Reasoning: Drawing Deductively Valid Conclusions

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As far as Joan’s opponent was concerned, the debate wasn’t going well. It was clear from the sea of nodding heads and sounds of “uh huh” and “yeah” that Joan was scoring points and convincing the audience; whereas, he seemed to be losing support every time he spoke. He wasn’t surprised; he had been warned. Joan had studied reasoning and now knew how to make people believe anything. Soon she would have everyone convinced that the war was justified and what was wrong was right. The way she’s going, she could probably make people believe that day is right. It certainly wasn’t fair, but what can you expect from someone who studied reasoning?

This fictional vignette was taken from a real-life incident. I was present at a debate where one debater accused the other of cheating by using reasoning. At the time, I thought that this was pretty funny because I had come to think of reasoning as an important critical thinking skill—the sort of skill that you would use to make valid conclusions when dealing with information that is complex and emotional. To the losing side of this debate, it was a trick. Trick, skill, or strategy, reasoning is the best way to decide whom and what to believe.

**LOGICAL AND PSYCHOLOGICAL**

*The trick, of course, is to reason well. It isn’t easy and it isn’t automatic.*

—Kahane (1980, p. 3)

Reasoning is often taken to be the hallmark of the human species. Colloquially, reasoning tells us “what follows what.” When we reason, we use our knowledge about one or more related statements that we can reasonably believe are true to determine if another statement, the conclusion, is true. A conclusion is an inferential belief that is derived from other statements. The ability to reason well is a critical thinking skill that is crucial in science, mathematics, law, forecasting, diagnosing, and just about every other context you can imagine. In fact, I can’t think of an academic or “real-world” context in which the ability to reason well is not of great importance.

Many definitions of the term critical thinking identify reasoning as central to the concept as seen in the definition that was derived from three rounds of rankings by school administrators in the United States. The procedure they used to derive their preferred definition of critical thinking is called the delphi technique, which refers to a method for achieving agreement among experts in some field. In this case, definitions were circulated among all participants three times. They agreed that “critical thinking is . . . cohesive, logical reasoning patterns” (Stahl & Stahl, 1991, p. 84).

**Pragmatism and Logic**

When we reason logically, we are following a set of rules that specify how we “ought to” derive conclusions. Logic is the branch of philosophy that explicitly states the rules for deriving valid conclusions. The laws of logic provide the standard against which we assess the quality of someone’s reasoning (Garnham & Oakhill, 1994). According to logic, a conclusion is valid if it necessarily follows from some statements that are accepted as facts. The factual statements are called premises. Conclusions that are not in accord with the rules of logic are illogical. Although we maintain that the ability for rational, logical thought is unique to humans, all too
often we reach invalid or illogical conclusions. This fact has led Hunt (1982, p. 121) to award "A flunking grade in logic for the world's only logical animal."

Psychologists who study reasoning have been concerned with how people process information in reasoning tasks. The fact is that, in our everyday thinking, the psychological processes quite often are not logical. In a classic paper on the relation between logic and thinking, Henle (1962) noted that even though everyday thought does not generally follow the formal rules of logic, people use their own imperfect rules. If we were not logical, at least some of the time, we wouldn't be able to understand each other, "follow one another's thinking, reach common decisions, and work together" (Henle, 1962, p. 374). To demonstrate this point, stop now and work on one of the problems Henle posed to her subjects in one of her studies:

A group of women were discussing their household problems. Mrs. Shivers broke the ice by saying: "I'm so glad we're talking about these problems. It's so important to talk about things that are in our minds. We spend so much of our time in the kitchen that, of course, household problems are in our minds. So it is important to talk about them." (Does it follow that it is important to talk about them? Give your reasoning.) (p. 370)

Do not go on until you decide if it is valid to conclude that Mrs. Shivers is correct when she says that it is important to talk about household problems. Why did you answer as you did?

When Henle posed this problem to graduate students, she found that some students arrived at the wrong answer (as defined by the rules of logic); whereas others arrived at the right answer for the wrong reasons. Consider the following answer given by one of her subjects: "No. It is not important to talk about things that are in our minds unless they worry us, which is not the case" (p. 370). Where did this subject go wrong? Instead of deciding if the conclusion followed logically from the earlier statements, she added her own opinions about what sorts of things it is important to talk about. Thus, even though the answer is incorrect as evaluated by the standard rules of logic, it is correct by the subject's own rules. Consider this answer: "Yes. It could be very important for the individual doing the talking and possibly to some of those listening, because it is important for people to 'get a load off their chest,' but not for any other reason, unless in the process one or the other learns something new and of value" (p. 370). This time, the participant gave the correct answer, but for the wrong reasons. This participant, like the first one, added her own beliefs to the problem instead of deriving her conclusions solely on the basis of the information presented. Henle has termed this error in reasoning the **failure to accept the logical task**.

It seems that in everyday use of reasoning, we don't determine if a conclusion is valid solely on the basis of the statements we are given. Instead, we alter the statements we're given according to our beliefs and then decide if a conclusion follows from the altered statements. We function under a kind of **personal logic** in which we use our personal beliefs about the world to formulate conclusions about related issues.

Psychologists and philosophers have puzzled over the finding that for some everyday and formal reasoning tasks, most people seem to behave as though they are using the rules of logic, but for other reasoning tasks, there seems to be little evidence that the laws of logic are being followed. In other words, whether most of us appear logical depends on the type of reasoning problem that is being studied. Simon and Kaplan (1989) do not find this state of affairs surprising. They believe that "intelligent behavior is adaptive and hence must take on strikingly different forms in different environments" (p. 38). More recent studies support the conclusion that people have more than one way of reasoning, sometimes following the laws of
logic and sometimes twisting or abandoning them. For example, Rips (2001, p. 133) concluded that “arguments have different roles and purposes, and people assess them differently depending on which purpose they have in mind.”

The word pragmatic refers to anything that is practical. In real life, people have a reason for reasoning, and sometimes the laws of logic are at odds with the setting, consequences, and commonly agreed on reasons and rules for deriving conclusions. As Henle’s participants showed in the previous example, in real life, we add our own beliefs and knowledge to the facts we are given when we determine if a conclusion is supported by the premises. In most everyday settings, this is a pragmatic or practical approach to reasoning problems.

**Inductive and Deductive Reasoning**

*Actual thinking has its own logic; it is orderly, reasonable, reflective.*

—Dewey (1933, p. 75)

A distinction is often made between inductive and deductive reasoning. (See Chapter 6, “Thinking as Hypothesis Testing” for a related discussion of this topic.) In inductive reasoning observations are collected that support or suggest a conclusion. It is a way of projecting information from known examples to the unknown (Heit, 2000). For example, if every person you have ever seen has only one head, you would use this evidence to support the conclusion (or suggest the hypothesis) that everyone in the world has only one head. Of course, you can’t be absolutely certain of this fact. It’s always possible that someone you’ve never met has two heads. If you met just one person with two heads, your conclusion must be wrong. Thus, with inductive reasoning you can never prove that your conclusion or hypothesis is correct, but you can disprove it.

When we reason inductively, we collect facts and use them to provide support or disconfirmation for conclusions or hypotheses. It’s how we discover what the world is like. Lopes (1982) described induction this way: “Scientists do it; lay people do it; even birds and beasts do it. But the process is mysterious and full of paradox . . . induction cannot be justified on logical grounds” (p. 626). We reason inductively both informally in the course of everyday living, and formally in experimental research. For this reason, hypothesis testing is sometimes described as the process of inductive reasoning. When we reason inductively, we generalize from our experiences to create beliefs or expectations. Sometimes inductive reasoning is described as reasoning “up” from particular instances or experiences in the world to a belief about the nature of the world.

In deductive reasoning, we begin with statements known or believed to be true, like “everyone has only one head,” and then conclude or infer that Karen, a woman you’ve never met, will have only one head. This conclusion follows logically from the earlier statement. If we know that it is true that everyone has only one head, then it must also be true that any specific person will have only one head. This conclusion necessarily follows from the belief; if the belief is true, the conclusion must be true. Deductive reasoning is sometimes described as reasoning “down” from beliefs about the nature of the world to particular instances. Rips (1988) argues that deduction is a general-purpose mechanism for cognitive tasks. According to Rips, deduction “enables us to answer questions from information stored in memory, to plan actions according to goals, and to solve certain kinds of puzzles” (p. 117). The notion of “reasoning up” from observations and “reasoning down” from hypotheses is schematically shown in Fig. 4.1.
Although it is common to make a distinction between inductive and deductive reasoning, the distinction may not be a particularly useful description of how people reason in real life. In everyday contexts, we switch from inductive to deductive reasoning in the course of thinking. Our hypotheses and beliefs guide the observations we make, and our observations, in turn, modify our hypotheses and beliefs. Often, this process will involve a continuous interplay of inductive and deductive reasoning. Thinking in real-world contexts almost always involves the use of multiple thinking skills.

**LINEAR ORDERING**

*Reasoning is simply a matter of getting your facts straight.*

—B. F. Anderson (1980, p. 62)
Joel is stronger than Bill, but not as strong as Richard. Richard is stronger than Joel, but not as strong as Donald. Who is strongest and who is second strongest?

Although I’m sure that you’ve never met Joel, Donald, Richard, and Bill, I’m also sure you could answer this question. The premises or statements in this problem give information about the orderly relationship among the terms; hence, it is called a **linear ordering** or **linear syllogism**. Like all deductive reasoning problems, the premises are used to derive valid conclusions—conclusions that must be true if the premises are true. In linear ordering problems, we’re concerned with orderly relationships in which the relationships among the terms can be arranged in a straight-line array.

**Linear Diagrams**

How did you solve the problem about Joel, Donald, Richard, and Bill? Most people work line by line, ordering the people as specified in each line:

“Joel is stronger than Bill, but not as strong as Richard” becomes:

```
Strong
↓  Richard
  ↓  Joel
  ↓  Bill
Not Strong
```
“Richard is stronger than Joel, but not as strong as Donald” adds Donald to the previous representation:

<table>
<thead>
<tr>
<th></th>
<th>Strong</th>
<th></th>
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</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Donald</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Richard</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Joel</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Bill</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Thus, it is easy to “see” that Donald is strongest and Richard is second strongest.

Research with linear syllogisms has shown that people rely, at least in part, on spatial imagery or some sort of spatial representation to answer the question.

Work through the following pairs of linear syllogisms. Try to decide if one member of each pair is easier to solve than the other:

1. A. Julio is smarter than Diana.
   Diana is smarter than Ellen.
   Who is smartest? Julio, Diana, Ellen, or don’t know.

   or

   B. JoAnne is taller than Susan.
   Rebeccah is taller than JoAnne.
   Who is shortest? JoAnne, Susan, Rebeccah, or don’t know.

2. A. Pat is not taller than Jim.
   Jim is shorter than Tiffany.
   Who is tallest? Pat, Jim, Tiffany, or don’t know.

   or

   B. Les is worse than Moshe.
   Harold is worse than Moshe.
   Who is worst? Les, Moshe, Harold, or don’t know.

3. A. Stuart doesn’t run faster than Louis.
   Louis doesn’t run slower than Dena.
   Who is slowest? Stuart, Lois, Dena, or don’t know.

   or

   B. Howard is fatter than Ace.
   Ace is thinner than Kyla.
   Who is thinnest? Howard, Ace, Kyla, or don’t know.

As you worked through these problems, did some seem more difficult to you than others? You probably found problem 1A to be the easiest. Research has shown that when the second term in the first premise is the first term in the second premise (Diana in problem 1A), and when the comparison terms are congruent (smarter, smarter, smartest), the linear ordering is fairly easy to solve. Problem 1B does not follow this simple form. The comparisons are between JoAnne and Susan and Rebeccah and Susan. In addition, the comparison terms are not congruent (taller, taller, shortest). The correct answer is 1A for Julio. The correct answer for 1B is Susan.

Problem 2A contains the negation term “not,” which adds to the complexity of the problem. In addition, information is given in terms of both taller and shorter, which makes this a difficult problem. The correct answer is Tiffany. (Pat could be the same
height or shorter than Jim.) You can represent this relationship graphically as:

Although problem 2B contains all congruent comparison terms (worse, worse, worst), some people find it tricky because we don't know if Les or Harold is worst. In addition, research has shown that it is more difficult to comprehend terms like “worse” than it is to use terms like “better” because it denotes that all three are bad, whereas “better” is a more neutral term. (The correct answer is “don't know.”) Problem 3A contains two negative terms as well as incongruent comparison terms (faster, slower, slowest). From the information given, we can't determine who is slowest. Problem 3B is somewhat easier because it doesn't contain negatives, but it does contain incongruent comparison terms (fatter, thinner, thinnest). The answer as to who is thinnest is Ace.

As you worked through these problems, you should have discovered some of the following psychological principles of linear orderings:

1. Orderings are easiest to solve when comparison terms are congruent (e.g., short, shorter, shortest).
2. Solutions will be facilitated if the second term in the first premise is the first term in the second premise (A is better than B; B is better than C).
3. Negations make the problem more difficult (e.g., A is not hairier than B).
4. Comparisons between adjacent terms (e.g., Julio and Diana in problem 1A) are more difficult than comparisons between end terms (Julio and Ellen) (Potts, 1972).
5. When you are faced with a difficult syllogism of any sort, a good strategy for solving it is to draw a spatial array. With a linear syllogism, draw a linear array, so that the relationships among the terms can be inspected visually.
6. Comparison terms that limit the meaning of a sentence, like worse and dumber, are more difficult to process than more general and neutral terms like better and smarter. The adjectives that connote a bias (e.g., worse, dumber) are called marked adjectives, whereas the neutral adjectives are called unmarked adjectives.

These summary remarks can be used as an aid for clear communication of linearly ordered information. When you want someone to understand a linear ordering, use congruent terms, make the second term in the first premise the first term in the second premise, and avoid negations and marked adjectives. These few rules for communicating linear information show a basic cognitive principle: Negative information (no, not) is more difficult to process than positive information, in part because it seems to place additional demands on working memory (Matlin, 2002). There are many advantages to using diagrams when dealing with verbal information, including reducing the load on working memory and making relationship obvious and visible.
Confusing Truth and Validity

Knowing is only part of being educated, thinking and reasoning with what we know completes it.

—Schauble and Glaser (1990, p. 9)

Logically, the rules for deciding if a conclusion is valid are the same no matter what terms we use. In the first example in this section, I could provide the premise that Donald is stronger than Richard or I could substitute any name that I wanted (Igor is stronger than Yu-Chin or any letter or symbol, C is stronger than A). The truth is not important in these examples, because the premises are treated as though they were true. This probably bothered some of you. Suppose I said,

Your sister is uglier than the wicked witch in the Wizard of Oz.

*You are uglier than your sister.*

Therefore, you are uglier than the wicked witch in the Wizard of Oz.

You’d probably protest this conclusion. You may not even have a sister, but given the premises, the conclusion is valid. Test it for yourself. However, that doesn’t make it true. Chapter 5 will address the issue of determining the truth or believability of the premises. So far, we’ve only considered the question of validity: whether a conclusion must be true if the premises are true. People very often have trouble separating truth from validity. This is particularly difficult when the conclusion runs counter to cherished beliefs or strong emotion.

Although the rules of logic dictate that content is irrelevant to the conclusions we formulate, in most real-life situations, content does influence how we choose valid conclusions. It is possible to construct deductive reasoning problems so that the beliefs most people maintain conflict with logical conclusions. Belief bias or confirmation bias occurs when an individual’s beliefs interfere with her or his selection of the logical conclusion. This effect has been demonstrated many times and is so pervasive that it interferes with good thinking in almost every context (Nickerson, 1998). We all seem to have difficulty in thinking critically when the reasoned conclusion is one that we do not believe to be true. Consider this example, which dates back to 1944 (Morgan & Morton). Obviously, most Americans in 1944 had very strong beliefs about World War II, which clearly influenced their reasoning process. When presented with deductive reasoning problems, Americans were more likely to select conclusions that agreed with their belief biases than conclusions that ran counter to their belief biases.

It should come as no surprise to you that human reasoning becomes illogical when we are discussing emotional issues. This is true for people in every strata of society, even for justices of the United States Supreme Court. When Justice William O. Douglas was new to the Supreme Court, Chief Justice Charles Evans Hughes gave him these words of advice, “You must remember one thing. At the constitutional level where we work, ninety percent of any decision is emotional. The rational part of us supplies the reasons for supporting our predilections” (Hunt, 1982, p. 129). Unfortunately, appellate legal proceedings are sometimes exercises in politics, with decisions changing as frequently as the political climate. Legal “reasoning” has sometimes served as a framework to persuade others that a conclusion is valid. If you understand how to formulate valid inferences, you’ll be able to withstand and recognize its misuse by those who would use it to their advantage.
IF, THEN STATEMENTS

Reason, of course, is weak, when measured against its never-ending task. Weak, indeed, compared with the follies and passions of mankind, which, we must admit, almost entirely control our human destinies, in great things and small.

—Albert Einstein (1879–1955)

If, then statements, like the other examples of reasoning presented in this chapter, use premises that are known or believed to be true to determine if a valid conclusion follows. If, then statements are concerned with contingency relationships—some events are dependent or contingent on the occurrence of others. If the first part of the contingency relationship is true, then the second part must also be true. If, then statements are sometimes called conditional logic or propositional logic. Work through the four following if, then statements. Decide if the third statement is a valid conclusion.

1. If she is rich, she wears diamonds.
   *She is rich.*
   Therefore, she wears diamonds.
   Valid or Invalid?

2. If she is rich, she wears diamonds.
   *She isn’t wearing diamonds.*
   Therefore, she isn’t rich.
   Valid or Invalid?

3. If she is rich, she wears diamonds.
   *She is wearing diamonds.*
   Therefore, she is rich.
   Valid or Invalid?

4. If she is rich, she wears diamonds.
   *She isn’t rich.*
   Therefore, she isn’t wearing diamonds.
   Valid or Invalid?

In each of these problems, the first premise begins with the word if; the then is not explicitly stated, but can be inferred (“then she wears diamonds”). The first part of this premise (“If she is rich”) is called the antecedent; the second part (“she wears diamonds”) is called the consequent.

Tree Diagrams

Like the other types of deductive reasoning problems, conditional statements can be represented with a spatial display. Tree diagrams, diagrams in which the critical information is represented along “branches,” like a tree, are used in several chapters in this book, and can be used to determine validity with if, then deductive reasoning problems. Tree diagrams are very handy representational forms in many situations and are well worth the trouble of learning to use. We will use tree diagrams in
Chapter 7 on understanding likelihood, Chapter 9 on problem solving, and Chapter 10 on creativity.

Tree diagrams are easy to begin. Every tree diagram begins with a “start” point. A start point is a dot on the paper that you label “start.” Everyone finds the first step easy.

- Start

The dots are more formally called nodes, and branches (lines) come out from nodes. The branches represent everything that can happen when you are at that node. In if, then problems, there are two states that are possible from the start node. In this example, either she is rich or she is not rich. There are two possibilities, so there will be two branches coming from the start node. The antecedent is the first event on the “tree” with a second branch representing the consequent. The validity of the conclusion can be determined by examining the branches. Let’s try this with the first problem.

“If she is rich” becomes:

```
<table>
<thead>
<tr>
<th>Rich</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not rich</td>
</tr>
</tbody>
</table>
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“She wears diamonds” is added as a second set of branches by showing that the “rich” node is always followed by “diamonds,” but the “not rich” node may or may not be followed by “diamonds.” We put both possibilities on the branches leading from “not rich” because we are not given any information about the relationship between being “not rich” and “wearing diamonds.”

When we are told that “She is rich,” circle the branch or branches that has this label and move along the branches from the “rich” node and conclude that she “wears diamonds.” There is only one node in this diagram that represents the possibility that she is rich, and this node has only one branch attached from it—the branch that leads to “wears diamonds.” Once you locate the “rich” node, the only possible consequent is “wears diamonds.” Thus, the conclusion to problem number 1 is valid. The technical term for this problem is affirming the antecedent. In this case, the second premise affirms or indicates the antecedent is true; therefore, its consequent is true.

Problem 2 also contains a valid conclusion. The tree diagram is exactly the same as in the first problem because the same if, then statements are made. In determining the validity of the conclusion, we begin with “She isn’t wearing diamonds,” which is represented at only one node, so we trace this back to the “not rich” node. Because
the second premise indicates that the consequent is not true, this sort of problem is technically called **denying the consequent**.

Many people are willing to conclude that problem 3 is also valid when, in fact, it is not. Although it must be assumed to be true that if she is rich, she wears diamonds, it is also possible that poor people wear diamonds. I have found that intelligent college students (and yes, many of their professors also) have difficulty with this problem. Because the second premise states that the consequent has occurred, this sort of problem is called **affirming the consequent**. It is fallacious (i.e., wrong) to believe that because the consequent is true, the antecedent must also be true. "If," in these reasoning problems, doesn’t mean “if and only if,” which is how many people interpret it. Of course, she may be rich, it may even be more likely that she is rich, but we cannot conclude that she is rich just because she is wearing diamonds. You can see this on the tree diagram. There are two different nodes labeled “wears diamonds,” one connected to the “rich” node and one connected to the “not rich” node. We cannot determine which must be true because either is possible.

The fallacy of affirming the consequent is one type of deductive reasoning error called **illicit conversion**. Illicit conversions, in if, then statements occur when people believe that “If A, then B” also means “If B, then A.”

Problem 4 is also invalid, although it is tempting to conclude that if she isn’t rich, she isn’t wearing diamonds. Can you guess the technical term for this sort of problem? It is called **denying the antecedent** because premise 2 states that the antecedent is false. Again, by starting at the “not rich” node, you can see that it is connected to both “wears diamonds” and “doesn’t wear diamonds,” so either is possible.

A summary of these four kinds of reasoning, with examples of each, is shown in Table 4.1.

Several popular advertisements take advantage of people’s tendencies to make invalid inferences from if, then statements. There is a commercial for yogurt that goes something like this:

Some very old people from a remote section of the former Soviet Union are shown. We’re told that it is common for people in this remote region to live to be 110 years old. We’re also told that they eat a great deal of yogurt. The conclusion that the advertisers want people to make is that eating yogurt will make you live 110 years.

**Table 4.1**

<table>
<thead>
<tr>
<th>Antecedent</th>
<th>Consequent</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Affirming the Antecedent</strong></td>
<td><strong>Affirming the Consequent</strong></td>
</tr>
<tr>
<td>Valid Reasoning</td>
<td>Invalid Reasoning</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td><strong>Example:</strong></td>
</tr>
<tr>
<td>If I am dieting, then</td>
<td>If Harry went to the supermarket,</td>
</tr>
<tr>
<td>I will lose weight.</td>
<td>then the refrigerator is full.</td>
</tr>
<tr>
<td>I am dieting.</td>
<td>The refrigerator is full.</td>
</tr>
<tr>
<td><strong>Therefore, I will lose weight.</strong></td>
<td><strong>Therefore, Harry went to the supermarket.</strong></td>
</tr>
<tr>
<td><strong>Denying the Antecedent</strong></td>
<td><strong>Denying the Consequent</strong></td>
</tr>
<tr>
<td>Invalid Reasoning</td>
<td>Valid Reasoning</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td><strong>Example:</strong></td>
</tr>
<tr>
<td>If it is raining, then my hair is wet.</td>
<td>If Judy and Bruce are in love, then they</td>
</tr>
<tr>
<td>It is not raining.</td>
<td>are planning to marry.</td>
</tr>
<tr>
<td><strong>Therefore, my hair is not wet.</strong></td>
<td><strong>Therefore, Judy and Bruce are not in love.</strong></td>
</tr>
</tbody>
</table>
Implicitly, we’re being told that if we eat yogurt, then we’ll live to be 110 years old. Of course, it’s possible to live to be 110 without ever tasting yogurt, and we have no reason to believe that yogurt added years to their lives. There is no basis for making a causal inference for believing that eating yogurt can cause anyone to live a long time. These remote Russians engage in strenuous physical labor most of their lives and do not come into contact with many outsiders who carry potentially contagious diseases. Either of these facts, or countless others, including heredity, could account for their longevity. (It is also possible that the longevity claim is subject to question.) The advertisers are obviously hoping that the viewers will fall prey to the fallacy of affirming the consequent and say to themselves, “If I eat yogurt, I will live to a very old age.”

If, Then Reasoning in Everyday Contexts

In questions of science, the authority of a thousand is not worth the humble reasoning of a single individual.


If, then statements, like linear orderings, appear implicitly in standard prose. Of course, we seldom find them neatly labeled “premise and conclusion.” Yet, they are often the basis for many common arguments. The fallacies of denying the antecedent and affirming the consequent in everyday contexts are quite common.

There is currently an acrimonious debate over the issue of providing junior and senior high school students with contraceptive information. The pro side argues that if students are given this information, then they will act responsibly when engaging in intercourse. Formally, this becomes: If students receive contraceptive information, then they will engage in “protected” intercourse. The con side argues that students should not engage in intercourse (whether protected or not); therefore, they should not receive contraceptive information. This is an example of the fallacy of denying the antecedent. It does not follow that if they are not given contraceptive information, then they will not engage in intercourse.

Here’s another example, virtually verbatim, from this morning’s news. The specific details are not important because examples of this sort probably can be gleaned from the news on any day of the week. Viewers were told that if the president of the United States handled a tense situation with Communist China well, then a tense international situation would be resolved without escalation of hostilities. The situation was resolved well (hostilities did not escalate), so the commentator concluded that the president handled the tense situation well. Of course, it is possible that the information in the if, then statement is really not true, and even if the president did a good job, the situation could get worse. When we reason deductively with the laws of logic, we assume that the propositions are true, so let’s put aside the very real possibility that we should not assume it to be true and apply the principles of if, then reasoning.
When the situation is drawn out in a decision tree, it is easy to see that it could have been resolved well, even if the president had not handled the tense situation well. A point that has been made repeatedly throughout this chapter is that people often do not reason according to the laws of formal logic without instruction in reasoning. This is an example where using the laws of logic would help us understand the situation better.

In everyday (practical) reasoning, we use information that is not stated in the premises in order to decide if the conclusion follows from the premises. One sort of knowledge we rely on is our knowledge about the content of the premises. The following two sentences demonstrate this point (Braine, 1978, p. 19):

If Hitler had had the atomic bomb in 1940, he would have won the war.

and

If Hitler had had one more plane in 1940, he would have won the war.

Although logic dictates that people should be able to reason identically with both of these premises and should avoid the fallacies of affirming the consequent and denying the antecedent, in fact most people find it easier to reason correctly with the first premise than the second. As with all of the forms of deductive reasoning that will be covered in this chapter, the content of the premises and our own belief biases influence the way we determine what sorts of conclusions we are willing to accept as valid. When we interpret if, then statements in everyday contexts, we rely on our knowledge about the content to decide if a conclusion follows. According to the rules of formal logic, we should be able to reason in ways that are independent of content. We should all arrive at identical, logically correct conclusions, no matter what the content is. Of course, humans are not perfect logic machines and there are important individual differences in the sorts of models people use to solve reasoning problems (Bucciarelli & Johnson-Laird, 1999). We do and should determine if the premises are true before deciding if a conclusion follows. (This point will be emphasized in Chapter 5.)

**Negation**

As seen in the previous section on linear reasoning, the use of negatives ("no," "not") in a reasoning problem makes it much more difficult to solve (Wason, 1969). These difficulties are apparent in the following examples in which either the antecedent or consequent is negative.

If the light is not green, I will go to Rome.

*It is not true that the light is not green.*

What, if anything, can you conclude?

If the letter is B, then the number is not 4.

*The number is not 4.*

What, if anything, can you conclude?

These are difficult to deal with because of the use of negation and its affirmation or denial. The first statement denies the negative antecedent (not (not green)). This is called a **double negation**. You can’t assume anything about the consequent when the antecedent is denied, even when the antecedent itself is negative. Look at the
second example. Most people incorrectly decide that it is correct to conclude from the second example that “The letter is B.” You should recognize this as an example of affirming the consequent. If you are having difficulty answering these questions, draw the corresponding tree diagrams, and the answer will “appear.”

I once heard a politician make a statement similar to these. He said, “It is not true that I do not favor the legislation.” It took me a few seconds to realize that he implied that he favored the legislation. He could have meant that he was neutral with respect to the legislation, neither favoring nor opposing it, but in the context, I interpreted his statement to mean that he favored the legislation. This is an example in which I used context to clarify intended meaning. When negative information is given, people take longer to solve reasoning problems and are less accurate, probably because the negative information (not or no) adds to the burden of working memory (Garnham & Oakhill, 1994; Noveck & Politzer, 1998).

**Confirmation Bias**

Confirmation bias, the predilection to seek and utilize information that supports or confirms your hypotheses or premises, can be seen in this classic problem (Johnson-Laird & Wason, 1970):

Four cards are lying face up on a table in front of you. Every card has a letter on one side and a number on the other. Your task is to decide if the following rule is true, “If a card has a vowel on one side, then it has an even number on the other side.” Which card or cards do you need to turn over in order to find out whether the rule is true or false? You may turn over only the minimum number necessary to determine if this rule is true. Please stop now and examine the cards below to determine which ones you would want to turn over. Don’t go on until you have decided which cards you would want to turn over.

![Card Diagram](image)

Few people select the correct cards in this problem, which has become known as the **four-card selection task**. It is a widely studied task that is popular in the literature of cognitive psychology. Most people respond “A only” or “A and 4.” The correct answer is “A and 7.” Can you figure out why? The best way to solve this reasoning problem is to draw a tree diagram that corresponds to the statement, “If a card has a vowel on one side, then it has an even number on the other side.” It should look like this:

![Tree Diagram](image)
If A doesn't have an even number on the other side, the rule is false. Similarly, if 7 has a vowel on the other side, the rule is false. What about D and 4? D is a consonant. It doesn't matter if there is an even or odd number on the back because the rule says nothing about consonants. Because 4 is an even number, it doesn't matter if there is a vowel or consonant on the back. The reason that this is such a difficult problem is that people interpret the rule to also mean "If a card does not have a vowel on one side, then it does not have an even number on the other side" or, without negatives, "If a card has a consonant on one side, then it has an odd number on the other side." These alternate interpretations are incorrect. Do you recognize the error as denying the antecedent? This is a robust (strong) effect. It is an extremely difficult task because of the crucial role of disconfirmation. People fail to appreciate the importance of a falsification strategy. That is, we need to think of ways to show that a hypothesis may be false, instead of looking for evidence that would show that a hypothesis may be correct. This is exacerbated with the incorrect assumption that the converse of the rule is also true. The only correct way to solve this problem is to select only cards that can falsify the rule.

Part of the difficulty people have with this task may be related to the abstract nature of the problem. After all, there is very little we do in our everyday life that relates vowels and even numbers. Try out a more realistic and less abstract version of this task (adapted from Johnson-Laird, Legrenzi, & Legrenzi, 1972):

In order to understand this task, you may need some background information (depending on your age). Many years ago, the United States Post Office had two different postage rates known as first-class and second-class mail. You could pay full postage, which was 5 cents, if you sealed your letter (first class), or you could pay a reduced, 3-cent rate, if you merely folded the flaps closed and didn't seal them (second class). (First-class mail had priority for delivery over second-class mail.)

Suppose you are a postal employee watching letters as they move across a conveyor belt. The rule to be verified or disconfirmed is: "If a letter is sealed, then it has a 5 cent stamp on it." Four letters are shown in Fig. 4.2. Which ones would you have to turn over to decide if the rule is true?

Stop now and work on this problem. Don't go on until you've decided which letters (at a minimum) you would have to turn over to test this rule.

Did you notice that this is the same task that was posed earlier? The correct answer is the first sealed envelope and the last envelope (the one with the 3 cent stamp). This is an easier problem than the more abstract one because people find it easier to understand that a letter that is not sealed could also have a 5 cent stamp on it than it is to understand that if the letter is not a vowel it could also have an even

![Fig. 4.2](image-url) Which of these letters would you turn over to decide if the following rule is true: "If a letter is sealed, then it has a 5-cent stamp on it." (Adapted from Johnson-Laird, Legrenzi, & Legrenzi, 1972.)
number on the back. Your tree diagram should look like this:

![Tree Diagram]

Johnson-Laird and Wason (1977) found that when the problem is presented in this realistic manner, 22 out of 24 subjects were able to solve the problem. Johnson-Laird and Wason concluded that our everyday experiences are relevant in determining how we reason.

Permission and Obligation Schemata

Many researchers have tried to understand why so many people have so much difficulty with the four-card selection task (I also find it very confusing), but have little difficulty when it is rephrased in the stamped-letter example. These are identical problems from the perspective of logic—the rules for reasoning are the same in the two problems.

Cheng and Holyoak (1985) explored the basic differences in how people think about these two problems. They postulated that when people use if, then reasoning for pragmatic purposes, they usually involve either the permission to do something, called permission schema (if something is true, then you have permission to do something else) or they involve an obligation or contractual arrangement, called obligation schema (if something is true, then you have an obligation to do something else). In real life, these are the two most common situations in which people use if, then reasoning. Instead of using the rules of formal logic, people tend to develop abstract general rules that work well in specific situations and help them to achieve their goals. Cheng and Holyoak found that the permission and obligation schemata operate across domains. In other words, it does not matter if the topic concerns stamped letters, an agreement to perform a job, or permission to borrow the car. Here is an example of each:

*If a passenger has been immunized against cholera, then he may enter the country.* (permission schema)

*If you pay me $100,000, then I’ll transfer ownership of this house to you.* (obligation schema)

When if, then statements involve permission or obligation, then people make few reasoning errors. Furthermore, when most people understand the rules of permission and obligation, the content of the statement doesn’t matter—people apply the rules appropriately across domains. Cheng and Holyoak (1985) also found that when they included a rationale for the rule, most of the people they asked to solve this problem had no difficulty with it. In the sealed envelope problem, they added the following rationale for the rule, “The country’s postal regulation requires that if a letter is sealed, then it must carry a 20-cent stamp” (p. 400). Thus, a rule that was
extremely difficult to apply when it was presented in an abstract form was easily used by most people when it was used in a familiar context with an explanation.

If, and Only If

Certain contexts seem to require that we understand them in a way that is inconsistent with the laws of logic. Suppose you are told: “If you mow the lawn, I’ll give you five dollars” (Taplin & Staudenmeyer, 1973, p. 542). This statement invites the interpretation, “If you do not mow the lawn, I won’t give you five dollars.” In the everyday inference we make from language, this is a valid conclusion, although it is erroneous from the perspective of formal logic. In understanding statements of the “If $p$, then $q$” variety, the conclusions that we are willing to accept as valid depend very much on what $p$ and $q$ are. In this lawn-mowing example, the intended meaning is “if, and only if you mow the lawn, then I’ll give you five dollars.” In dealing with real-world if, then statements, you need to decide whether the intended message is “if $p$, then $q$” or “if, and only if $p$, then $q$.” The important point of this example is that context is irrelevant to the laws of logic, which are the same whether you are talking about pay for mowing a lawn or turning over a card to check an abstract rule. It is not surprising that people vary their thinking depending on context because context is important in real-life settings.

Chained Conditionals

We can make things just a little more complicated (just what you were hoping for), by building on if, then statements and making them into longer chains. A chained conditional occurs when two if, then statements are linked so that the consequent of one statement is also the antecedent of the other statement. In skeleton form, or fill-in-the-blank form, this becomes:

If A, then B. If B, then C.

As before, it doesn’t matter what we use to fill in for A, B, and C, if we are reasoning according to the laws of logic. For example, “If Jodi wants to be a physicist, then she will study calculus. If she is studying calculus, then she has a final exam on Wednesday.” With this conditional chain, we can conclude that she has a final exam on Wednesday, if we learn that she wants to be a physicist.

Don’t be tempted to assume that every time you have three terms, you have a chained conditional. Consider this example.

If she wants to be a physicist, then she will study calculus.
If she wants to be a physicist, then she will have an exam on Wednesday.

These are two conditional statements, but they do not have the chained structure because the consequent of one statement is not the antecedent of the other statement.

If, Then Reasoning in Legal Contexts

Consider the sad saga of an American star who was accused of killing his ex-wife and her friend. The specifics of this American tragedy are not relevant because there
are always similar crimes in which the key to the defense or prosecution hinges on if, then reasoning. In this particular case, the suspect had an excellent alibi from 11 p.m. and later on the night of the killing. In other words,

If the murder occurred any time from 11 p.m. or later, the defendant is innocent.

The prosecutor attempted to show that the murder occurred prior to 11 p.m. Suppose that she was successful in convincing the jury that the murder occurred at 10:30. What can we conclude about the guilt or innocence of the defendant?

To make it easier for you, I have drawn the tree diagram that corresponds to this real-life situation.

I hope that you determined that if the murder occurred at 10:30, we do not know if the defendant is guilty or innocent. Unless there is other evidence that "proves beyond a reasonable doubt" that the defendant committed these grisly murders, then the jury must acquit him. They cannot convict a man because of the error of denying the antecedent. If anyone tries to tell you that this critical thinking stuff is a "bunch of bunk" (or some more colorful phrase), then give him or her this example in which misunderstanding could lead to a wrongful conviction. Whom would you want on a jury that decides your guilt or innocence—people who think critically or those who rush to a hasty decision and are easily misled with persuasive techniques?

**COMBINATORIAL REASONING**

_We recognize the gravity of the challenge to get our students to think, to think critically, and even to think scientifically. Certainly it is abundantly clear to me that science education fails if it doesn't tackle the matter of thinking._

—Munby (1982, p. 8)

One approach to enhancing reasoning skills is based on a model of intelligence that was proposed by the Swiss psychologist Jean Piaget. Piaget was primarily concerned with the way people acquire knowledge and the way cognitive processes change throughout childhood and early adulthood. According to Piaget, there are four broad developmental periods (each broken into stages). As people move from infancy into adolescence, their cognitive abilities mature in qualitatively distinct stages culminating with the ability to think in orderly, abstract ways. Piaget's examples of abstract thought involve thinking skills that are needed to understand scientific concepts. One of the scientific reasoning skills that Piaget believed to be important is **combinatorial reasoning**, which is use of systematic and orderly steps
when making combinations so that all possible combinations are formed. Here is a classic task that involves this skill:

**Mixing Colorless Chemicals.** This task involves mixing chemicals until a yellow color is obtained. Suppose that you were given four bottles of odorless, colorless liquids. They appear to be identical except for being labeled 1, 2, 3, and 4. You are also given a fifth beaker labeled $X$, which is the “activating solution.” The activating solution is always needed to obtain the yellow color, which results from a chemical reaction. How would you go about finding which of the chemicals in combination will yield the yellow color?

**Some rules:** The amount of each chemical is not important, nor is the order in which you combine them. It may help you in working on this problem to visualize the materials as presented in Fig. 4.3.

Stop now and think about how you would approach this problem. Do not go on until you have written down all of the tests you would perform.

How did you approach this problem? Did you realize that you needed an organized plan or did you begin by randomly mixing the liquids? The best approach to this task is a very methodical one. It must include mixing each liquid separately with the activating solution ($1 + X$, $2 + X$, $3 + X$, $4 + X$), then carefully mixing two liquids at a time with $X$ ($1 + 2 + X$, $1 + 3 + X$, $1 + 4 + X$, $2 + 3 + X$, $2 + 4 + X$, $3 + 4 + X$), then three at a time with $X$ ($1 + 2 + 3 + X$, $1 + 2 + 4 + X$, $1 + 3 + 4 + X$, $2 + 3 + 4 + X$), then all four at once ($1 + 2 + 3 + 4 + X$), being careful to observe which combinations would yield the yellow color. Look over the way the chemicals were combined in a systematic manner so that no combinations would be missed or duplicated. This technique of systematic combinations will be needed to perform the reasoning tasks in the next section.

**SYLLOGISTIC REASONING**

Nothing intelligible ever puzzles me.
Logic puzzles me.

—Lewis Carroll (1832–1898)
**SYLLOGISTIC REASONING**

Syllogistic reasoning is a form of reasoning that involves deciding whether a conclusion can properly be inferred from two or more statements. One type of syllogistic reasoning is categorical reasoning. Categorical reasoning involves quantifiers or terms that tell us how many. Quantifiers are terms like “all,” “some,” “none,” and “no.” The quantifiers indicate how many items belong in specified categories.

A syllogism usually consists of two statements that are called premises and a third statement called the conclusion. In categorical syllogisms, quantifiers are used in the premises and conclusion. The task is to determine if the conclusion follows logically from the premises.

The premises and conclusion of a syllogism are classified according to mood. (The word mood has a special meaning in this context that is unrelated to its more usual meaning about how someone feels.) There are four different moods, or combinations of positive and negative statements with the terms “all” or “some.” The four moods are:

<table>
<thead>
<tr>
<th>Mood</th>
<th>Abstract Example</th>
<th>Concrete Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Universal Affirmative</td>
<td>All A are B.</td>
<td>All students are smart.</td>
</tr>
<tr>
<td>Particular Affirmative</td>
<td>Some A are B.</td>
<td>Some video games are fun.</td>
</tr>
<tr>
<td>Universal Negative</td>
<td>No A are B.</td>
<td>No smurfs are pink.</td>
</tr>
<tr>
<td>Particular Negative</td>
<td>Some A are not B.</td>
<td>Some democrats are not liberals.</td>
</tr>
</tbody>
</table>

As you can see from this table, a statement is universal if it contains the terms “all” or “no”; it is particular if it contains the term “some”; it is negative if it contains “no” or “not”; and it is affirmative if it is not negative. Thus, it should be easy to classify the mood of any statement by identifying the key terms.

Several syllogisms are presented here. Each consists of two premises and a conclusion. Work through each syllogism and decide if the conclusion is valid (V) or invalid (I). To be valid, the conclusion must always be true given its premises. In other words, when you decide that a syllogism is valid, you are saying “if the premises are true, then conclusion must be true.” In other words, “Does the conclusion follow from the premises?” If you can think of one way that the conclusion could be false when the premises are true, then it is invalid. Don’t go on until you have worked through these syllogisms.

1. Premise #1: All people on welfare are poor.  
   **Premise #2:** Some poor people are dishonest.  
   Conclusion: Some people on welfare are dishonest. Valid or Invalid?

2. Premise #1: No parents understand children.  
   **Premise #2:** Some teachers understand children.  
   Conclusion: Some parents are teachers. Valid or Invalid?

3. Premise #1: Some lawyers are not smart.  
   **Premise #2:** Some smart people are rich.  
   Conclusion: Some lawyers are rich. Valid or Invalid?

4. Premise #1: All physics students are good in math.  
   **Premise #2:** Some coeds are physics students.  
   Conclusion: Some coeds are good in math. Valid or Invalid?

5. Premise #1: All Americans need health insurance.  
   **Premise #2:** Everyone who needs health insurance should vote for it.  
   Conclusion: All Americans should vote for health insurance. Valid or Invalid?
According to the rules of logic, it should not matter if the syllogisms are presented in abstract terms of A's and B's (e.g., Some A's are not B's), nonsense terms like zev and creb (All zev are creb), or meaningful terms like lawyers and cool (No lawyers are cool). The logical rules for deciding if a conclusion can be validly inferred from the premises remain the same. We're really saying "All _____ are ______." It should make no difference how we fill in the blanks; any letters, nonsense or meaningful words, or even fancy pictures should be handled in the same way. However, from a psychological perspective, there are important content differences, and people have difficulty using the rules of syllogistic reasoning when the conclusion is not one that they believe to be true, even if logically it follows from the premises. One way to avoid the problem of having one's biases affect how we reason with quantifiers is to use circle diagrams, which, like linear diagrams and tree diagrams, alleviate the limitations of short-term memory and make relationships obvious and visible.

How did you go about deciding if the conclusions were valid? There are two different types of strategies that can be used with syllogisms to determine if a conclusion follows from its premises. If you've been reading the chapters in order, then you know that a common approach to improving thinking is the deliberate use of both spatial and verbal strategies. The same two approaches apply here. First, I will present a spatial method for testing conclusions, then I will provide some verbal rules that can also be used. Either method will "work," but you'll probably find that you prefer one method over the other. I have been teaching this material to college students for many years and have found that individual students have very strong preferences for either circle diagrams or verbal rules.

Circle Diagrams for Determining Validity

One way of determining if a conclusion is true is with the use of circle diagrams that depict the relationships among the three terms (A, B, C or whatever we used to fill in the blanks). The degree to which the circles overlap depicts the inclusion or exclusion of the categories.

There are several different methods of drawing diagrams to depict the relationships among the terms in a syllogism. One of these methods is known as Venn Diagrams, named for a 19th century English mathematician and logician who first introduced them. These are the same diagrams that you probably used in mathematics classes if you ever studied set theory. (This was a very popular way to teach the "new math," before it was abandoned and replaced with the "old math.") A second method of diagramming relationships is known as Euler Diagrams. According to popular lore, this method was devised by Leonard Euler, an 18th century Swiss mathematician, who was given the task of teaching the laws of syllogistic reasoning to a German princess. Because the princess was having difficulty understanding the task, Euler created a simple procedure that could be used to understand the relationships among the terms and to check on the validity of inferences. A third method is called the ballantine method because of its use of three overlapping circles. In all of these methods, circles are used to indicate category membership. The differences among these methods is not important here, and the general strategy of checking conclusions with circle drawings will be referred to as circle diagrams. If you've learned a different method of circle diagrams in another context (e.g., a class on set theory or a logic class), then continue to use that method as long as it works well for you.

Look very carefully at Fig. 4.4.
FIG. 4.4. Circle diagrams depicting correct interpretations of the premises used in syllogisms. Note that “all” can have two correct interpretations, “some” can have four correct interpretations, “no” has one correct interpretation, and “some-not” can have three correct interpretations.
The four moods that statements in syllogisms can have are listed in the left-hand column of Fig. 4.4. Next to each statement are circle diagrams that are correct depictions of the relationships in the statement. Stop now and look very carefully at Fig. 4.4. One circle represents everything that is A, and a second circle represents everything that is B. For the purposes of deductive reasoning, it does not matter what A and B are. In the example in Fig. 4.4, A is used to stand for angels and B is used to stand for bald, but it could be anything. I could just as easily used A to stand for college students and B to stand for punk rockers.

Look at the way the circles are combined so that they form a “picture” of what is being said in words. Let’s start in the middle of the figure, with “universal negative,” the easiest example. When we say, “No A are B,” this means that nothing that is in category A is also in category B. This is depicted by drawing a circle labeled A and one labeled B that do not touch or overlap in any way. There is only one way to draw this relationship. Notice that when we say, “No A are B,” we are also saying that “No B are A.” Can you see that from the circle diagram? Every time you have a universal negative, the relationship will be “pictured” with two circles that do not overlap—one for things that are A and one for things that are B.

Consider now universal affirmative, “All A are B.” Again we use two circles—one labeled A and one labeled B. And again, we want to draw the two circles so that they represent the relationship in which everything that is A is B. As you can see in Fig. 4.4, there are two different ways of depicting this relationship because there are two possible correct ways of understanding what it means. By drawing the A circle inside the B circle, we are depicting the case where “All A are B,” but there are some B that are not A (some bald people are not angels). The second drawing shows the case where “All A are B,” and “All B are A” (all bald people are angels). Either of these two interpretations could be true when we are told that “All A are B.”

Don’t be discouraged if this seems difficult to you. It will soon be easier as it becomes more meaningful and you work your way through the examples. Look at the other two possibilities in Fig. 4.4. There are three possible ways to depict particular negative (Some A are not B) and four possible ways to depict particular affirmative (Some A are B). Now look at all of the moods and notice the different ways that two circles can be combined. There are five different possible ways to combine two circles, and each combination represents a different meaning!

1. A and B do not overlap:

```
  A  B
```

2. A and B are the same circle:

```
  AB
```
3. A is inside B:

4. B is inside A:

5. A and B partially overlap:

Let's draw circle diagrams to depict the relationships in Syllogism 1. The first two sentences are the premises. Write out each premise and next to each premise, draw the appropriate circle diagrams. For example, the first premise states, "All people on welfare are poor." In skeletal form, it is "All A are B" with A standing for "people on welfare" and B standing for "poor." You should recognize this as universal affirmative. Go to Fig. 4.4, look across from universal affirmative, and you will see that there are two possible ways to draw circles that correspond to this premise. Repeat this with the second premise: Some poor people are dishonest. You already decided that A = people on welfare, and B = poor. The new term, dishonest, can be represented by C. The second premise then becomes "Some B are C." This is an example of particular affirmative. Look across from particular affirmative on Fig. 4.4 and you will see that there are four possible ways to draw circles to represent this relationship. The only difference is that for Premise 2, we are using the letters B and C to stand for the categories. Thus, the first two premises will look like this:

A = people on welfare; B = poor; C = dishonest.

1. All people on welfare are poor.
   (All A are B.)
2. Some poor people are dishonest.
(Some B are C.)

To determine if the conclusion is valid, we systematically combine each of the figures in the first premise with each of the figures in the second premise. If we find one combination that would not correspond to the conclusion, then we can stop and decide that the conclusion is invalid. If we make all possible combinations of figures from Premise 1 and figures from Premise 2, and they are all consistent with the conclusion, then the conclusion is valid. In other words, if all combinations of Premise 1 with Premise 2 support the conclusion, then the conclusion is valid. The first few times you work on these, it may seem laborious, but you will soon "see" the answers and find ways to shortcut the process of working through all the combinations.

Here is the conclusion:
Some poor people on welfare are dishonest.
(Some A are C).

Premise 1 has two possible drawings and Premise 2 has four possible drawings. You can see that I labeled the two Premise 1 drawings 1a and 1b and the four Premise 2 drawings 2a, 2b, 2c, and 2d. To work systematically, you need to use the combinatorial reasoning rules that were presented in the last section. Start with 1a and combine it with 2a, then 1a and 2b, 1a and 2c, 1a and 2d. Then repeat the pattern by combining 1b with 2a, then 1b with 2b, then 1b with 2c, and finally 1b with 2d. Of course, you hope that you won't have to go through this entire procedure because
you can stop as soon as you find one combination that violates the conclusion that "Some A are C." Work along with me.

When I combine these two depictions, I will get a figure with A inside B and B inside C:

This combination shows a result that is consistent with the conclusion that "Some A are C." Go on!

When I combine 1b and 2b, I get a depiction where A is inside the B/C circle.

This is consistent with the conclusion that "Some A are C." Go on!

This gets a little tricky here, because there are several different ways to combine 1a and 2c and we have to try all of them until we run out of combinations or find one that is not consistent with the conclusion. Here we draw all ways that A can be inside B and C can be inside B.
A and C are the same circle inside B.

![Diagram](image)

This is still consistent with “Some A are C.” Go on!
A and C partially overlap inside B.

![Diagram](image)

This is still consistent with “Some A are C.” Go on!
A and C are two circles inside B.

![Diagram](image)

This does not agree with the conclusion that “Some A are C.”
Stop here!

I know that this seems like a lot of work, but after you work a few problems, you can spot the combinations that will make a conclusion invalid, so you will not need to try every possible combination. Until then, work systematically through all combinations. A list of steps for checking the validity of conclusions with circle diagrams is shown in Table 4.2. Stop now and look over the steps. Refer back to them as we work through the rest of the syllogisms.

### TABLE 4.2
**Steps for Determining the Validity of Conclusions Using Circle Diagrams**

1. Write out each premise and the conclusion of the syllogism.
2. Next to each statement, draw all correct diagrams using the diagrams shown in Fig. 4.1.
3. Systematically combine all diagrams for Premise 1 with all diagrams for Premise 2. Try Premise 1a (the first diagram for Premise 1) with Premise 2a (the first diagram for Premise 2). Continue combining Premise 1a with all Premise 2 diagrams, then go on and combine all Premise 1b with all Premise 2 diagrams. Continue in this manner (Premise 1c with all Premise 2 diagrams, then Premise 1d with all Premise 2 diagrams) until
4. You find one diagram in which the conclusion is invalid or
5. You have tried all combinations of Premise 1 and Premise 2 diagrams.

*Note.* Sometimes there will be more than one way to combine diagrams from the two premises. Be sure to try all combinations.

When trying out all combinations, remember that there are five possible ways to combine two circles: (a) A inside B, (b) B inside A, (c) A and B overlapping partially, (d) A and B with no overlap (two separate circles), and (e) A and B represented by one circle (A and B are the same circle). These five possibilities are shown below.
Let's try Syllogism 2.
A = parents; B = understand children; C = teachers.
No parents understand children.
(No A are B.)

Premise 1a

Some teachers understand children.
(Some C are B.)

Premise 2a  Premise 2b

Premise 2c  Premise 2d

No parents are teachers.
(No A are C.)

Conclusion A
The two circles that depict the first premise are only one figure because it is Universal Negative, and two separate circles are needed to depict this relationship. It is labeled 1a. The second premise is Particular Affirmative, which is depicted with four figures (2a, 2b, 2c, 2d). The conclusion is Universal Negative, so it is also depicted with one figure consisting of two separate circles. Now combine 1a + 2a, 1a + 2b, 1a + 2c, and 1a + 2d. You can stop as soon as you find one combination that is not consistent with the conclusion and decide that it is invalid, or try all combinations and then decide that it is valid.

As you work through all combinations of the circle drawing that can be combined from the premises, you will see that it is invalid. (If you would like more practice with syllogisms, you can find several more “worked examples” in Thinking Critically About Critical Thinking, the workbook that accompanies this text.)

Here are the answers to the next three syllogisms presented on page 157:

3. From the premises you were given, is it valid to conclude that “Some lawyers are rich”?
   Nope—it’s invalid.
4. From the premises you were given, is it valid to conclude that “Some coeds are good in math”?
   Yes!
5. From the premises you were given, is it valid to conclude that “All Americans should vote for health insurance”? Yes, it is.

Verbal Rules for Determining Validity

It’s a peculiar thing about circle diagrams: Some people love working on them and others seem to hate them. The problem in working with them is trying all possible combinations of representations for both premises. People who prefer to think spatially seem to “see” the combinations with apparent ease, but those who prefer verbal modes of representation seem to have more difficulty. For those of you who have difficulty combining premises into circle relationships, take heart because there are verbal rules for determining if the conclusion of a syllogism is valid. These rules will work just as well as circle diagrams. Sternberg and Weil (1980) found that verbal and spatial strategies draw on different abilities and that the effectiveness of a given strategy depends on one’s preferred mode of thought. There are five rules that can be used to determine the validity of a conclusion. In order to use these rules there are two additional terms that you need to learn.

There are three categories named in syllogisms, the A, B, and C, or whatever category names we substitute for them in more concrete examples. One of these categories is called the middle term. To determine which is the middle term, go to the conclusion. There are two categories in the conclusion; one is the subject of the sentence, the other is in the predicate. The category that is not mentioned in the conclusion is the middle term. It is called the middle term because it links the other two terms in the premises. Look back at Syllogism 1. The conclusion is “Some people on welfare are dishonest.” “People on welfare” is the subject of this sentence, and “dishonest” is the predicate. The middle term is “poor.” The middle term is in both premises, but it is not in the conclusion.

The second term that you need to know is distributed. A term is distributed if the statement applies to every item in the category (Govier, 1985). Consider the four
TABLE 4.3
Distributed and Undistributed Terms in the Four Moods of Syllogisms

<table>
<thead>
<tr>
<th>Case</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>All A are B.</td>
<td>A is distributed. (A is modified by “all.”)</td>
</tr>
<tr>
<td></td>
<td>B is undistributed. (B is undistributed because there may be some B that</td>
</tr>
<tr>
<td></td>
<td>are not A.)</td>
</tr>
<tr>
<td>Some A are B.</td>
<td>Both A and B are undistributed.</td>
</tr>
<tr>
<td>No A are B.</td>
<td>Both A and B are distributed. (Both A and B are modified by “no.”)</td>
</tr>
<tr>
<td></td>
<td>(This is the same as saying that “No B are A.”)</td>
</tr>
<tr>
<td>Some A are not B.</td>
<td>A is undistributed.</td>
</tr>
<tr>
<td></td>
<td>B is distributed. (B is modified by “not.”)</td>
</tr>
</tbody>
</table>

TABLE 4.4
Rules for Determining Validity of Conclusions
When Reasoning with Quantifiers

1. If the conclusion is negative, one premise must be negative, and conversely, if one premise
   is negative, the conclusion must be negative.
2. The middle term must be distributed in at least one premise.
3. Any term that is distributed in the conclusion must be distributed in at least one premise.
4. If both premises are particular, there are no valid conclusions.
5. If one premise is particular, the conclusion must be particular.
6. At least one premise must be affirmative. (There are no valid conclusions with two
   negative premises.)

types of category relationships shown in Table 4.3. Next to each one I’ve indicated which terms are distributed and which terms are undistributed. As you will see in
Table 4.3, categories that are modified by “all,” “no,” and “not” are distributed.

Look carefully at the statement “All A are B.” B is undistributed in this statement
because there may be some B that are not A, so the statement is not about every B.
On the other hand, consider “No A are B.” In this case, B is distributed because
when we say “No A are B,” we are also saying “No B are A.” Thus, in the second
case, the statement is about all B.

For a conclusion to be valid, the syllogism must pass all of the rules in Table 4.4.
If it fails on any one of them, then it is invalid.

Let’s apply these rules to the syllogisms we’ve already solved with circle

diagrams.

Syllogism 1.

A = people on welfare, B = poor, C = dishonest
All people on welfare are poor. (All A are B.)
Some poor people are dishonest. (Some B are C.)
Some people on welfare are dishonest. (Some A are C.)

The middle term for this syllogism is B. It is the one mentioned in both premises
and is missing from the conclusion. The first rule starts “if the conclusion is nega-
tive.” Because the conclusion is positive, we can immediately go on to the second
rule. The second rule states that the middle term must be distributed in at least one
premise. Let’s check this. The middle term is B (poor people). Is it modified by “all”
or “not” in either premise? It is not distributed in either premise, so we can stop
here. This conclusion is invalid! But, of course, you already knew that because you
discovered that it was invalid when you completed the circle diagrams.
Let's try the verbal rules with the second syllogism.

**Syllogism 2.**

A = parents, B = understands children, C = teachers
No parents understand children. (No A are B.)
Some teachers understand children. (Some C are B.)
No parents are teachers. (No A are C.)

The first rule says that if the conclusion is negative, then one premise must be negative, and vice versa. The conclusion is negative and so is one premise, so we can check the next rule.

The second rule is that the middle term must be distributed in one premise. What is the middle term? It is B, the one not mentioned in the conclusion. It is distributed in the first premise, so we can move on. The third rule is that any term distributed in the conclusion must be distributed in at least one premise. Both A and C are distributed in the conclusion. A is distributed in the first premise, but C is not distributed in a premise, so stop here. This conclusion is invalid!

Briefly, here are the answers to the remaining syllogisms.

**Syllogism 3.**

A = lawyers, B = smart, C = rich
Some lawyers are not smart. (Some A are not B.)
Some smart people are rich. (Some B are C.)
Some lawyers are rich. (Some A are C.)

fails #1: passes the first part because the conclusion is not negative; fails the second part because the first premise is negative and the conclusion is positive.
Invalid!

**Syllogism 4.**

All physics students are good in math. (All A are B.)
Some coeds are physics students. (Some C are A.)
Some coeds are good in math. (Some C are B.)
passes #1: There are no negatives.
passes #2: The middle term is A. A is distributed.
passes #3: No term in the conclusion is distributed.
passes #4: Both premises are not particular.
passes #5: One premise is particular and the conclusion is particular.
passes #6: At least one premise is affirmative.
Valid!

**Syllogism 5.**

All Americans need health insurance. (All A are B.)
Everyone who needs health insurance should vote for it. (All B are C.)
All Americans should vote for health insurance. (All A are C.)
passes #1: There are no negatives.
passes #2: The middle term is B. B is distributed.
passes #3: A is distributed in the conclusion and the first premise.
passes #4: Both premises are universal, not particular.
passes #5: No premise is particular.
passes #6: At least one premise is affirmative.
Valid!
Syllogisms in Everyday Contexts

Somewhere during the last section, you may have said to yourself, “Why bother!” It may seem that syllogisms are artificial stimuli created solely to make work for students and teachers. If you did have this thought, you were questioning the ecological validity of syllogisms. Ecological validity concerns the real-world validity or applications of a concept outside of the laboratory or classroom. In other words, do people use syllogistic reasoning in real-world contexts?

Syllogistic reasoning and the other types of reasoning like linear ordering and if, then statements are sometimes considered as a subset of problem solving. Often, when solving a problem, we begin with statements that we believe or know to be true (the premises) and then decide which conclusions we can logically infer from them.

Syllogisms also appear implicitly in normal English prose. Of course, in natural context, the premises and conclusions aren’t labeled, but the underlying structure is much the same. They are especially easy to spot in legal and political arguments, and thus often appear on standardized tests for college, graduate, and law school admissions.

Here is an example of syllogistic reasoning that may seem more like the kind of syllogism you’d find in everyday contexts: The death sentence should be declared unconstitutional. It is the cruelest form of punishment that is possible, and it is also very unusual. The Constitution specifically protects us against cruel and unusual punishment.

Can you conclude from these statements that the death sentence is unconstitutional? Try to formulate these sentences into standard syllogism form (two premises and a conclusion). Use circle diagrams or the five rules to check on the validity of the conclusion. Stop now and work on this natural language syllogism.

Your syllogism should be similar to this:

Premise 1: The death sentence is cruel and unusual punishment.
Premise 2: Cruel and unusual punishment is unconstitutional.
Conclusion: The death sentence is unconstitutional.

If we put this in terms of A, B, and C, this roughly corresponds to:

A = the death sentence
B = cruel and unusual punishment
C = unconstitutional

This then becomes:

All A are B.
All B are C.
All A are C.

In its abstract form, this becomes a syllogism that can be tested with either circle diagrams or verbal rules that will determine if the conclusion validly follows from the premises. The point here is that syllogisms are often contained in everyday arguments. Medical providers are often faced with problems that take this form: Everyone with disease X will have results from the lab test of Y. Some people with results from the lab test of Y will not have disease X. Although this does not “look like”
some combination of "all," "some", "no," and "some not," can you see how it is the
same sort of problem with different terms to represent these relationships? Often,
we don’t recognize syllogistic statements because they are not neatly labeled by
premise and conclusion, but if you get in the habit of looking for them, you may be
surprised how frequently they can be found.

**Missing Quantifiers**

*If there is any equality now, it has been our struggle that put it there. Because*
*they said “all” and meant “some.” All means all.*

—Beah Richards (in Beilensen & Jackson, 1992, p. 22)

When syllogisms are found in everyday use, the quantifiers are often missing.
Sometimes this absence is done deliberately in the hope that you will infer one par-
ticular quantifier (e.g., assume “all” instead of the more truthful “some.”) Here is an
example of categorical reasoning used in a presidential campaign. A presidential
candidate (in the U. S. primaries) was questioned about his extramarital affairs. He
responded this way: I have not been perfect in my private life, but we have had
other great presidents who were also not perfect in their private lives.

Let’s convert this to a categorical syllogism:

Premise 1: I am not perfect (in my private life).
Premise 2: Some great presidents were not perfect (in their private lives).
Conclusion: I will be a great president.
( implied)

In its abstract form this becomes:

A = I (the speaker)
B = people who are not perfect
C = great presidents

or

All A are B.
Some C are B.
All A are (will be) C.

The conclusion he wanted listeners to draw is that he would also be a great presi-
dent. Check the validity of this conclusion either with circle diagrams or the five
rules. Is the implied conclusion valid? Note also his choice of words to describe his
extramarital affairs (not perfect).

In everyday language, the quantifiers may be different from those used here.
"Every" and "each" may be used as substitutes for "all," and "many" and "few"
may be used as substitutes for "some." It is a simple matter to change them to the
quantifiers used here and then check the conclusion for its validity (Nickerson, 1986).

Here is an example (with some editing) that I recognized in a recent conversation.
"People who go to rock concerts smoke dope. Jaye went to a rock concert. Therefore,
Jaye smokes dope." The validity of this everyday syllogism depends on whether the
speaker believes that "All people who go to rock concerts smoke dope" or "Some
people who go to rock concerts smoke dope.” In understanding statements like these, it’s important that you specify which missing quantifier is intended. If “some” is intended, then you quickly point out that it is not valid to conclude that Jaye was among those who smoke dope. If “all” is intended, then you can question whether it is the appropriate quantifier.

**Changing Attitudes with Syllogisms**

The basic organization of two premises and a conclusion is frequently used to change attitudes. When used in this fashion, the first premise is a belief premise, the second premise is an evaluation of that belief or a reaction to the belief premise, and the conclusion is the attitude (Shaver, 1981). The basic structure is like this:

Belief premise
Evaluation premise
Attitude Conclusion

Consider how this works in the following example (Shaver, 1981):

Preventing war saves lives.  
**Saving lives is good.**  
Therefore, preventing war is good.

Over time, attitude syllogisms become linked so that the conclusion from one syllogism is used as the evaluation premise of another:

Defense spending prevents war.  
\[ \text{Preventing war is good.} \]  
Therefore, defense spending is good.

In these syllogisms, the middle term (remember what this means?) becomes the reason for the conclusion. In general, the greater the number of syllogisms with the same conclusion that we believe are true, the greater the support for the conclusion. If I wanted you to conclude that defense spending is good, I’d also tell you that:

Defense spending creates jobs.  
**Creating jobs is good.**  
Therefore, defense spending is good.

The quantifiers are implicit in these syllogisms, but the underlying organization is the same. It’s a matter of determining if a conclusion follows from the premises.

**Common Errors in Syllogistic Reasoning**

*At this point in the history of psychology, when it is claimed that machines can think, it seems strange to say that people cannot.*

—Ceraso and Protivera (1971, p. 400)

Some syllogisms are more difficult to solve than others. An analysis of the erroneous conclusions that people make has revealed that the errors fall into distinct
types or categories. One category of errors that we will consider here is illicit conversions.

**Illicit Conversions**

No, this term has nothing to do with people who make you change religions when you don't want to. It has to do with changing the meaning of a premise. When most people read statements like “All A are B,” the representation they form in their mind is one in which it is also true that “All B are A” (Chapman & Chapman, 1959). As you should realize by now, “All A are B” is not the same as “All B are A.” Transforming a premise into a nonequivalent form is a type of error known as an illicit conversion. An example of an illicit conversion is if, then reasoning is the erroneous assumption that “If A, then B” is the same as “If B, then A.” In real-world terms, knowing that “all Republicans voted for this bill” is not the same as saying that everyone who voted for this bill was Republican. These are not equivalent statements.

Another common illicit conversion is the belief that “Some A are not B” also implies that “Some B are not A.” The second statement is not equivalent to the first. Here are circle diagrams of these two statements. As you can see more clearly in their diagrams, they are not identical statements. To make this point clearer, consider the difference between “Some of the children are not immunized” and “Some of those immunized are not children.”

**A = children, B = immunized**

1. Some A are not B.
   Some children are not immunized.

   ![Diagram 1a](image)

2. Some B are not A.
   Some immunized are not children.

   ![Diagram 1b](image)

3. Some A intersect B.
   Some children intersect with immunized.

   ![Diagram 1c](image)
2. Some B are not A.
   Some of those immunized are not children.

PROBABILISTIC REASONING

The straight path of reason is narrow, the tempting byways are many and easier of access.

—Joseph Jastrow

In everyday reasoning, we don’t view premises as “truths” that will necessarily require certain conclusions; instead, we think of premises as statements that either support or fail to support certain conclusions. Probabilistic reasoning occurs when we use the information we have to decide that a conclusion is probably true or probably not true. In everyday reasoning, we rely on notions of probability to assess the likelihood of a conclusion being true. Although probability is discussed in Chapter 6, it is also a reasoning skill that we need to consider in this context.

Suppose you learn that people who have untreated diabetes are frequently thirsty, urinate often, and experience sudden weight loss. You notice that you have these symptoms. Does it necessarily follow that you have diabetes? No, of course not, but these symptoms do make a diagnosis of diabetes more likely. In everyday contexts, much of our reasoning is probabilistic.

Consider this example presented by Polya (1957, p. 186):

If we are approaching land, we see birds.
Now we see birds.
Therefore, it becomes more credible that we are approaching land.

In a shorthand format this becomes:

If A, then B.
B is true.
Therefore, A is more probable than it was before we knew that B is true.

Much of our everyday reasoning is of this sort, and although A is not guaranteed with probabilistic reasoning, it does become more probable after we’ve told the second premise. When viewed from the perspective of if, then reasoning, we would be committing the fallacy of affirming the consequent. However, in real life we need to consider many variables and goals. Although seeing birds doesn’t guarantee that land is near, I’d be getting happy if I saw birds while I was drifting and lost at sea.
Probabilistic reasoning is often a good strategy or "rule of thumb," especially because few things are known with absolute certainty in our probabilistic world. From the standpoint of formal logic, it is invalid to conclude that a land is near. As long as you understand the nature of probabilities and the distinction between probabilistic and valid (must be true if the premises are true) reasoning, considering probabilities is a useful way of understanding and predicting events. When we reason in everyday contexts, we consider the strength and likelihood of the evidence that supports a conclusion and often decide if a conclusion is probable or improbable, not just merely valid or invalid. This point is explained more fully in Chapter 7 on understanding probabilities.

As much of our reasoning is dependent on the rules of probability, McGuire (1981) has coined the term probabilogical to describe the joint effects of these disciplines on the way we think. Accordingly, we place greater faith in conclusions when we believe that the premises are highly probable than when we believe that the premises are unlikely.

**Bounded Rationality**

*Nothing has an uglier look to us than reason, when it is not on our side.*


Does the fact that people often do not use the laws of logic when they reason mean that we mere mortals are illogical or irrational (not reasoned)? Many psychologists object to the idea that most people are illogical. As you have seen, people reason differently depending on the context and seem to be able to use the rules of reasoning better when the valid conclusion is one that we believe to be true than when it is not. In the real world, the content of our reasoning does matter, so perhaps it is not surprising that we find it difficult to reason from false or questionable premises. It seems that people are rational, but with some limitations. The term bounded rationality is used to describe this state of affairs (Gigerenzer & Goldstein, 1996). We usually need to reach conclusions and make decisions with incomplete information and under time limits, and we rarely have "true premises." For example, we know if we are asking permission or making an obligation, and the very different implications of if, then statements under these situations.

**REASONING IN EVERYDAY CONTEXTS**

*Reasoning is the only ability that makes it possible for humans to rule the earth and ruin it.*

—Scriven (1976, p. 2)

Sylogisms, linear orderings, disjunctions, and if, then statements are commonly found in everyday conversation. Of course, they are embedded in discourse and not labeled by premise or conclusion. They are sometimes used in ways that seem either to be deliberately misleading, or at least to capitalize on the common reasoning errors that most people make.
If you pay careful attention to bumper stickers, you’ll probably be surprised to find that many are simple reasoning problems. Consider the bumper sticker I saw on a pick-up truck:

<table>
<thead>
<tr>
<th>Off-road users are not abusers.</th>
</tr>
</thead>
</table>

The off-road users that this bumper sticker refers to are dirt bike riders who enjoy racing through open land (unpaved areas). Many people are concerned that this sport is destroying our natural resources by tearing up the vegetation. This bumper sticker is designed to present the opposing view. Notice how this is accomplished. The term “all” is implied in the first premise, when in fact “some” is true. You should recognize this as a syllogism with missing quantifiers.

Another popular bumper sticker that relies on missing quantifiers to make the point is:

<table>
<thead>
<tr>
<th>If guns are outlawed, only outlaws will have guns.</th>
</tr>
</thead>
</table>

This is a standard if, then statement. The implied conclusion is “don’t outlaw guns.”

Suppose someone responded to this bumper sticker by suggesting that if guns are outlawed, approximately 80% of the crimes of violence and 90% of the petty crimes that are committed with a gun would probably be committed with a less dangerous weapon. How does an argument like this refute the if, then statement and its implied conclusion on the bumper sticker?

Here is a disjunctive argument that was common during the Vietnam War: America, love it or leave it! You may be surprised to learn that this was a slogan for those who went to fight in Vietnam. The implication was that antiwar protest meant that you didn’t love America. In Chapter 5, I’ll return to the use of disjunctions and ask if there really are only two options when we are given two options.

**Reasoning With Diagrams**

Although it seems like a lot of work to get used to thinking with diagrams, they are useful in many situations where you have to check relationships and conceptualize. The following discussion is loosely based on a discussion by Rubinstein and Pfeiffer (1980) that I have applied to the events surrounding the Los Angeles riots that occurred in 1992.

In 1992, following an unpopular verdict in which Los Angeles police officers were acquitted of the crime of beating a suspect, an event that was captured on video, a massive, bloody riot occurred. In the painful trials that followed, the prosecution attempted to show that a particular defendant was at the scene of the riot. One piece of evidence was a footprint that was at the site. The strategy for the defense was to show that many people could have left that particular footprint, but the prosecution tried to show that few people other than the defendant could have left the footprint. Look at these two diagrams.
An expert from the Nike shoe company was called to testify that the print was left by a Nike sneaker. The prosecution then showed that the defendant owned a pair of Nikes in the same size as the footprint. This shrinks the size of the circle, so that few people besides the defendant would fit those particular shoes.

By contrast, the defense tried to widen the circle by showing that many people in that neighborhood wear Nike sneakers and that it was a popular shoe size. Each side, in turn, tried to widen and then narrow the circle in an attempt to persuade the jury that the defendant and few others could have left that footprint or many people could have left that footprint.

Similar strategies are used implicitly in many trials. Here is a quote from an article that appeared in the Los Angeles Times (Timnick, October 18, 1989). It is a description of a trial for an accused child molester: “Telling an attentive jury in Los Angeles Superior Court that the totality of evidence ‘draws the ring around R. B. and P. B. closer and tighter, to the extent that you should find them guilty.’” Here the idea of drawing smaller and smaller circles was used explicitly in the prosecution’s arguments. Once you get used to using diagrams as a thinking aid, you will find that you will use them often.

REASONING GONE WRONG

I hope that you are developing an appreciation for the critical importance of good thinking. If you are not yet convinced, then I expect that this section will be a “chilly awakening.” In later chapters, I will continue to develop the theme that there are many people who want to persuade you to believe that something is true—for a variety of reasons. Often they will be trying to sell you something—a product, a philosophy, a political candidate or point of view, or even a new view of history. Groups that are attempting to rewrite history are called revisionists. Your only defense against the onslaught of “sales” pitches is critical thinking. I heard a revisionist
APPLYING THE FRAMEWORK

1. What Is the Goal?

In deductive reasoning, the goal is to determine which conclusions are valid given premises or statements that we believe are true. When you identify your goal as a deductive reasoning task, you will use the reasoning skills presented in this chapter.

2. What Is Known?

In everyday prose, you will have to convert phrases and sentences into a reasoning format. You will have to determine what the premises are before you can decide whether they support a conclusion. Often quantifiers are missing and conclusions are left unstated. Sometimes you will have to consider context to decide if "if, then" really means "if, and only if, then." You will have to decide if you are reasoning with implied or explicit quantifiers, if there is a linear ordering, and whether an if, then statement is being made.

Perhaps, most importantly, you need to determine if you should be assuming that the premises are true. A conclusion is valid if it follows from the premises, but good reasoning from poor premises will not produce desirable outcomes.

3. Which Thinking Skill Will Get You to Your Goal?

The following skills to determine whether a conclusion is valid were presented in this chapter. Review each skill and be sure that you understand how and when to use each one.

- Discriminating between deductive and inductive reasoning
- Identifying premises and conclusions
• Using quantifiers in reasoning
• Solving categorical syllogisms with circle diagrams
• Solving categorical syllogisms with verbal rules
• Understanding the difference between truth and validity
• Recognizing when syllogisms are being used to change attitudes
• Using linear diagrams to solve linear syllogisms
• Watching for marked adjectives
• Using the principles of linear orderings as an aid to clear communication
• Reasoning with if, then statements
• Using tree diagrams with if, then statements
• Avoiding the fallacies of confirming the consequent and denying the antecedent
• Examining reasoning in everyday contexts for missing quantifiers

4. Have You Reached Your Goal?

This is an accuracy check on your work. When determining valid conclusions from categorical syllogisms, did you get the same answer with both the rules for syllogisms and the circle diagrams? Did you consider all combinations of representations when drawing your diagrams? Did you consciously consider common fallacies and biases so as to be sure to avoid them? Does your answer make sense?

CHAPTER SUMMARY

1. Deductive reasoning is the use of premises or statements that we accept as true to derive valid conclusions.
2. People don’t approach reasoning problems according to the laws of formal logic. Instead of determining whether a conclusion logically follows from the premises as they are stated, there is a tendency to alter the premises according to one’s own beliefs and then decide whether a conclusion follows from the altered statements.
3. Human reasoning is often biased by beliefs about emotional issues.
4. It is common to confuse truth with validity. Validity refers to the form of an argument and is unrelated to content. If a conclusion necessarily follows from the premises, then it is valid. The topic of truth and believability of premises are addressed in the next chapter.
5. In linear orderings, we use premises to establish conclusions about ordered relationships. A good strategy for solving linear orderings is to use a spatial representation with the items arranged in an ordered manner.
6. In if, then statements a conditional relationship is established. As in syllogisms and linear orderings, the premises that are given are used to determine valid conclusions.
7. “If” is frequently interpreted as “if and only if” in if, then statements. Although this conversion is an error according to the rules of formal logic, sometimes it is justified by the context in which it is embedded.
8. Confirmation bias is the predilection or tendency to seek and utilize information that supports or confirms the hypothesis or premise that is being considered. The “four-card selection task” is a demonstration of this robust bias.
9. Quantitative syllogisms indicate which terms belong in the categories that are specified. Statements in syllogisms can take one of four different moods: universal affirmative, particular affirmative, universal negative, and particular negative.

10. When syllogisms involve meaningful terms and categories, people often use their knowledge of the categories and their beliefs about the topics to determine which conclusions are valid instead of reasoning from the form of the syllogism.

11. Circle diagrams are useful aids for understanding relationships and checking inferences in syllogisms. The extent to which circles overlap depicts category inclusion and exclusion. An alternative to circle diagrams that many people prefer is to check conclusions for validity using the verbal rules of syllogisms.

12. The greatest difficulty in using circle diagrams is being certain that all combinations of the two premises have been represented.

13. Illicit conversions are common errors in syllogisms. The most frequent illicit conversion is to interpret “All A are B” as also meaning that “All B are A.”

14. Diagrams are useful reasoning tools in many situations. The logic of circle diagrams is frequently used in legal settings and other settings in which evidence is considered.

**TERMS TO KNOW**

Check your understanding of the concepts presented in this chapter by reviewing their definitions. If you find that you’re having difficulty with any term, be sure to reread the section in which it is discussed.

**Reasoning.** Has two forms: deductive and inductive. When reasoning deductively, we use our knowledge of two or more premises to infer if a conclusion is valid. When reasoning inductively, we collect observations and formulate hypotheses based on them.

**Conclusion.** An inferential belief that is derived from other statements.

**Logic.** A branch of philosophy that explicitly states the rules for deriving valid conclusions.

**Valid.** A conclusion is valid if it must be true if the premises are true. It “follows from” the premises.

**Premises.** Statements that allow the inference of logical conclusions.

**Illogical.** Reaching conclusions that are not in accord with the rules of logic.

**Failure to Accept the Logical Task.** In everyday reasoning, we alter the statements we’re given according to our personal beliefs and then decide if a conclusion follows from the altered statements. We reject the logical task of deciding if a conclusion follows from the statements as they are given.

**Personal Logic.** The informal rules that people use to determine validity.

**Pragmatic.** Anything that is practical. In this context, the consideration of context and purpose when engaging in real-world reasoning tasks.

**Inductive Reasoning.** Observations are collected that suggest or lead to the formulation of a conclusion or hypothesis.

**Deductive Reasoning.** Use of stated premises to formulate conclusions that can logically be inferred from them.

**Linear Ordering.** Also known as linear syllogism. Reasoning that involves the inference of orderly relationships along a single dimension (e.g., size, position) among terms.
Linear Syllogism. See linear ordering.

Marked Adjectives. Adjectives that connote bias when they appear in a question (e.g., poor, dumb, or small). When asked “How poor is he,” it is presumed that the response will be toward the poor extreme and not toward the rich extreme.

Unmarked Adjectives. Adjectives that are neutral in that they don’t connote a particular direction when they appear in a question (e.g., big, smart, tall). When asked “How big is he?” the response could be a larger or a small number. Compare with marked adjective.

Belief Bias. Also known as confirmation bias. The interference of one’s personal beliefs with the ability to reason logically.

If, Then Statements. Statements of a contingency relationship such that if the antecedent is true, then the consequent must be true.

Contingency Relationships. Relationships that are expressed with if, then statements. The consequent is contingent or dependent on the antecedent.

Conditional Logic. Also known as propositional logic. Logical statements that are expressed in an if, then format.

Antecedent. In if, then statements, it is the information given in the “if” clause appealing to your reason.

Consequent. In if, then statements, it is the information given in the “then” clause.

Tree Diagrams. Diagrams in which the critical information is represented along the branches of a “tree.”

Affirming the Antecedent. In if, then reasoning, the second premise asserts that the “if” part is true.

Denying the Consequent. In if, then reasoning, the second premise asserts that the “then” part is false.

Affirming the Consequent. In if, then reasoning, the second premise asserts that the “then” part is true.

Illicit Conversion. Illicit conversions, in if, then statements occur when people believe that “If A, then B” also means “If B, then A.”

Denying the Antecedent. In if, then reasoning, the second premise asserts that the “if” part is false.

Double Negation. The denial of a negative statement.

Four-Card Selection Task. A task that is often used to demonstrate confirmation biases. Subjects are required to indicate which of four cards they need to turn over in order to verify a rule about the contents of each side of the card. Overwhelmingly, subjects only select cards that will confirm the hypothesis that they are considering instead of seeking information that would disconfirm their hypothesis.

Permission Schema. Informal rules that people use when reasoning with if, then statements that pragmatically give permission.

Obligation Schema. Informal rules that people use when reasoning with if, then statements that pragmatically create an obligation.

Chained Conditional. Two if, then statements linked so that the consequent of one statement is also the antecedent of the other statement.

Combinatorial Reasoning. The use of systematic and orderly steps when making combinations so that all possible combinations are formed.

Syllogistic Reasoning. A form of reasoning that involves deciding whether a conclusion can be properly inferred from two or more statements that contain quantifiers.

Categorical Reasoning. A type of syllogistic reasoning in which the quantifiers “some,” “all,” “no,” and “none” are used to indicate category membership.
**Terms to Know**

**Quantifiers.** Terms like "all," "some," "none," and "no" that are used in syllogisms to indicate category membership.

**Syllogism.** Two or more premises that are used to derive a valid conclusion or conclusions.

**Mood.** Used to classify the premises and conclusions of a categorical syllogism. There are four moods that are dependent on the quantifiers used in the statements. The four moods are: universal affirmative (all A are B); particular affirmative (some A are B); universal negative (no A are B); and particular negative (some A are not B).

**Universal Affirmative.** The mood of statements in a categorical syllogism with the format "All A are B."

**Particular Affirmative.** The mood of statements in a categorical syllogism with the format "Some A are B."

**Universal Negative.** The mood of statements in a categorical syllogism with the format "No A are not B."

**Particular Negative.** The mood of statements in a categorical syllogism with the format "Some A are not B."

**Circle Diagrams.** A spatial strategy for determining the validity of a conclusion in a categorical syllogism. Circles are used to represent category membership.

**Middle Term.** In a categorical syllogism it is the term that is omitted from the conclusion and is mentioned in both premises.

**Distributed.** In a categorical syllogism a term is distributed when it is modified by "all," "no," or "not."

**Ecological Validity.** Concerns the real-world validity or applications of a concept outside of the laboratory.

**Illicit Conversions.** Transformations of the premises in a syllogism into nonequivalent forms (e.g., converting "All A are B" into "All B are A").

**Probabilogical.** Term coined to label the joint influences of probability and logic on the way we think.

**Bounded Rationality.** People are rational, within limits. People do not behave like logic machines, but use thinking shortcuts to save time.