatory power of the inference is as strong as possible. Consider Smith's words in the following passage:

Smith: I'm going to have some excellent pizza this evening.

Jones: I'm glad to hear it. How do you know?

Smith: I'm going to Adriatico's. They always make a great pizza.

Here, Smith justifies his belief that the pizza will be excellent — it comes from Adriatico's, where the pizza, he claims, is *always* great: in the past, present and future.

As stated by Smith, the inference that the pizza will be great this evening is valid. However, making the inference valid in this way often means making the general premise false: it's not likely that the pizza is great *every single* time; Smith is overstating the case for emphasis. Note that Smith does not need to use a universal proposition in order to convince Jones that the pizza will *very likely* be good. The inference to the conclusion would be strong (though not valid) if he had said that the pizza is "almost always" great, or that the pizza has been great on all of the many occasions he has been at that restaurant in the past. The strength of the inference would fall to some extent—it would not be guaranteed to be great this evening—but a slightly weaker inference seems appropriate, given that sometimes things go contrary to expectation.

Sometimes the laws of nature make constructing contexts for valid arguments more reasonable. Now consider the following passage, which involves a scientific law:

> Jack is about to let go of Jim's leash. The operation of gravity makes all unsupported objects near the Earth's surface fall toward the center of the Earth. Nothing stands in the way. Therefore, Jim's leash will fall.

(Or, as Spock said in a Star Trek episode, "If I let go of a hammer on a planet that has a positive gravity, I need not see it fall to know that it has in fact fallen.") The inference above is represented in canonical form as follows:

(U1) Jack is about to let go of Jim's leash.
(U2) The operation of gravity makes all unsupported objects near the Earth's surface fall toward the center of the Earth.
(U3) Nothing stands in the way of the leash falling.
(U4) ∴ Jim's leash will fall toward the center of the Earth.

As stated, this argument is valid. That is, if you pretend that they are true or accept them "for the sake of argument", you would *necessarily* also accept the conclusion. Or, to put it another way, there is no way in which you could hold the premises to be true and the conclusion false.

Although this argument is valid, it involves idealizing assumptions similar to the ones we saw in the pizza example. P_2 states a physical law which is about as well confirmed as any statement about the world around us you care to name. However, physical laws make assumptions about the situations they apply to—they typically neglect things like wind resistance. In this case, the idealizing assumption is just that nothing stands in the way of the leash falling. This can be checked just by looking, but this check can go wrong. Perhaps there is an invisible pillar underneath Jack's hand? Perhaps a huge gust of wind will come? These events are much less likely than Adriatico's making a lousy pizza, but they are still possible.

Thus we see that using scientific laws to create a context where deductive validity is possible is a much safer bet than simply asserting whatever exceptionless rule pops into your head. However, it still involves improving the quality of the inference by introducing premises that are less likely to be true.

So deduction is possible in artificial contexts like logical puzzles and legal codes. It is also possible in cases where we make idealizing assumptions or imagine exceptionless rules. The rest of the time we are dealing with induction. When we do induction, we try for strong inferences, where the premises, assuming they are true, would make the truth of the conclusion very likely, though not necessary. Consider the two arguments in Figure **??**

A **strong** argument	A **weak** argument

Note that the premises in neither inference *guarantee* the truth of the conclusion. For all the premises in the first one say, Jack could be one of the 8% of Republicans from Texas who did not vote for Bush; perhaps, for example, Jack soured on Bush, but not on Republicans in general, when Bush served as governor. Likewise for the second; the driver could be one of the 49%.

So, neither inference is valid. But there is a big difference between how much support the premises, if true, would give to the conclusion in the first and how much they would in the second. The premises in the first, assuming they are true, would provide very strong reasons to accept the conclusion. This, however, is not the case with the second: if the premises in it were true then they would give only weak reasons for believing the conclusion. thus, the first is strong while the second is weak.

As we said earlier, there there are only two options with respect to validity—valid or not valid. On the other hand, strength comes in degrees, and sometimes arguments will have percentages that will enable you to exactly quantify their strength, as in the two examples in Figure **??**.

However, even where the degree of support is made explicit by a percentage there is no firm way to say at what degree of support an inference can be classified as strong and below which it is weak. In other words, it is difficult to say whether or not a conclusion is *very likely* to be true. For example, In the inference about whether Jack, a Texas Republican, voted for Bush. If 92% of Texas Republicans voted for Bush, the conclusion, if the premises are granted, would very probably be true. But what if the number were 85%? Or 75%? Or 65%? Would the conclusion very likely be true? Similarly, the second inference involves a percentage greater than 50%, but this does not seem sufficient. At what point, however, would it be sufficient?

In order to answer this question, go back to basics and ask yourself: “If I accept the truth of the premises, would I then have sufficient reason to believe the conclusion?". If you would not feel safe in adopting the conclusion as a belief as a result of the inference, then you think it is weak, that is, you do not think the premises give sufficient support to the conclusion.

Note that the same inference might be weak in one context but strong in another, because the degree of support needed changes. For example, if you merely have a deposit to make, you might accept that the bank is open on Saturday based on your memory of having gone to the bank on Saturday at some time in the past. If, on the other hand, you have a vital mortgage payment to make, you might not consider your memory sufficient justification. Instead, you will want to call up the bank and increase your level of confidence in the belief that it will be open on Saturday.

Most inferences (if successful) are strong rather than valid. This is because they deal with situations which are in some way open-ended or where our knowledge is not precise. In the example of Jack voting for Bush, we know only that 92% of Republicans voted for Bush, and so there is no definitive connection between being a Texas Republican and voting for Bush. Further, we have only statistical information to go on. This statistical information was based on polling or surveying a sample of Texas voters and so is itself subject to error (as is discussed in the chapter on induction in the complete version of this text. A more precise version of the premise might be “92% $\pm$ 3% of Texas Republicans voted for Bush.".

At the risk of redundancy, let’s consider a variety of examples of valid, strong and weak inferences, presented in standard form.

(X1) David Duchovny weighs more than 200 pounds.
(X2) $\therefore$ David Duchovny weighs more than 150 pounds.

The inference here is valid. It is valid because of the number system (here applied to weight): 200 is more than 150. It might be false, as a matter of fact, that David Duchovny weighs more than 200 pounds, and false, as a matter of fact, that David Duchovny weighs more than 150 pounds. But if you *suppose* or *grant* or *imagine* that David Duchovny weighs more than 200 pounds, it would then *have* to be true that David Duchovny weighs more than 150 pounds. Next:

This inference is valid. It is valid because of order of the months in the Gregorian calendar and the placement of the New Year in this system. Next:

As written, this inference is valid. If you accept for the sake of argument that all men are mortal (as the first premise says) and likewise that Professor Pappas is a man (as the second premise says), then you would

(Y1) Armistice Day is November 11th, each year.
(Y2) Halloween is October 31st, each year.
(Y3) ∴ Armistice Day is later than Halloween, each year.

(Z1) All people are mortal.
(Z2) Professor Pappas is a person.
(Z3) ∴ Professor Pappas is mortal.

have to accept also that Professor Pappas is mortal (as the conclusion says). You could not consistently both (i) affirm that all men are mortal and that Professor Pappas is a man and (ii) deny that Professor Pappas is mortal. If a person accepted these premises but denied the conclusion, that person would be making a mistake in logic.

This inference's validity is due to the fact that the first premise uses the word "all". You might, however, wonder whether or not this premise is true, given that we believe it to be true only on our experience of men *in the past*. This might be a case of over-stating a premise, which we mentioned earlier. Next:

(1) In 1933, it rained in Columbus, Ohio on 175 days.
(2) In 1934, it rained in Columbus, Ohio on 177 days.
(3) In 1935, it rained in Columbus, Ohio on 171 days.
(4) ∴ In 1936, it rained in Columbus, Ohio on at least 150 days.

This inference is strong. The premises establish a record of days of rainfall that is well above 150. It is possible, however, that 1936 was exceptionally dry, and this possibility means that the inference does not achieve validity. Next:

This inference is an appeal to a source. In brief, you should think about whether the source is reliable, is biased, and whether the claim is consistent with what other authorities on the subject say. You should apply all these criteria to this argument for yourself. You should ask what issues, if any, the Bible is reliable on. If you believe humans had any role in writing the Bible, you can ask about what biases and agendas they might have had. And you can think about what other sources—religious texts or moral experts—say on this issue. You can certainly find many who disagree. Given the controversial nature of this issue, we will not give our evaluation. We will only encourage you to think it through systematically.

This reasoning is weak. Both premises use the word "some" which doesn't tell you a lot about many professional philosophers published books

(1) The Bible says that homosexuality is an abomination.
(2) ∴ Homosexuality is an abomination.

(1) Some professional philosophers published books in 2007.
(2) Some books published in 2007 sold more than 100,000 copies.
(3) ∴ Some professional philosophers published books in 2007 that sold more than 100,000 copies.

and how many books sold more than 100,000 copies in 2007. This means that you cannot be confident that even one professional philosopher sold more than 100,000 copies. Next:

(1) Lots of Russians prefer vodka to bourbon.
(2) ∴ George Bush was the President of the United States in 2006.

No one (in her right mind) would make an inference like this. It is presented here as an example only: it is clearly weak. It's hard to see how the premise justifies the conclusion to any extent at all.

To sum up this section, we have seen that there are two styles of reasoning, deductive and inductive. The former tries to use valid arguments, while the latter contents itself to give arguments that are merely strong. The section of this book on formal logic will deal entirely with deductive reasoning. Historically, most of formal logic has been devoted to the study of deductive arguments, although many great systems have been developed for the formal treatment of inductive logic. On the other hand, the sections of this book on informal logic and critical thinking will focus mostly on inductive logic, because these arguments are more readily available in the real world.

Key Terms

1. **Cogent**

2. **Cognitive Bias**

3. **Confirmation bias**

4. **Deductive**

5. **Fallacy**

6. **Inductive**

7. **Invalid**

8. **Sound**
9. **Strong**
10. **Valid**
11. **Weak**

Part II

Critical Thinking

Part III

Appendices

Other Symbolic Notation

In the history of formal logic, different symbols have been used at different times and by different authors. Often, authors were forced to use notation that their printers could typeset.

In one sense, the symbols used for various logical constants is arbitrary. There is nothing written in heaven that says that $\sim$ must be the symbol for truth-functional negation. We might have specified a different symbol to play that part. Once we have given definitions for well-formed formulae (wff) and for truth in our logic languages, however, using $\sim$ is no longer arbitrary. That is the symbol for negation in this textbook, and so it is the symbol for negation when writing sentences in our languages SL or QL.

This appendix presents some common symbols, so that you can recognize them if you encounter them in an article or in another book.

Summary of Symbols

negation	$\sim$, $\neg$
conjunction	&, $\wedge$, $\bullet$
disjunction	$\vee$
conditional	$\rightarrow$, $\supset$
biconditional	$\leftrightarrow$, $\equiv$

Negation Two commonly used symbols are the *hoe*, '$\neg$', and the *swung dash*, '$\sim$.' In some more advanced formal systems it is necessary to distinguish between two kinds of negation; the distinction is sometimes represented by using both '$\neg$' and '$\sim$.'

Disjunction The symbol '$\vee$' is typically used to symbolize inclusive disjunction.

Conjunction Conjunction is often symbolized with the *ampersand*, '&.' The ampersand is actually a decorative form of the Latin word 'et' which means 'and'; it is commonly used in English writing. As a symbol in a formal system, the ampersand is not the word 'and'; its meaning is given by the formal semantics for the language. Perhaps to avoid this confusion, some systems use a different symbol for conjunction. For example, '$\wedge$' is a counterpart to the symbol used for disjunction. Sometimes a single dot, '$\cdot$', is used. In some older texts, there is no symbol for conjunction at all; 'A and B' is simply written 'AB.'

Material Conditional There are two common symbols for the material conditional: the *arrow*, '$\rightarrow$', and the *hook*, '$\supset$.'

Material Biconditional The *double-headed arrow*, '$\leftrightarrow$', is used in systems that use the arrow to represent the material conditional. Systems that use the hook for the conditional typically use the *triple bar*, '$\equiv$', for the biconditional.

Quantifiers The universal quantifier is typically symbolized as an upside-down A, '$\forall$', and the existential quantifier as a backwards E, '$\exists$.' In some texts, there is no separate symbol for the universal quantifier. Instead, the variable is just written in parentheses in front of the formula that it binds. For example, 'all x are P' is written $(x)Px$.

In some systems, the quantifiers are symbolized with larger versions of the symbols used for conjunction and disjunction. Although quantified expressions cannot be translated into expressions without quantifiers, there is a conceptual connection between the universal quantifier and conjunction and between the existential quantifier and disjunction. Consider the sentence $\exists xPx$, for example. It means that *either* the first member of the UD is a P, *or* the second one is, *or* the third one is, ... Such a system uses the symbol '$\bigvee$' instead of '$\exists$.'

Polish notation

This section briefly discusses sentential logic in Polish notation, a system of notation introduced in the late 1920s by the Polish logician Jan Łukasiewicz.

Lower case letters are used as sentence letters. The capital letter N is used for negation. A is used for disjunction, K for conjunction, C for the conditional, E for the biconditional. ('A' is for alternation, another name for logical disjunction. 'E' is for equivalence.)

notation of SL	Polish notation
$\sim$	N
$\wedge$	K
$\vee$	A
$\rightarrow$	C
$\leftrightarrow$	E

In Polish notation, a binary connective is written *before* the two sentences that it connects. For example, the sentence $A \wedge B$ of SL would be written Kab in Polish notation.

The sentences $\sim A \rightarrow B$ and $\sim(A \rightarrow B)$ are very different; the main logical operator of the first is the conditional, but the main connective of the second is negation. In SL, we show this by putting parentheses around the conditional in the second sentence. In Polish notation, parentheses are never required. The left-most connective is always the main connective. The first sentence would simply be written $CNab$ and the second $NCab$.

This feature of Polish notation means that it is possible to evaluate sentences simply by working through the symbols from right to left. If you were constructing a truth table for $NKab$, for example, you would first consider the truth-values assigned to b and a, then consider their conjunction, and then negate the result. The general rule for what to evaluate next in SL is not nearly so simple. In SL, the truth table for $\sim(A \wedge B)$ requires looking at A and B, then looking in the middle of the sentence at the conjunction, and then at the beginning of the sentence at the negation. Because the order of operations can be specified more mechanically in Polish notation, variants of Polish notation are used as the internal structure for many computer programming languages.

Part IV

Glossary

Argument A collection of statements, called the premises, that provides evidential support to another statement, called the conclusion. 16

Canonical form A method for representing arguments where each premise is numbered and written on a separate line. The premises are followed by a horizontal bar and then the conclusion. Statements in the argument may be paraphrased for brevity and indicator words are removed. 17

Cogent A property of arguments that holds when the argument is strong and the premises are true. 31

Cognitive bias a habit of reasoning that can become dysfunctional in certain circumstances. Often these biases are not a matter of explicit belief. See also *fallacy* 27

Conclusion The part of an argument that is being provided evidence. 10, 16

Conclusion Indicator A word or phrase such as "therefore" used to indicate that what follows is the conclusion of an argument. 17

Confirmation bias The tendency to discount or ignore evidence and arguments that contradict one's current beliefs. 27

Content neutrality the feature of the study of logic that makes it indifferent to the topic being argued about. If a method of argument is considered rational in one domain, it should be considered rational in any other domain, all other things being equal. 10

Critical thinker A person who has both sharpened their reasoning abilities using metareasoning and deploys those sharpened abilities in real world situations.. 11

Critical thinking The use of metareasoning to improve our reasoning in practical situations. Sometimes the term is also used to refer to the results of this effort at self improvement, that is, reasoning in practical situations that has been sharpened by reflection and metareasoning. 11

Deductive A style of arguing where one attempts to use valid arguments. 32

Expository passage A nonargumentative passage that organizes statements around a central theme or topic statement. 21

Fallacy A common mistake in reasoning. Fallacies are generally conceived of as mistake forms of inference and are generally explained by arguments represented in canonical form. See also *cognitive bias*. 29

Formal logic A way of studying logic that achieves content neutrality by replacing parts of the arguments being studied with abstract symbols. Often this will involve the construction of full formal languages. 11

Inductive A style of arguing where one attempts to use strong arguments. 32

Inference the act of coming to believe a conclusion on the basis of some set of premises. 19

Informal logic The study of arguments given in ordinary language. 11

Invalid A property of arguments that holds when the premises do not force the truth of the conclusion. The opposite of valid. 28

Logic The part of the study of reasoning that focuses on argument. 10

Metacognition Thought processes that are applied to other thought processes See also *metareasoning*. 10

Metareasoning Using reasoning to study reasoning. See also *metacognition*. 10

Narrative A nonargumentative passage that describes a sequence of events or actions. 22

Practical argument An argument whose conclusion is a statement that someone should do something. 15

Premise A statement in an argument that provides evidence for the conclusion. 10, 16

Premise Indicator A word or phrase such as "because" used to indicate that what follows is the premise of an argument. 17

Rhetoric The study of effective persuasion. 12

Simple statement of belief A kind of nonargumentative passage where the speaker simply asserts what they believe without giving reasons. 20

Sound A property of arguments that holds if the argument is valid and has all true premises. 30

Statement A unit of language that can be true or false. 13

Strong A property of arguments which holds when the premises, if true, mean the conclusion must be likely to be true. 31

Truth evaluable A property of some objects (such as bits of language, maps, or diagrams) that means they can be appropriately assessed as either true or false. 13

Valid An argument is valid just in case its premises entail its conclusion. In other words, it is impossible for the premises to be true and the conclusion false. 26

Weak A property of arguments that are neither valid nor strong. In a weak argument, the premises would not even make the conclusion likely, even if they were true. 31