Chapter 8
Thinking and Intelligence
Section 8.1

What Is Thinking?
Thinking Is the Manipulation of Mental Representations

• Thinking
  – The mental manipulation of representations of information we encounter in our environments
  – Cognitive psychologists study thought and the understanding that results from thinking
Thinking Is the Manipulation of Mental Representations

- **Analogical representations**: Mental representations that have some of the physical characteristics of objects
- **Symbolic representations**: Abstract mental representations that consist of words or ideas

- See figure 8.2 next slide
(a) [Image of a violin]

(b) Violin
Thinking Is the Manipulation of Mental Representations

• Mental maps
  – Mental maps include a combination of analogical and symbolic representations

• See figure 8.3 next slide
Thinking Depends on Categorization of Concepts

• Schemas and the categorization of concepts
  – Schemas are our prior knowledge and experience with information
  – Schemas are related to the organization of analogical and symbolic representations in our minds
Thinking Depends on Categorization of Concepts

• Schemas and the categorization of concepts
  – When we use a schema to group things based on shared properties, we create a category
  – **Concept:** A mental representation of objects, events, or relations around common themes

• See figures 8.5a, 8.5b and table 8.1 next slide
(a) Category: group that is based on knowledge of shared properties

Country Music Instruments

- Guitar
  - Usually has six strings
  - Played by plucking

- Fiddle/violin
  - Usually has four strings
  - Played with a bow

Orchestral Music Instruments

- Trumpet
  - Has brass tubing
  - Played by blowing into it

(b) Concept: specific knowledge about a particular object

<table>
<thead>
<tr>
<th>TABLE 8.1</th>
<th>Models of Organizing Concepts</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>MODEL</strong></td>
<td><strong>WAY OF CATEGORIZING CONCEPTS</strong></td>
</tr>
<tr>
<td>Defining attribute model</td>
<td>• Concepts are organized in hierarchical categories.</td>
</tr>
<tr>
<td></td>
<td>• Concepts are characterized by attributes (features) necessary for an object to be a member of a category.</td>
</tr>
<tr>
<td></td>
<td>• No one concept in the category is a better fit than any other.</td>
</tr>
<tr>
<td>Prototype model</td>
<td>• Concepts are organized in hierarchical categories.</td>
</tr>
<tr>
<td></td>
<td>• The prototype is the concept that is the “most typical” category member.</td>
</tr>
<tr>
<td></td>
<td>• Other concepts are categorized as similar or different from the prototype based on how many characteristics they share with the prototype.</td>
</tr>
<tr>
<td>Exemplar model</td>
<td>• Concepts are not organized hierarchically.</td>
</tr>
<tr>
<td></td>
<td>• No single concept is the best member of a category.</td>
</tr>
<tr>
<td></td>
<td>• All examples, or exemplars, of concepts in a category equally represent the category.</td>
</tr>
</tbody>
</table>

The category of Sports refers to “an athletic activity, often competitive, requiring physical skill.”

One subordinate category could be Team Sports. This category could include the concepts “baseball” and “basketball.”

Another subordinate category might be individual Sports. This category could include the concepts “skiing” and “surfing.”

In the category Sports, the prototype might be “baseball.”

Characteristics of “baseball” might include that the game uses a ball.

Sports with shared characteristics (“basketball”) are similar to the prototype.

Sports with dissimilar characteristics (“surfing”) are different from the prototype.

The category of Sports is equally represented by all exemplars in the category (including “baseball,” “basketball,” “surfing,” etc.).
Thinking Depends on Categorization of Concepts

• Defining attribute model
  – A way of thinking about concepts. A category is characterized by a list of features that determine if an object is a member of the category

• See figure 8.6 next slide
Thinking Depends on Categorization of Concepts

• Prototype model
  – A way of thinking about concepts. Within each category, there is a best example—a prototype—for that category

• See figure 8.8 next slide
<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Oranges</th>
<th>Grapes</th>
<th>Tomatoes</th>
<th>Olives</th>
</tr>
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<tbody>
<tr>
<td>Seeds</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
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<tr>
<td>Edible</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Sweet</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Psychology in Your Life  Figure 8.8  Copyright © 2014 W. W. Norton & Company, Inc.*
Thinking Depends on Categorization of Concepts

• Exemplar model
  – A way of thinking about concepts. All concepts in a category are examples (exemplars); together, they form the category
Thinking Depends on Categorization of Concepts

• Stereotypes
  – Cognitive schemas that allow for easy, fast processing of information about people, events, or groups, based on their membership in certain groups
  – Gender role stereotypes are the socially prescribed behaviors for females and males

• See figures 8.10a, 8.10b next slide
Section 8.2

How Do We Make Decisions and Solve Problems?
8.2 How Do We Make Decisions and Solve Problems?

• **Reasoning**
  – Using information to determine if a conclusion is valid or reasonable

• **Decision making**
  – Attempting to select the best alternative among several options

• **Problem solving**
  – Finding a way around an obstacle to reach a goal

• See figures 8.11a, 8.11b next slide
You use decision making to select between options. In 2008, a 9-month-old girl’s uncle had to decide whether to carry her through a burning apartment building or drop her several stories into the arms of a police officer waiting below. The uncle said, “I looked into his eyes and saw that he would catch her. Then I let her go.”

You use problem solving to overcome obstacles. For example, how did this man solve the problem of getting out of the corner he painted himself into?
How We Think Biases Decision Making

• An algorithm is a set of procedures to follow when thinking and making a decision

• “Rule of thumb” decisions are generally fine—good enough in our daily lives
How We Think Biases Decision Making

• Heuristics
  – **Heuristic**: A shortcut (rule of thumb or informal guideline) used to reduce the amount of thinking that is needed to make decisions
  – The availability heuristic is the tendency to make a decision based on information that comes most easily to mind
How We Think Biases Decision Making

• Heuristics

  – The representativeness heuristic is the tendency to place people or objects in a category if they are similar to the concept that is the prototype

  – The representativeness heuristic can lead to faulty reasoning if we fail to take other information into account (e.g., the base rate)
How We Think Biases Decision Making

- Framing
  - How information is presented affects how that information is perceived and influences decisions

- The paradox of choice
  - When too many options are available, especially when all of them are attractive, we experience conflict and indecision

- See figures 8.14a, 8.14b next slide
(a)

(b)

*Psychology in Your Life*  Figure 8.14
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We Solve Problems to Achieve Goals

• Subgoals
  – In many cases, solving the problem requires breaking the task into subgoals

• See figure 8.15 next slide
(a) The goal: Move the disks to the peg on the other end. You can move only one disc at a time. You cannot place a larger disc on top of a smaller disc.

(b) The solution:
1. Break the task down into subgoals. The first subgoal is to move the largest disc to the farthest peg.
2. The smallest disc is moved first to the farthest peg.
3. The middle disc is moved to the middle peg.
4. The smallest disc is moved to the middle peg on top of the middle disc.
5. The largest disc is moved to the farthest peg. This move achieves the first subgoal.
6. The next subgoal is to move the middle disc to the farthest peg. The smallest disc is moved to the first peg.
7. The middle disc is moved to the farthest peg. This move achieves the second subgoal.
8. Finally, to reach the main goal, the smallest disc is moved to the farthest peg.
We Solve Problems to Achieve Goals

• Working backward
  – Working backward is helpful when the appropriate steps for solving a problem are not clear; it involves proceeding from the goal state to the initial state

• Analogy
  – Finding an appropriate analogy for a problem can help achieve goals

• See figures 8.16a, 8.16b next slide
We Solve Problems to Achieve Goals

• Sudden insight
  – Insight is the metaphorical lightbulb that goes on in your head when you suddenly realize the solution to a problem
  – Wolfgang Kohler, insight in chimpanzees experiment

• See figure 8.17 and table 8.2 next slide
The goal: The chimpanzees want to reach the bananas, which are out of reach.

The solution: As shown here, the chimp in Köhler’s study seemed to suddenly realize a solution. It stacked several boxes on top of each other and stood on them to reach the bananas. This behavior suggested that the chimp solved the problem through insight.

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**TABLE 8.2**

<table>
<thead>
<tr>
<th>TECHNIQUE</th>
<th>CHARACTERISTICS</th>
<th>SAMPLE PROBLEM</th>
<th>SOLUTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subgoals</td>
<td>Identify the goal state and several subgoals to be achieved.</td>
<td>Talia wants to repair the car muffler, but she doesn’t have enough money to pay for repairs.</td>
<td>To reach the goal of having enough money for repairs, she researches the best price, cuts spending for a month, and works more.</td>
</tr>
<tr>
<td>Working backward</td>
<td>Begin from the goal state and work backward to the current state.</td>
<td>Bradley wants to graduate in 2 years, but he isn’t sure what courses he needs to take.</td>
<td>First he identifies the credits needed to graduate, then the credits needed per term, then the credits needed this term, and finally the classes that provide the needed credits for this term.</td>
</tr>
<tr>
<td>Analogy</td>
<td>Identify a previously solved problem that is similar to the current problem.</td>
<td>Roberto cooks beef with broccoli, but the broccoli ends up soggy.</td>
<td>He thinks about how, when he mows the lawn with his shirt on, his shirt gets damp with sweat. In the same way, moisture from the beef ruins the broccoli. Next time, he cooks the beef and broccoli separately, then combines them.</td>
</tr>
<tr>
<td>Insight</td>
<td>Take a break from actively thinking about the problem.</td>
<td>Amelia has a hard time solving a difficult calculus problem.</td>
<td>She puts the problem away for a while. When she returns later on, the answer pops into her mind.</td>
</tr>
</tbody>
</table>
We Overcome Obstacles to Solve Problems

• Restructuring
  – Thinking about a problem in a new way in order to solve it

• Overcoming mental sets
  – **Mental sets**: A tendency to approach a problem in the same way that has worked in the past, which may make it harder to solve it

• See figure 8.18 next slide
(a) The goal: Connect the dots by using at most four straight lines. Most participants consider only solutions that fit within the square formed by the dots.

(b) The solution: Restructure the mental representation to include solutions in which the lines can extend beyond the boundary formed by the dots.
We Overcome Obstacles to Solve Problems

• Overcoming functional fixedness
  – **Functional fixedness**: A tendency to think of things based on their usual functions, which may make it harder to solve a problem

• See figures 8.19a, 8.19b next slide
The goal: Attach the candle to the wall using only a pack of matches and a box of tacks.

The solution: The box for the tacks can be used as a stand for the candle, and the candle can be lit with the matches.
Section 8.3
What Is Intelligence?
8.3 What Is Intelligence?

- **Intelligence**
  - The ability to use knowledge to reason, make decisions, make sense of events, solve problems, understand complex ideas, learn quickly, and adapt to environmental challenges

- See figure 8.20 next slide
Albert Einstein developed the general theory of relativity. He is considered by many to be the “father of modern physics.” His intelligence quotient (IQ) is thought to have been 160.

The contestants at the 2012 Scripps National Spelling Bee demonstrated their spelling skills. They drew on their knowledge of word meanings, word origins, and the rules and irregularities of English.

The rapper, songwriter, producer, and actor Eminem is one of the best-selling musicians in the world. In July 2012, Eminem became the first person to reach 60 million “friends” on Facebook.

In 2012, the Austrian skydiver Felix Baumgartner successfully free fell from Earth’s stratosphere, from a height of 28,000 feet.

The talk-show host, media mogul, and philanthropist Oprah Winfrey is arguably one of the most influential women in the world. She was the first African American billionaire.
One General Factor May Underlie Intelligence

• IQ scores reveal intelligence
  – Alfred Binet
  – **Intelligence quotient (IQ):** An index of intelligence originally computed by dividing a child’s estimated mental age by the child’s chronological age, then multiplying this number by 100

• See figure 8.21 next slide
Intelligence is due to one general factor.

Binet

Intelligence quotient
One General Factor May Underlie Intelligence

- General intelligence
  - Charles Spearman
  - **General intelligence**: The idea that one general factor underlies intelligence

- See figure 8.22 next slide
There May Be Multiple Aspects of Intelligence

- Fluid and crystallized intelligence
  - Raymond Cattell
  - **Fluid intelligence**: Intelligence that reflects the ability to process information, particularly in novel or complex circumstances
  - **Crystallized intelligence**: Intelligence that reflects both the knowledge a person acquires through experience and the ability to use that knowledge

- See figure 8.23 and table 8.3 next slide
### Table 8.3
#### Theories of Intelligence

<table>
<thead>
<tr>
<th>MODEL</th>
<th>KEY CHARACTERISTICS</th>
<th>EXAMPLE</th>
</tr>
</thead>
</table>
| General intelligence | - There is a single factor underlying intelligence.  
|                      | - This factor tends to yield higher IQ scores.                                                                                                                                                                       | Marisol’s high IQ score reveals that she has high general intelligence. |
| Fluid and crystallized intelligence | - General intelligence is made up of fluid and crystallized intelligence.  
|                      | - Fluid intelligence: thinking quickly and flexibly in novel, complex situations.  
|                      | - Crystallized intelligence: knowledge from experience that is used to solve problems.                                                                                                                   | Michael shows fluid intelligence when he quickly and calmly thinks of another way to present his data after his laptop dies.  
|                      |                                                                                                           | Elena’s strong crystallized intelligence helps her know the answers to crossword puzzles. |
| Multiple intelligences | - Many intelligences are not measurable by IQ tests.  
|                      | - These intelligences include musical, bodily-kinesthetic, linguistic, mathematical/logical, spatial, intrapersonal, and interpersonal.                                                                                       | Brian can play any tune on his guitar after hearing it once. He is probably high in musical intelligence.  
|                      |                                                                                                           | Shanice shows high intrapersonal intelligence when she creates a study plan based on knowledge of her own study habits. |
| Triarchic theory      | - There are three aspects of intelligence.  
|                      | - Analytical intelligence: skill in solving problems and puzzles.  
|                      | - Creative intelligence: ability to think in new and interesting ways.  
|                      | - Practical intelligence: skill in dealing with everyday tasks.                                                                                                                                                    | Viktor shows strong analytical intelligence because he is a highly strategic chess player.  
|                      |                                                                                                           | John shows creative intelligence because he can survive anywhere with just a few dollars in his pocket. |
|                      |                                                                                                           | Zahara may be low in practical intelligence because she constantly loses her car keys. |
| Emotional intelligence | - Emotional intelligence: skills in managing emotions and recognizing them in other people.                                                                                                                        | When Glynnis feels herself getting angry with her boss, she takes a walk so she can calm down. She likely has high emotional intelligence. |
There May Be Multiple Aspects of Intelligence

- Multiple intelligences: The idea that people have many different types of intelligence that are independent of one another
There May Be Multiple Aspects of Intelligence

• Multiple intelligences
  – Howard Gardner
  – Multiple intelligences are: Bodily-kinesthetic, linguistic, mathematical/logical, spatial, intrapersonal, and interpersonal

• See figure 8.24 next slide
There May Be Multiple Aspects of Intelligence

• Multiple intelligences
  – Robert Sternberg
  – **Triarchic theory**: The idea that people have three types of intelligence: analytical, creative, and practical
There May Be Multiple Aspects of Intelligence

• Multiple intelligences
  – Robert Sternberg’s triarchic theory:
    – Analytical intelligence is similar to that measured by standard intelligence tests
    – Creative intelligence involves the ability to gain insight and solve novel problems
    – Practical intelligence refers to dealing with everyday tasks

• See figure 8.25 next slide
There May Be Multiple Aspects of Intelligence

• Emotional intelligence (EI)
  – This form of intelligence consists of four abilities: managing our own emotions, using our emotions to guide our thoughts and actions, recognizing other people’s emotions, and understanding emotional language
Intelligence Is a Result of Genes and Environment

• Behavior genetics
  – Behavioral geneticists study the genetic basis of behaviors and traits such as intelligence
  – Twin and adoption studies

• See figure 8.26 next slide
The graph shows the IQ correlation for different relationships:

- **Raised together**:
  - Related by both genetics and environment: 0.8
  - Related only by genetics: 0.5
  - Related only by environment: 0.3

- **Raised apart**:
  - Related by both genetics and environment: 0.7
  - Related only by genetics: 0.4
  - Related only by environment: 0.1

- **Adoptive**:
  - Related by both genetics and environment: 0.1
  - Related only by genetics: 0
  - Related only by environment: 0.5

- **Identical twins raised together**:
  - Related by both genetics and environment: 1
  - Related only by genetics: 1
  - Related only by environment: 0

- **Identical twins raised apart**:
  - Related by both genetics and environment: 0
  - Related only by genetics: 0.5
  - Related only by environment: 1

The table below shows the genetic similarity for different relationships.

<table>
<thead>
<tr>
<th>Relationship</th>
<th>Genetic similarity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Siblings</td>
<td>0.5</td>
</tr>
<tr>
<td>Siblings</td>
<td>0.5</td>
</tr>
<tr>
<td>Siblings</td>
<td>0</td>
</tr>
<tr>
<td>Identical twins</td>
<td>1</td>
</tr>
<tr>
<td>Fraternal twins</td>
<td>0.5</td>
</tr>
<tr>
<td>Identical twins</td>
<td>1</td>
</tr>
</tbody>
</table>

*Psychology in Your Life  Figure 8.26
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Intelligence Is a Result of Genes and Environment

- Environmental factors
  - Poor nutrition
  - Prenatal factors (e.g., the parents’ intake of drugs and alcohol)
  - Postnatal factors (e.g., family, social class, education, cultural beliefs, and our own drug and alcohol use)
- An enriched environment can aid in the development of intelligence

See figures 8.27, 8.28 next slide
Section 8.4

How Do We Measure Intelligence?
8.4 How Do We Measure Intelligence?
Intelligence Is Assessed With Psychometric Tests

• All psychometric tests have some features in common
  – **Reliability**: How consistently a psychometric test produces similar results each time it is used
  – **Validity**: How well a psychometric test measures what it is intended to measure
Intelligence Is Assessed With Psychometric Tests

• Achievement and aptitude tests
  – **Achievement test**: A psychometric test that is designed to test what knowledge and skills a person has learned, ACT
  – **Aptitude test**: A psychometric test that is designed to test a person’s ability to learn— that is, the person’s future performance, SAT
Intelligence Is Assessed With Psychometric Tests

• Intelligence tests
  – Alfred Binet: Original intelligence test
  – Lewis Terman: Stanford-Binet test
  – David Wechsler: The Wechsler Adult Intelligence Scale
Intelligence Is Assessed With Psychometric Tests

• Intelligence quotient
  – **Mental age**: An assessment of a child’s intellectual standing compared with that of same age peers; determined by comparing the child’s test score with the average score for children of each chronological age
  – Normal distribution

• See figure 8.30 next slide
The average IQ is 100.

68.3% of people have IQ scores between 70 and 130.

A person’s IQ must be in the top 2% of the distribution of IQ scores to be eligible for entry into Mensa, the society for highly intelligent people.
Intelligence Is Assessed With Psychometric Tests

- Validity and reliability
  - For psychometric tests to be useful, they must be standardized, they must have reliability, and they must have validity

- See figures 8.31a, 8.31b next slide
(a) Validity

LOW
Results do NOT measure what they intended to.

HIGH
Results measure what they intended to.

(b) Reliability

LOW
Different test results from one time to another

HIGH
Similar test results from one time to another

Psychology in Your Life  Figure 8.31
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Intelligence Is Assessed With Psychometric Tests

• Cultural bias

  – One important criticism of intelligence tests is that they may penalize people who belong or don’t belong to particular cultures or groups
Intelligence Is Associated With Cognitive Performance

• Speed of mental processing
  – People who score lower on intelligence tests consistently respond more slowly on tests of reaction time than those who score higher on intelligence tests
  – Choice reaction time
Intelligence Is Associated With Cognitive Performance

• Working memory and attention
  – General intelligence scores are also closely related to working memory
  – The link between working memory and general intelligence may be attention

• See figures 8.33a and 8.33b next slide
Intelligence Is Associated With Cognitive Performance

• Intelligence and the brain
  – Many studies have documented a relationship between brain size and intelligence; however, these findings are only correlations

• Savants
  – Have minimal intellectual capacities in most domains, but at a very early age demonstrate exceptional ability in some “intelligent” process
  – Rain Man
Many Factors Determine Group Differences in Intelligence

• The most controversial aspect of intelligence testing over the last century has been the idea that genetics can explain overall differences in intelligence scores between racial groups
Many Factors Determine Group Differences in Intelligence

• Biological differences
  – The first issue to consider is whether “race” is a biologically meaningful concept
  – The vast majority of genes—perhaps as many as 99.9 percent—are identical among all humans

• See figures 8.36a, 8.36b next slide
Many Factors Determine Group Differences in Intelligence

• Environmental differences
  – Even if there are differences in IQ score between races, we cannot conclude that race causes the differences if there are any environmental differences between the groups
Many Factors Determine Group Differences in Intelligence

• Stereotype threat
  – **Stereotype threat**: Apprehension about confirming negative stereotypes related to a person’s own group
  – It has been found that stereotyped groups perform worse than non-stereotyped groups when they are being evaluated. This effect is reversed when the threat is reduced, such as when an exam is presented as non-evaluative