Thinking and Intelligence

Brief Chapter Outline

I. Problem Solving
   A. Blocks to Problem Solving
   B. Solution Strategies

II. Thinking Under Uncertainty
   A. Judging Probability
   B. Hypothesis Testing

III. Intelligent Thinking
   A. Intelligence Testing
   B. Controversies About Intelligence

Detailed Chapter Outline

*PsychSim 5 Tutorial: My Head Is Spinning*
Students might complete this module before beginning Chapter 6 in class. The focus of the module is mental rotation, which is not covered in the text. However, the module is interactive and supplements the text while whetting students’ appetites for the information in the chapter, particularly the first section of the chapter. The simulated experiment is from work done by Cooper and Shepard (1973); it will seem easy to students until they engage as participants. The notion of reaction time, common in cognitive psychological research, is introduced, and students can compare their performances in the experiment with the performances of the participants in Cooper and Shepard’s sample. Sex differences in performance are also discussed, along with potential explanations for why such differences exist.

*Class Activity: Mental Imagery and Reaction Time*
Another way to begin this chapter is to use an exercise developed by Thompson (2000). He presents a simple way to introduce the notions of mental imagery and reaction time. First, prepare two handouts, one containing the large-difference items in the following list, the second containing the small-difference items. Mix up the items on the two handouts to put them in a randomized order.
Tell students that they will decide which word in a pair represents a bigger stimulus, and then write a couple of examples on the board (for example, baseball/basketball, dog/cat). Give each student one handout, face down on the desk. Tell students not to turn over the handouts until instructed by you to do so. When each student has a handout, tell the class that they will have 25 seconds to go through 24 stimulus pairings, decide which of two stimuli is larger, and write a checkmark beside it. When students count up the number of items checked, students in the large size difference condition consistently complete more stimulus pairings than students in the small size difference condition. The average number of responses in each condition can be divided by 25 to obtain a “number of responses per second” number, which can serve as a rough approximation of reaction time. Once you tally the class results (or a sample of class results in a larger class), you can discuss how students made their decisions. Thompson suggests breaking students into groups to discuss possible explanations.

This activity also provides a means of reviewing the two-group between-subjects experimental design.

This video illustrates the application of imagery to improve athletic skills. The video focuses on how visualization of a gymnastic sequence helps a gymnast perfect a complex routine. Excellent animation helps viewers understand the neural basis for this type of “learning without doing.” A search of PsycINFO indicates that mental visualization has been applied to a wide variety of sports (including, but not limited to, golf, basketball, swimming, and horseback riding). In a comprehensive review of the uses of mental imagery in athletics, Jones and Stuth (1997) discuss and critique existing research concerning the use of imagery for rehabilitation, control or arousal, and performance enhancement. In an online journal devoted to sports psychology, Short, Ross-Stewart, and Monsma (2006) also discuss applications of imagery (http://www.athleticinsight.com/Vol8Iss3/ImageryResearch.htm).


Thinking is the processing of information to solve problems and make judgments and decisions.

I. Problem Solving

A problem is a situation in which there is a goal but no clearly stated way to reach the goal. A well-defined problem has clear specifications of the start state (where people are), goal state (where people want to be), and processes for reaching the goal state (how to get there). An ill-defined problem lacks clear specification of the start state, goal state, and processes for reaching the goal state.

A. Blocks to Problem Solving

Problem solving involves two steps: interpreting the problem and trying to solve the problem.

1. Interpreting the problem:

   a. Fixation is the inability to create a new interpretation of a problem. For instance, in the nine-dot problem presented on text page 230, the directions do not say one cannot go “outside” the mental square formed by the nine dots. Once that information is pointed out, the solution to both the four- and three-line solutions is easy.

   b. Functional fixedness is the inability to see that an object can have a function other than its typical one; it limits the ability to solve problems that require using an object in a novel way. For example, if people need a screwdriver and don’t have one, they tend not to see that a dime could be used to serve the purpose of a screwdriver. To combat functional fixedness, people should systematically consider the possible novel uses of all the various objects in the problem environment.

2. Solving the problem:

   a. Past experience with problem solving can lead to mental set, the tendency to use previously successful solution strategies without considering others that are more appropriate for the current problem. In the two-letter series problems presented on text page 229, mental set hinders people because they view the letters in the series as single entities and look for relationships between them; they do not see each of the letters as part of some larger entity.
Sometimes when searching for new approaches to a problem, people may experience *insight*, the intuition of a new way of interpreting a problem that immediately gives them the solution. The frontal cortex may actually hinder insight rather than facilitate it. Reverberi, Toraldo, D’Agostini, and Skrap (2005) found that patients with damage to their lateral frontal cortex actually outperformed healthy participants on insight problems like the one on page 232. Recent research suggests insight might be located in the right anterior temporal lobe.

To combat blocks to problem solving, people should ask themselves questions such as “Is the interpretation of the problem unnecessarily constraining?”; “Does it obscure possible solutions?”; “Can any of the objects in the problem be used in novel ways to solve it?”; and “Is a new type of solution strategy needed?”

**B. Solution Strategies**

If people need a new solution strategy, they may consider two types.

1. An **algorithm** is a step-by-step procedure that guarantees a correct answer to a problem. For example, using multiplication correctly guarantees the correct solution to a multiplication problem and looking at an inventory list guarantees you will find every item. But what if the item you’re looking for is large and easy to spot?

2. A **heuristic** is a solution strategy that seems reasonable given past experiences with solving problems, especially similar problems. A heuristic may pay off with a quick correct answer, but it also may lead to no answer or an incorrect one.

   Example: When going through a new grocery store looking for pickles, people could go up and down every aisle, examining each product until they found the pickles (using an algorithm). Or they could examine the signs above the aisles for the word “Condiments” and assume that pickles will be in that aisle (using a heuristic).

   a. In the **anchoring and adjustment heuristic**, an initial estimate is used as an anchor and then this anchor is adjusted up or down; however, because of the anchor, this adjustment is usually insufficient to allow people to perceive reality in an objective fashion. For instance, when meeting a new person, the first impression forms an anchor. Individuals may or may not adjust the anchor by processing subsequent information about the person. In the “real world,” anchoring may have costs attached. A good example that you may have experienced is the inclusion of minimum payment information on credit card statements. These minimum payment amounts can act as psychological anchors. In a hypothetical bill-paying experiment, manipulating the inclusion of minimum payment information, Stewart (2009) found that the inclusion of this information led to significant reductions in partial payment amounts, which would lead to increased interest charges.

*Lecture Enhancer/Class Activity: Video*

We located an excellent video on YouTube that illustrates the anchoring and adjustment heuristic—as well as heuristic thinking more generally—using a clip from the TV show “The Price is Right.” This video can be found at http://www.youtube.com/watch?v=3IPVJq0ZX4U. First, as always, make sure this link is live before calling it up in class. Second, be sure your students are familiar with the show, and most important, with the “contestant’s row” part of the show, where four people are called from the audience and must bid on a prize to win their way on stage to try to win more prizes. To win in contestant’s row, a person must bid the closest to the actual retail price of the prize presented, without going over the actual retail price. Thus, if a contestant is the last person to bid, he may bid only $1 if he believes the other contestants have gone over the actual retail price and are thus ineligible to win.
To demonstrate anchoring and adjustment, you can start the video at 0:55, when a contestant named Keith is called out of the audience and into contestant’s row. Because he is the new member of contestant’s row, Keith bids first on the next prize, which is a large, stylish clock. Keith’s bid is $1 (at 1:56 into the video). We find that students often snicker at this bid, so perhaps briefly stop the video and ask what’s so funny. Indeed, unless the other contestants overbid, Keith cannot win the prize. After hearing the other three contestants’ bids, the actual retail price of $2,020 is announced at 2:17 into the video. Stop the video here so that students can see all four contestants’ bids (the highest is only $900, far less than the actual price of the clock). Keith’s initial bid acted as an anchor (on the low side) and although the other contestants adjusted away from the anchor, the adjustments were insufficient to bring them close to the actual retail price. Interestingly, each successive bid by the three contestants after Keith got a little closer to the actual retail price.

You may wish to continue this video to again demonstrate anchoring and adjustment, as well as general heuristic thinking. The next prize contestants bid on is a model train set. The initial bid from the new contestant is $701. While this person is bidding, Keith is clearly interacting with the audience, not paying attention to what is happening on contestant’s row. When he bids, he bids $700, which makes it impossible for him to win the prize unless his bid is exactly correct (it isn’t). Here is an example of general heuristic thinking: Keith heard “seven-oh-one,” but did not process it carefully enough to use it to his advantage; instead he used that information as a shortcut to make his (mindless) bid. Once again, looking at all four bids (shown at 4:47 into the video), there appears to be an anchoring effect, as no contestant came close to the actual price of $1,614. We do not believe anything in the video after this point illustrates any additional course information.

It is also important to emphasize that given this nonempirical clip, we do not know how a comparison group, not given an initial anchor, would have bid on these prizes. It may well be that the constants simply were unfamiliar with the price of the prizes on which they were bidding. However, at least in theory, this video can stimulate interest in anchoring and adjustment. Further, for any fan of “The Price is Right,” extraordinarily high bids can and do serve as anchors that sometimes cause all contestants to overbid. In other instances, it results in contestants breaking free from the anchor and winning with a bid of $1.

b. The working backward heuristic is an attempt to solve a problem by working from the goal state backward to the start state. For instance, consider the following situation: Water lilies growing in a pond double in area every 24 hours. On the first day of spring, only one lily pad is on the surface of the pond. Sixty days later, the entire pond is covered. On what day is the pond half covered? If people work backward from the fact that the pond is completely covered on the 60th day, they can solve this question easily: Half of the pond must be covered on the 59th day.

c. The means-ends analysis heuristic involves breaking down a problem into subgoals and working toward decreasing the distance to the goal state by achieving the subgoals. For example, when students are writing a major term paper, they should be encouraged to (and perhaps shown how to) break down this big task into smaller tasks (choosing and narrowing a topic, researching, outlining, writing the body, writing the introduction and conclusion) that, when completed, will result in a finished term paper.
**Web-Based Homework Activity: Tower of Hanoi**

Students typically enjoy trying the Tower of Hanoi problem themselves. You might invite them to try the problem online, prior to reading the chapter. There are multiple Web sites that include this exercise. All sites permit students to attempt the problem with varying numbers of disks. Two sample sites include SuperKids at [http://www.superkids.com/aweb/tools/logic/towers/](http://www.superkids.com/aweb/tools/logic/towers/) and MazeWorks at [http://www.mazeworks.com/hanoi/index.htm](http://www.mazeworks.com/hanoi/index.htm).

Most of these types of demonstrations require that a Java program is installed on the computer. Java is available at [http://java.sun.com/javase/downloads/index.jsp](http://java.sun.com/javase/downloads/index.jsp). Please contact your information technology personnel to determine which version is compatible with your computing needs.

**Worth Video Anthology for Introductory Psychology: Problem Solving in the Genus Corvus (Crows, Ravens, and Magpies) (1:30)**

This brief clip illustrates a bird confronted with the problem of gaining access to food at the bottom of a glass tube. Because this clip does not include audio, instructors might encourage students to watch closely from the beginning.

**Worth Video Anthology for Introductory Psychology: Can Chimpanzees Plan Ahead? (2:10)**

This video illustrates a chimpanzee rapidly solving an unfamiliar maze. Because she makes only a few mistakes, the chimpanzee’s ability to negotiate the maze suggests she is planning ahead.

**Worth Video Anthology for Introductory Psychology: Teaching Language to Chimpanzees (4:10)**

This third video illustrates a bonobo, a great ape, who has learned to comprehend language and identify more than 200 linguistic symbols. In one particularly interesting segment, the bonobo, sitting on a living room couch, responds appropriately to a request to “Please give the doggie a bite of your hot dog.” Researcher Sue Savage-Rumbaugh suggests that the bonobo’s level of language comprehension is equivalent to that of a 5- to 7-year-old child. For further information about bonobos, students might visit [http://www.bonobo.org](http://www.bonobo.org).

Links to other great resources include The Great Ape Trust at [http://www.greatapetrust.org](http://www.greatapetrust.org) and a Ted talk given by Sue Savage-Rumbaugh at [http://www.ted.com/talks/susan_savage_rumbaugh_on_apes_that_write.html?quote=113](http://www.ted.com/talks/susan_savage_rumbaugh_on_apes_that_write.html?quote=113)

### II. Thinking Under Uncertainty

The **probability** of an event is the likelihood that it will happen; probability ranges from 0 (never happens) to 1 (always happens). An event with 0.5 probability of occurring is maximally uncertain because it is equally likely to occur and not to occur.

In addition to judging the uncertainty of events in our environment, people attempt to reduce uncertainty about the world by trying to find out how various events are related to one another. People develop and test nonscientific hypotheses about how events in the world are related. For example, as mentioned in the text, people will test the hypothesis that they have a specific disease because of a positive result on a medical screening test for that disease.

#### A. Judging Probability

Cognitive psychologists Amos Tversky and Daniel Kahneman identified and conducted research on two main heuristics people often use to make judgments about probabilities—the representativeness heuristic and the availability heuristic.
1. The **representativeness heuristic** is a rule of thumb for judging the probability of membership in a category on the basis of how well an object resembles (represents) that category. The more representative the object is, the more probable it is. For example, suppose people hear about an individual who likes to write, read, and interpret poetry. Is it more likely that this individual is (a) a hockey fan or (b) an English professor who likes hockey?

The **conjunction rule** states that the likelihood of the overlap of two uncertain events cannot be greater than the likelihood of either of the two separate events because the overlap is only part of each event. The **conjunction fallacy**, which occurs when people use the representativeness heuristic, is incorrectly judging the overlap of two uncertain events to be more likely than the occurrence of either of the two events independently and explains why people tend to chose option (b), even though it is impossible for option (b) to be correct.

The **gambler’s fallacy** is the erroneous belief that a chance process is self-correcting; that is, that an event that has not occurred for a while is more likely to occur. People believe that short sequences (for example, a series of nine coin tosses) should reflect the long-run probabilities. People believe random sequences should look random (represent randomness). If a coin lands “heads” eight times in a row, people think there is a greater chance of it being “tails” on the ninth toss. One of the most famous examples of the gambler’s fallacy occurred in a Monte Carlo casino in 1913 when a roulette wheel landed on black 26 times in a row. During that run, most people bet against black since they felt that red must be due. They assumed that the roulette wheel would somehow correct the imbalance and cause the wheel to land on red. The casino ended up making millions of francs.

**Class Activity: Demonstrating the Gambler’s Fallacy**

Riniolo and Schmidt (1999) presented a simple way to demonstrate the gambler’s fallacy. Although this exercise requires the use of sports (i.e., football games in the fall or basketball games in the spring), it does not require students to know anything about sports. Have students pick about 10 professional football games (in the fall, basketball games in the spring), noting the point spreads, each week (preferably at the start of the term so that you gather plenty of data) on the last class period prior to the weekend, when the games are typically played. When we have used this activity, it typically takes 5 minutes at most to do this. We post the games with their point spreads from Yahoo Sports at the front of the room, and ask students to write down which team (with point spread) they are picking to win each of the games they’ve chosen. Students will need to keep track of whether their picks won or lost each week. The results of these picks are now the database needed for the demonstration.

We tell students that, of course, they have a 50 percent chance to pick the winner of each game correctly. Now, have them imagine they are in Las Vegas, and they decide to actually bet on games, but lose the first four games they bet on. What are the odds they will pick the winner of next (fifth) game?

We have used this demonstration with typically 4 or 5 weeks of data from student picks, and with about 30 students in a class, so we usually have about 1,500 data points to work with in a class. Similar to Riniolo and Schmidt, we find that students’ picks are correct anywhere from 49 percent to 54 percent of the time. We then ask students to look for instances in which they went on a “streak” of picking four games correctly in a row. For each such streak, we have students record the outcome of the next pick. Similar to Riniolo and Schmidt, our students picked the next game correctly 51 percent of the time (the authors of this demonstration used “streaks” of three correct games in a row and hence had more data in this regard than we did). Likewise, after incorrectly picking four games in a row, our students picked the next game correctly 50 percent of the time. In short, the outcomes of previous picks were unrelated to the outcomes of current picks, the essence of the gambler’s fallacy.

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If you start this activity when either football or basketball season is beginning, you should have at least several weeks of data by the time you reach this chapter. If you have students start collecting data at mid-semester, you can still use this exercise, just with fewer data points.


People tend to use the representativeness heuristic because the mind categorizes information automatically. As the brain constantly recognizes the objects, events, and people in our world, it puts them into categories.

2. The **availability heuristic** is the mental shortcut that the more available an event is in memory, the more probable it is. For instance, people can think of more words beginning with the letter \( r \) than with \( r \) as the third letter because they organize words in memory based on the first letters, not by their third letters (actually, words with \( r \) as the third letter are more frequent).

An event may be prominent in memory because it happened recently or because it is particularly striking or vivid. For instance, deaths from shark attacks are highly publicized, creating greater fear of death due to shark bite than death due to diabetes, when diabetes is a far more likely cause. Another example is that after the terrorist attacks on Sept. 11, 2001, many people cancelled their holiday flight plans and opted to drive to vacation destinations rather than risk flying. However, roughly five times as many Americans died in motor vehicle accidents during the 111 days between 9/11/01 and 12/31/01 than died in the terrorist attacks in NYC and Washington, DC. A more recent example is the Sandy Hook shooting incident. While the mass shooting was widely publicized, many more people are killed each and every day with guns than the total number of victims in Sandy Hook and the movie theater shooting in Aurora, Colorado, combined.

Availability in memory also plays a key role in what is termed a dread risk; that is, a low-probability, high-damage event in which many people are killed at one point in time. For instance, people may be more afraid to fly than to drive because of the availability of high-profile plane crashes. Interestingly, people are 37 times more likely to die in a car accident than in a commercial plane crash.

To overcome the representativeness and availability heuristics, people should make sure they have not overlooked relevant probability information and plausible reasons for differential availability.

*PsychInvestigator: Decision Making*

This interactive video resource assists students in understanding the bias inherent in decision-making processes. From the biphasic decision-making process to message framing, how we judge things is easily influenced. Political framing of terms like “death tax” alters the way we think about issues. Students then complete an experiment in which they make decisions between absolutely and probability. Results are analyzed, key terms are reviewed and a quiz is available to test knowledge of the material.

**B. Hypothesis Testing**

1. **Confirmation bias** is the tendency to seek evidence that confirms one’s beliefs. That is, people test their beliefs about the world not by trying to disconfirm them but by trying to confirm them.
Class Activity: The Four-Card Selection Problem

Although this activity is in the text, students often need to perform it several times before they understand it. Draw four boxes on the board, filling the first box with the letter A, the second box with the letter K, the third box with the number 4, and the last box with the number 7. Then tell the class to consider this rule: If a card has a vowel on one side, then it has an even number on the other side. Then tell students to select the card or cards that definitely must be turned over to determine whether the rule is true or false for these four cards. Most students will probably select cards A and 4. The card showing A is a good choice because an odd number on the back of this card would falsify the rule, but the card showing 4 is not. The card showing 7 would be a better choice because if it had a vowel on the other side, it would falsify the rule. No matter what is on the other side of the K and 4 cards, the rule is still true! This is not an easy exercise for students to comprehend, so if you use this activity, be prepared for a lot of questions, debate, and even disbelief.

a. An illusory correlation is the erroneous belief that two variables are related when they actually are not related. If people believe that a relationship exists between two things (for example, wearing a shirt of a certain color and getting a good grade on a test), then people will tend to notice and remember instances that confirm this relationship, ignoring all disconfirming instances: the confirmation bias at work.

b. Belief perseverance is the tendency to cling to one’s beliefs in the face of contradictory evidence. Person-who reasoning is questioning a well-established finding based on awareness of one person who violates the established finding. For example, a student may insist that eating a steak and a baked potato loaded with butter, sour cream, cheese, and salt for dinner is healthy because his grandfather did so every night for 50 years and lived to be 90 years old.

2. Testing medical hypotheses. Physicians (and patients) seem to have some difficulty in interpreting positive test results for medical screening tests, such as for various types of cancer and HIV. They often overestimate the probability that a patient has a disease on the basis of one positive test result. Both doctors and patients have been found to overestimate these conditional probabilities. In medicine, probabilities are often expressed in percentages rather than as numbers between 0 and 1.0. The base rate (prevalence) of a disease is simply the probability with which it occurs in the population. The sensitivity rate for a screening test is the probability that a patient will test positive if she has the disease, and the false-positive rate is the probability that a patient will test positive if she does not have the disease.

Now, try this problem: Estimate the probability that a woman has breast cancer given a positive mammogram result and a base rate for this type of cancer of 1 percent, a sensitivity rate for the test of 80 percent, and a false positive rate for the test of 9.6 percent.

If you acted like the doctors, you overestimated the probability. Almost all of the doctors estimated this probability to be around 75 percent. The correct answer, however, is much less, only around 8 percent. To correctly compute the conditional probability that someone has the disease given a positive test result, Gigerenzer (2002) recommends that you convert all of the percentages (probabilities) into natural frequencies, simple counts of events. According to Gigerenzer, natural frequencies represent the way humans encoded information before probabilities were invented and are easier for our brains to understand.

It would be helpful to consult Figure 6.2 at this point before presenting the following analysis to the class.

- Given a base rate of 1 percent, we would expect 10 (1 percent of 1,000) women to have breast cancer.
• Of these 10, we expect 8 (80 percent of 10) to test positive because the test has a sensitivity rate of 80 percent. The results for these 8 women are called true positives because these women have breast cancer and their test results were positive. The test results for the other 2 women are called false negatives because these women have breast cancer but their test results were negative.
• Among the 990 (1,000–10) women without breast cancer, 95 (9.6 percent of 990) will test positive given the 9.6 percent false positive rate. The results for these 95 women are called false positives because these women do not have cancer but their test results were positive. The results for the remaining 895 women are called true negatives because these women do not have cancer and their test results were negative.
• Thus, 103 (8 + 95) women in the sample of 1,000 will test positive, but only 8 are true positives. Thus, the conditional probability that a woman testing positive actually has cancer is the percentage of positive test results that are true positives, 8/103 = .077 (7.7 percent).

III. Intelligent Thinking

Finding a definition of intelligence that most psychologists can agree on is not easy to do.

PsychSim 5 Tutorial: Get Smart
This module is useful for introducing this section of the text, particularly the controversy surrounding what is meant by intelligence, which the module defines as “a term psychologists use to describe individual differences in cognitive ability” and “a capacity to function well in one’s environment.” The module stresses that intelligence cannot be measured objectively. After a brief glimpse into Spearman’s ideas (also covered in the text), the Wechsler Adult Intelligence Scale (WAIS) is examined. Many test items (not actual test items but items that are similar to the real WAIS) representing subscales of the nonverbal and verbal abilities sections are presented. Then the notion of multiple intelligences is presented, with an emphasis on Gardner’s and Sternberg’s theories of multiple intelligences. Savant syndrome, evidence in favor of the multiple intelligence argument, is discussed. Then creativity, defined as “an ability to generate useful new ideas or solutions to problems,” is presented, along with the notion of emotional intelligence. The module concludes with a return to the idea that intelligence seems to be grounded in an ability to adapt to one’s surroundings; thus, a person can be highly intelligent in one situation, but not in another situation.

Other videos to introduce the topic of intelligence include the following:

Worth Video Anthology for Introductory Psychology: Hothouse Babies: Mother Tries to Teach Her Two-Year-Old Multiplication (1:52)
This video shows a mother trying to teach tasks to her daughter that are beyond the daughter’s level of development. Within the realm of cognitive development, this video allows for discussion of nature versus nurture, issues of “gifted” and “normal” children, and the potential importance of structuring children’s time.

Worth Video Anthology for Introductory Psychology: Psychologist Ellen Winner Discusses “Gifted” Children (3:15)
This video provides an operational definition of what is meant by “gifted” children, a definition that consists of three characteristics: precocity, rage to master, and marching to their own drummer. This video expands on these characteristics, giving examples from different life domains. The origins of giftedness are also discussed.
This is another excellent video resource to help students understand the history and purpose of intelligence testing, from Binet to current methods of testing such as the WAIS. Limitations of intelligence testing as well as bias from test scores are discussed.

A. Intelligence Tests

Intelligence tests have been embedded in the nature–nurture controversy since they were first developed.

1. Intelligence tests were first developed in late nineteenth-century England and early twentieth-century France.
   a. Sir Francis Galton tried to develop an intelligence test for the purpose of eugenics, selective reproduction to enhance the capacities of the human race. Galton believed in the genetic determination of intelligence and thought he could measure intelligence by measuring various aspects of the human brain and nervous system (a strong emphasis on nature). He developed tests of sensory abilities and reaction time and tested thousands of people, although the tests turned out not to be good predictors of intelligence. Galton invented the basic mathematics behind correlational statistics.
   b. In France in the early twentieth century, Alfred Binet and Theophile Simon were working on the problem of mental retardation. They developed a test for diagnosing children who were subnormal. Published in 1905, this test was the first accepted test of intelligence. Here is how it worked: Mental age is typically associated with a child’s level of performance. If a child's mental age is less than his or her chronological age, the child needs remedial work. Binet and Simon’s work emphasized the effect of nurture on intelligence.
   c. Lewis Terman at Stanford University revised Binet and Simon’s test for use with American schoolchildren. In 1916, Terman’s revision became known as the Stanford-Binet test, and Terman used the classic intelligence quotient formula suggested by William Stern, a German psychologist.

   The intelligence quotient (IQ) formula was

   \[ \text{IQ} = \left( \frac{\text{mental age}}{\text{chronological age}} \right) \times 100 \]

   When a child’s mental age as assessed by the test was greater than the child’s chronological age, the child’s IQ was greater than 100. When a child’s mental age as assessed by the test was less than the child’s chronological age, the child’s IQ was less than 100. The IQ formula is no longer used because it is biased against older people.

   d. David Wechsler was chief psychologist at Bellevue Hospital in New York City in the 1930s and was in charge of adult patients of diverse backgrounds. The Stanford-Binet test was not designed to assess adult intelligence, and the IQ was particularly problematic for adults because at some point the mental age levels off but the chronological age keeps increasing (a person’s IQ declines simply because of natural aging). In 1939, Wechsler developed his own test, the Wechsler Bellevue Scale; the name was changed to the Wechsler Adult Intelligence Scale—WAIS—in 1955. The WAIS is a battery of both verbal tests (such as vocabulary and comprehension) and performance (nonverbal) tests (such as block design and picture arrangement).

Class Activity: Intelligence Testing

The author of the textbook, Richard Griggs, has developed two “intelligence tests” you can give to your students. These are not “real” intelligence tests but rather the means of introducing students to the notions of psychometrics and the difficulty inherent in operationalizing the concept of intelligence. Make enough copies of both tests for each student in the class to have one.
Explain to the class that they will be taking an intelligence test. They will write responses to 24 numbered problems, so they should number a piece of paper from 1 to 24. The problems will consist of a combination of words, letters, and pictures that represent a common saying in the English language. Then give students an example problem, such as STTHEROY, and ask them to think it through (correct response: “the inside story”).

Allow 60 seconds for the first test. After 60 seconds are up, have students stop writing and count the number of items they answered. (We have had not problems with student anonymity issues.) To estimate central tendency and variability in performance, count backwards from 24 to 0, and ask students to raise their hands when you reach the number of responses they wrote down.

Go over the answers to the test. Usually, students have no problem coming up with the answers. Thus, students will think the test is easy and their performance a function of the limited amount of time to complete it, providing a chance to bring up the notion of validity.

You can then introduce the second test, saying that the first test was merely practice. On the second test, students have 5 minutes. However, the items on the second test, as you probably noticed, are much more difficult, and students gain little by the additional time. In fact, we find that most students do worse on the second test than on the first.

After the 5 minutes are up, estimate central tendency and variability again, but do not provide answers (so that students can have the joy of insight). We find that students who did well on the first test tend to do well on the second test, thus attesting to test reliability. This leads us into a discussion of test standardization, reliability, and validity.
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Answers to the First “Intelligence Test”

1. Sandbox
2. Man Overboard
3. I understand
4. Reading between the lines
5. Long underwear
6. Crossroads
7. Downtown
8. Tricycle
9. Split-level
10. Three degrees below zero
11. Neon lights
12. Circles under the eyes
13. Highchair
14. Paradise
15. Touchdown
16. Six feet underground
17. Mind over matter
18. He’s beside himself
19. Backward glance
20. Life after death
21. GI overseas
22. Space program
23. See-through blouse
24. Just between you and me

Answer to Advanced “Intelligence” Test

1. Split-second timing
2. A long letter from home
3. All between us is over now
4. Six of one, half a dozen of another
5. It’s a small world after all
6. Unfinished symphony
7. Blood is thicker than water
8. Seven-up
9. Condescending
10. Scrambled eggs
11. No two ways about it
12. Line up in alphabetical order
13. A gross injustice
14. The odds are overwhelming
15. He’s an exponent of capitalism
16. Astronaut
17. Ambiguous
18. A wolf in sheep’s clothing
19. Sailing, sailing, over the seven seas
20. Assassinate
21. For no apparent reason whatsoever
22. A little misunderstanding between friends
23. A bad spell of weather
24. He came out of nowhere


2. Deviation IQ scores involve standardization, a process that allows test scores to be interpreted according to test norms. A test is given to a large, representative sample of the relevant population, and the scores of the sample serve as norms for interpretation of other scores. For example, Terman standardized his Stanford-Binet on American children of various ages. Any child’s raw score could be compared with the standardization norms to calculate the child’s mental age.

   Wechsler collected standardization data for various adult age groups, and the data for each age group formed a normal distribution (see Figure 6.4). To calculate a person’s deviation IQ, Wechsler compared how far the person’s raw score was from the mean raw score in terms of standard deviation units from the mean. To make the deviation scores resemble the IQ formula, he set the mean to 100 and the standard deviation to 15. Deviation IQ score is 100 plus or minus (15 x the number of standard deviation units a person’s raw test score is from the mean of the relevant age group norms).

3. In addition to being standardized, a good test must possess two other characteristics, namely, reliability and validity.

   a. Reliability is the extent to which the scores for a test are consistent. In the test-retest method, the test is given twice to the same sample, and the correlation coefficient for the two sets of scores is computed. A reliable test yields a strong positive correlation, at least of +0.70.
Alternate form reliability can be assessed if multiple forms of the test are available. A researcher gives different forms of the test to the same sample at different times and computes the correlation coefficient for performance on the two forms.

Split-half reliability is determined by correlating performance on two halves of one test (for example, odd- and even-numbered items).

b. **Validity** is the extent to which a test measures what it is supposed to measure (content validity) or predicts the behavior it is supposed to predict (predictive validity).

It is important to note that if a test is valid, it will also be reliable. However, a test can be reliable but not valid (for example, using wrist size to measure intelligence; wrist size is reliable, but it is not valid as a measure of intelligence).

B. **Controversies About Intelligence**

**Worth Video Anthology for Introductory Psychology: Savant Music Skills (5:14)**

This video highlights a child named Rex who is blind and has autistic-like symptoms but has been described as a musical genius. This is an excellent video to introduce the concept of multiple intelligences, specifically in cases where individuals like Rex have impaired functioning in most areas of their lives but excel in one particular area. One of the individuals interviewed describes his abilities as though “the musical software is already in Rex.”

The argument about whether intelligence is a single general ability or a collection of specific abilities has been debated for more than one hundred years.

1. Several scientists have come up with theories of intelligence.
   a. Charles Spearman argued that intelligence is a function of two types of factors: (1) a factor of general intelligence, g, and (2) a factor of specific intellectual abilities such as reasoning, s. Spearman believed that the g factor was more important because people who did well on one subtest usually did well on most of the subtests, and people who did poorly on one subtest usually did poorly on most of the subtests. Contemporary research has shown the g factor to be a good predictor of performance both in school and at work.
   b. L. L. Thurstone argued for the importance of several mental abilities: verbal comprehension, number facility, spatial relations, perceptual speed, word fluency, associative memory, and reasoning. Thurstone identified these abilities via **factor analysis**, a statistical technique that identifies clusters of test items that measure the same ability (factor).
   c. Raymond Cattell and James Horn proposed two types of intelligence, which have been of particular interest to researchers in aging. Fluid intelligence refers to abilities independent of acquired knowledge, such as abstract reasoning, logical problem solving, and the speed of information processing. Crystallized intelligence refers to accumulated knowledge and verbal and numerical skills.
   d. Howard Gardner’s theory of multiple intelligences includes eight independent types of intelligence (summarized in Table 6.1):
      - **Linguistic intelligence**: Language ability in reading, writing, and speaking
      - **Logical-mathematical intelligence**: Mathematical problem solving and scientific analysis
      - **Spatial intelligence**: Reasoning about visual spatial relationships
      - **Thinking**: Processing of information to solve problems and make judgments and decisions
      - **Musical intelligence**: Musical skills such as the ability to compose and understand music
      - **Bodily-kinesthetic intelligence**: Skill in body movement and handling objects
      - **Intrapersonal intelligence**: Understanding of oneself
- Interpersonal intelligence: Understanding of other people
- Naturalist intelligence: Ability to discern patterns in nature

e. Robert Sternberg’s triarchic theory of intelligence proposes three types of intelligence:
   - Analytical intelligence: Essentially what is measured by standard intelligence tests, the necessary skills for good academic performance
   - Practical intelligence: Good common sense or “street smarts”
   - Creative intelligence: Ability to solve novel problems and deal with unusual situations

f. Cognitive researcher Keith Stanovich (2009a, b) argues that intelligence is a meaningful, useful construct. Unlike Gardner and Sternberg, Stanovich is not interested in expanding the definition of intelligence; rather, he argues that intelligence is only one component of good thinking and thus by itself is not sufficient to explain such thinking. The other critical component is our ability to think and act rationally, which is not assessed by standard intelligence tests. Stanovich coined the term “dysrationalia” to describe this failure to think and behave rationally despite having adequate intelligence. One cause of dysrationalia is that we tend to be cognitive misers, taking the easy way out to avoid thinking too much. This is the reason we have developed a whole set of heuristics and biases (many—such as anchoring, representativeness, and confirmation bias—were discussed earlier in this chapter) to limit the amount of thinking in which we need to engage.

Table 6.2 presents a summary of these theories of intelligence.

Worth Video Anthology for Introductory Psychology: Savant Art Skills: In Autism and Dementia (5:55)
This video details the work of a 14-year-old artist with autism. The subject, Jonathan, did not begin drawing until he was 10. Jonathan’s mother described the transition from believing that she had a handicapped child to realizing that her child was incredibly gifted (Jonathan’s artwork sells for up to $2,000 each in NYC art galleries.) The contrast between Jonathan’s artwork and his difficulties with basic life skills is striking and an excellent conversation starter with students.

Student Video Tool Kit Activities: Savant Music Skills
This activity includes a video, Musically Speaking (3:25), which illustrates savant syndrome. Miller (1999) has explained that individuals with savant syndrome have a general intellectual impairment, but demonstrate exceptional skill in one particular area. The existence of savant syndrome, publicized in the movie Rain Man, provides support for the conception of multiple intelligences. In the video, a man who cannot accurately report his age or his experience with playing the piano (or count to three using his fingers) shows how he has mastered a wide repertoire of musical compositions and how he can instantaneously rearrange music to conform to the styles of multiple composers (e.g. classical music performed by contemporary musicians).


2. Most contemporary psychologists believe that both heredity (nature) and environmental experiences (nurture) are important in determining intelligence. The disagreement is over the relative contribution of each influence to intelligence.
Genetic similarity studies are important in determining the relative contribution of nature and nurture to intelligence. Identical twins have 100 percent genetic similarity; fraternal twins and siblings have 50 percent similarity; two unrelated people have 0 percent similarity. If intelligence were due to heredity, the average correlations between intelligence scores should decrease as genetic similarity decreases, and researchers have found this to be the case.

However, other experimental results support environmental influences on intelligence. For example, if identical twins are raised together, the correlation between their intelligence test scores is +0.86, but if identical twins are raised apart, the correlation falls to +0.72.

Here is an example of the joint influence of nature and nurture on intelligence. The average correlation between fraternal twins raised together (+0.60) is less than that for identical twins reared apart (+0.72), indicating the influence of heredity. The average correlation is greater than that for ordinary siblings reared together (+0.47), indicating environmental influences, because the environmental influences on fraternal twins are more similar than those on ordinary siblings at different ages.

There is a correlation between the intelligence test scores of adopted children and the scores of their adoptive parents, but it disappears as the children age. The reverse is true, however, for the correlation between the scores of adopted children and the scores of their biological parents: it increases. The stronger relationship between a person’s intelligence and that of the person’s biological parents means that nature plays a larger role in determining a person’s intelligence than do environmental experiences.

Heritability determines a reaction range, genetically determined limits for an individual’s intelligence, but the quality of the person’s environmental experiences determines where the individual falls within the reaction range.

Heritability is an index of the degree of variation of a trait that is due to heredity within a given population. Most research estimates that 50 percent to 70 percent of the variation in intelligence test scores is due to heredity. Because the figure is not 100 percent, heredity and environment must interact to determine intelligence. Heritability is a group statistic; it is not relevant to individual people. Heritability has nothing to do with the differences that have been observed between populations, such as the difference in scores of Asian versus American schoolchildren.

The Flynn effect is the steady improvement in average intelligence scores over the past century in the United States and other Western industrialized nations. Proposed explanations involve many environmental factors, such as better nutrition and more education.

**Class Activity/Assignment: Psychometrics**

These questions (or variations on these questions) can be used to illustrate and help students learn the principles of psychometrics. The questionnaire can be used as an assignment or an in-class activity. This activity can also be used when teaching Chapter 8 (Personality).

1) Explain each of the following testing concepts. For each concept, explain one way that it can be established for a particular test.
   a. Reliability
   b. Validity
   c. Standardization

2) Consider the following distribution of five scores: 39, 45, 32, 56, 33. Use this distribution to calculate the following statistics.
   a. Mean
   b. Median
   c. Mode
   d. Range
   e. Standard deviation
3) In a distribution of 20 scores, suppose all scores are 17. What is the value of the
   a. mean?
   b. range?
   c. standard deviation?
4) In class, we defined the standard deviation as “a special kind of average.”
   a. What is it an average of?
   b. Why do researchers generally prefer the standard deviation to the range as a measure of variability?
5) In statistics, what makes a distribution of scores “normal?”
6) Suppose you gave a test of impulsiveness to a large, representative group of people. Assume that the scores are normally distributed, with a mean on the test of 100 and a standard deviation of 20. Use this information to answer the following questions.
   a. What percentage of people scored between 80 and 100 on the test?
   b. What is the percentile rank for a person who scored 60 on the test?
   c. What is the score of a person who is two standard deviations below the mean?
   d. What percentage of test takers scored below 120?

Answers to Class Activity/Assignment: Psychometrics

1) a. Reliability is the extent to which the scores for a test are consistent. There are three ways to establish reliability. In test-retest, the same test is given to the same people at two different times, and the scores of the two test occasions are correlated. In alternate form reliability, two tests that measure the same underlying construct/trait are given, usually at one time, and the scores on the two tests are correlated. Split-half reliability is perhaps the most “convenient” form of reliability to calculate because it requires giving one test to people just one time and correlating the scores on two “halves” of the test.
   b. Validity is the extent to which a test measures what it is supposed to measure (content validity) or predicts what it is supposed to predict (predictive validity).
   c. Standardization is the process that allows test scores to be interpreted by test norms. A test is standardized by being given to a large, representative group of people, and establishing “meaningful scores” (statistics) that allow for comparison.
2) a. 41
   b. 32
   c. no mode; all scores occur once
   d. 24 + 56 – 32
   e. 9.87
3) a. 17
   b. 0 = 17 – 17
   c. 0
4) a. The standard deviation is an average of the extent to which scores in a distribution tend to stray from (are scattered around) the mean.
   b. The standard deviation uses all scores in a distribution in its calculation, whereas the range uses only two numbers in its calculation. The standard deviation is less affected than is the range by extreme scores.
5) The distribution forms a symmetrical shape such that an equal number of scores fall above and below the mean. In addition, the measures of central tendency (the mean, median, and mode) are all approximately equal.
6) a. 34 percent
   b. 16th percentile
   c. 60
   d. 84 percent