Chapter 9

Cognition

Psychology involves the scientific study of the behavior and mental processes of human and nonhuman animals. The term **cognition** refers to the mental processes portion of the study of psychology and can be translated simply to mean thinking. The term *thinking* alone, however, does not do justice to the complex and varied processes that comprise cognition. Cognitive psychologists investigate the wide range of processes that make up thinking, including perception, memory, attention, reasoning, language, and problem solving. Cognitive neuroscientists take the study of thought even further to determine the neural processes and brain regions responsible for various types of cognitions. This chapter on cognition addresses four of the largest and most integrated areas of cognitive research: memory, language, thinking, and problem solving.

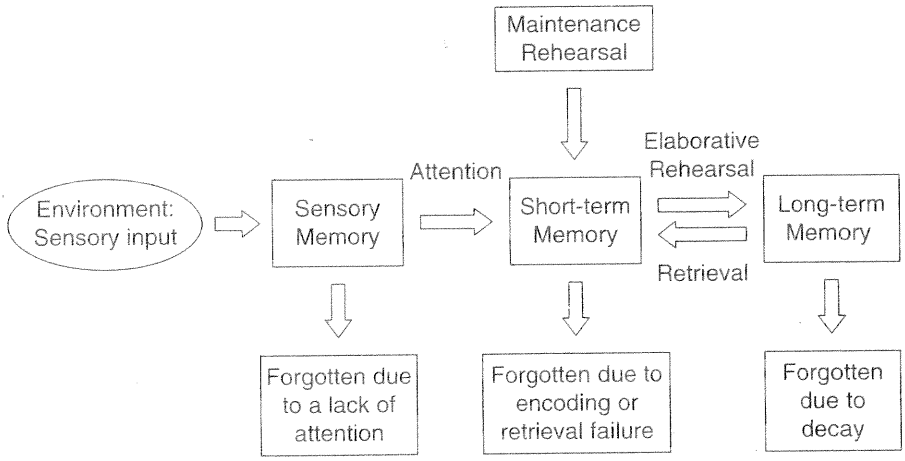
Memory

Memory is the cognitive process that allows individuals to retain knowledge of information and events and is the result of three processes: encoding, storage, and retrieval. Cognitive psychologists investigating memory examine the process in terms of **information processing** or how information travels through the nervous system including perception, memory creation, reasoning, and formulating responses. Information processing theorists have presented a variety of stage models to explain human cognition, but the theory that has received the most attention is the Atkinson and Shiffrin information-processing model of memory.

The three stage **information-processing model of memory** developed by Atkinson and Shiffrin describes memory as a sequential process moving through three distinct stages: sensory memory, short-term memory, and long-term memory. A visual representation of this model is represented in Figure 9.1. Information flows from one stage to the next as it is encoded, stored, and retrieved. The original concept of short-term memory within this model has been expanded by Alan Baddeley and renamed *working memory* and consists of additional components. Within the **working memory model** there is a *central executive* that controls and directs attention through a *visuospatial sketchpad* (visual picture) and *phonological loop* (verbal rehearsal). Items must go through

the working memory to get to long-term storage and must return to working memory to be consciously recalled.

Figure 9.1. Atkinson and Shiffrin's Three-Stage Information-Processing Model of Memory



Encoding

During the process of **encoding**, information is combined, organized, and placed into memory. If information received from the environment does not get placed into memory or if it is not attended to, it will not move past this stage and is referred to as **encoding failure**. Encoding of information happens both automatically and as the result of conscious effort by the individual. **Automatic processing** involves carrying out mental activity quickly and without effort. **Effortful processing**, on the other hand, requires attention and generally results in longer-lasting memories. **Selective attention** processes play a significant role in determining what information is transferred from sensory memory to short-term memory or from short-term into long-term memory. If information is not very important or interesting, the individual is less likely to pay attention or engage in effortful processing, and the result will be either encoding failure or problems with retrieval. One example of the effect attention can have on information being processed is the cocktail-party effect. The **cocktail-party effect** is the ability we possess to focus our attention on one voice while ignoring any other noises that are happening, yet still be aware enough to pick up relevant information like our name. Information that is not being attended to that is happening

in the background most likely is not being processed and will not be available for retrieval later.

Craik and Lockhart's **levels-of-processing model of memory** states that the attention given to the process of encoding will impact future recall. Deeper levels of processing as opposed to shallow levels of processing create more durable memories that can be recalled easier. In order to create deeper memories, one must either enrich the encoding process through rehearsal or choose a more effective type of encoding. **Rehearsal** involves the deliberate, conscious repetition of information. The most effective rehearsal involves the use of elaboration by making as many connections between the new material and what is already known as possible. **Elaborative rehearsal** that utilizes connections to previously learned material provides better retention rates than **maintenance rehearsal** that involves merely repeating information. Examples of maintenance rehearsal include repeating a phone number as one is dialing or stating a fact in one's head over and over until the start of the test. When you study for a test by explaining the vocabulary to yourself in your own words and create original examples, you are using elaborative rehearsal, which is more effective because it involves deeper processing. A particularly effective type of elaborative rehearsal is the **self-reference effect** or the tendency for an individual to have improved recall for information that personally relates to their life. In one study, participants were given a list of adjectives to memorize. Half of the participants were instructed to also rate the list of adjectives in terms of how much each word related to them and half merely memorized the list. The individuals that evaluated the adjectives for personal relevance remembered more words overall because they were personally meaningful, thus demonstrating the self-reference effect.

STUDY TIP

The self-reference effect states that information that is encoded along with a personal connection will be easier to recall. With this in mind, it is important to connect the psychology terms you are learning to personal examples while studying the material. Try to imagine a time when the cocktail-party effect applied to you personally. For example, while talking to a friend at a dance, you were unaware of the noise going on around you, but when you heard your name called as the winner of a prize, you immediately paid attention.

There are also three types of encoding that can impact the ability to retrieve memories at a later date. The method that we use to encode information affects how well we remember the information later. The three types of encoding are visual, acoustic, and

semantic (meaning). Craik and Tulving conducted an experiment that examined which type of encoding—visual, acoustic, or semantic—would result in the best recall. Participants in the experiment were shown words they would need to remember followed by one of three types of questions. They were either asked if the word was written in capitals, rhymed with another word, or was a type of some item. The results indicated that the amount of recall was related to the type of encoding that was used. Words that were shallowly encoded with **visual** memory (written in capitals) had low recall. Words that were intermediately encoded with **acoustic** memory (rhymes with . . .) had better recall. Words that were deeply encoded with **semantic** memory (type of . . .) had the best recall. Semantic encoding, or the processing of meaning, provides the strongest results for memory retention.

STUDY TIP

Be careful to not confuse visual encoding and visual imagery.

- *Visual encoding* refers to how the memory system processes what we experience in terms of a visual image. Whereas, *visual imagery* refers to the mental picture that has been created in one's mind. Visual encoding does not provide deep processing for better recall, while visual imagery does.
- For example, when visually encoding the word *elephant* you would be looking at the individual letters on the screen. However, when you use visual imagery, there is a picture of a four-legged animal in your mind that represents an elephant.

Storage

Individuals use three different mental stages to build their memories: sensory memory, short-term memory, and long-term memory. (See Table 9.1.) Psychologists believe that memory starts at the stage known as **sensory memory**, sometimes called the *sensory register,* where a very short-lived recording of sensory information occurs. George Sperling investigated sensory memory by presenting participants with a grid containing twelve letters for a limited amount of time. Participants were instructed to recall as many letters as they could after the image disappeared. Most participants were able to report about four letters, but Sperling hypothesized that they actually saw more letters, but their perception of the other letters faded while they were reporting what they saw. Sperling used a system of tones to direct participants' ability to recall. If the participant heard a high tone, they were instructed to report what they had seen on the top row, if they heard a medium tone they were instructed to report what they

had seen on the middle row, and a low pitched tone indicated that they should report what they had seen on the bottom row. The tone was presented *after* the letters were removed so the participants were no longer looking at the actual letters but instead had to rely on the visual trace that remained. Sperling analyzed the recall of the participants and found that the visual sensory store could hold a large amount of information, but only for a very limited time before fading or being passed along to the next stage of memory. Furthermore, sensory memory contains two main types of memories—iconic and echoic. **Iconic memory** (visual sensory store) is the retention of a brief visual image for a fraction of a second so that a person can keep track of an experience from moment to moment. **Echoic memory** (auditory sensory store) is the storage of a brief auditory stimulation for a few seconds. Sensory memory is capable of absorbing enormous amounts of information, but most of it disappears very quickly, either by entering short-term memory or because of a lack of attention. Cognitive psychologists believe that the purpose of sensory memory is to collect potential data about the world and hold onto the material briefly for processing to take place.

Table 9.1. Comparison of the Three Stages of Memory

Stage	Duration	Capacity
Sensory Memory	Seconds	Limitless
Short-term Memory	10 to 30 seconds	Seven, plus or minus two
Long-term Memory	Limitless	Limitless

STUDY TIP

Iconic memory is *not* the same as eidetic imagery. Iconic memory happens in sensory memory and involves the retention of a fleeting visual image. On the other hand, eidetic imagery refers to a visual mental image that remains for a longer period of time (minutes to months). Eidetic imagery is what is actually meant by a photographic memory and is a rare ability that occurs more often in children.

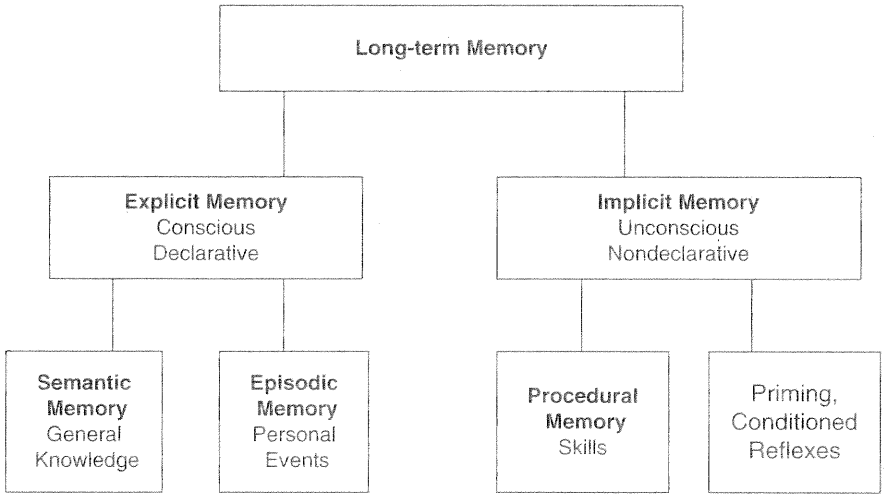
If the individual is not distracted and the information is meaningful, it will then be passed from sensory memory to the second stage known as **short-term memory,** which is also called working memory, because it allows information to be stored long enough to solve problems. Short-term memory is the information storage a person would use

to remember a phone number long enough to make a call. Researchers Peterson and Peterson discovered just how quickly a short-term memory fades. Participants were provided with a group of three-consonants to remember such as KDF. After performing a distraction task, participants were asked to recall the original group of letters. Without rehearsal, subjects could retain the information for only approximately ten to thirty seconds. More specific information about the limits of the capacity of short-term memory was discovered by **George Miller**. In general, people can remember seven items at a time, give or take a few, which is one reason why phone numbers are seven digits long. George Miller said that 7 was the magic number for short-term memory capacity and that individuals could retain 7 **items plus or minus** 2 (5 to 9 items if you want to be more direct than Miller). Even a short interruption will destroy all the information in the short-term store, and in general most short-term memory will fade in a matter of seconds unless extra effort is applied to transfer the information to long-term memory. The process of **rehearsal** allows items in short-term memory to be retained and facilitates the transfer of material from short-term to long-term memory. In most cases, the amount of time allocated for rehearsal is a significant variable relating to how well material is retained. Rehearsal can also be helped by the process of chunking. Short-term memory can store only about seven items; however, some items are larger than others. **Chunking** or grouping related items into meaningful units can increase the amount of material that can be held in short-term memory. This process is used when combining the numbers 4–1–4 into a single area code or the words *American Psychological Association* into the acronym *APA*. Chess masters can memorize entire boards in a few seconds by mentally grouping pieces on the board according to location, function, and so on.

Long-term memory is the third stage of memory and is considered to be a generally permanent storage capable of containing a limitless amount of information. The limitless nature of long-term memory ultimately cannot be proven, but evidence is provided by individuals who possess remarkable levels of memory.

Long-term memory storage is very complex and involves multiple brain areas. Individuals with different types of amnesia have specific problems related to long-term memory based on where the injury occurred. From these case studies, psychologists have been able to divide long-term memory into several different types of memory. Major categories of long-term memory include explicit and implicit memories. Explicit memories (declarative) may either be semantic or episodic, and implicit memories (nondeclarative) include priming, conditioned reflexes, and procedural memories. See Figure 9.2.

Figure 9.2. Different Kinds of Memory



Explicit (declarative) memory can be consciously recalled when requested and sometimes becomes disrupted because of age or amnesia. This type of memory will include conversations, facts and events, and everything we normally think of as memory. Specifically there are two types of explicit memory—semantic and episodic—that are both processed in the hippocampus. **Semantic memory**, a type of explicit memory, contains general knowledge or facts, including grammar, words, dates, and theories. **Episodic memory**, also a type of explicit memory, consists of personal experiences and events tied to particular times and places. Think of episodic memories as episodes in the story of your life. Examples of episodic memories would include what happened at the first high school dance you attended or the day you graduated from high school. In general, episodic memories are more easily distorted and forgotten than semantic memories. A **flashbulb memory** is a specific type of episodic memory that involves an especially detailed remembrance of an event that is highly personal and intensely emotional. They are called flashbulb memories because it feels like a camera flash went off preserving the memory in photographic detail. Subsequent research has revealed that although memories for significant events are recalled in greater detail than everyday occurrences, they are not as photographic in quality as was once believed. The better recall for flashbulb events is due in part to the fact that emotionally significant events seem to be encoded more strongly by the brain and because we continually retrieve and rehearse these memories as a result of their significance to us personally.

STUDY TIP

Flashbulb memories are strong emotional experiences that often lead to memories that are clear and long-lasting. Examples of flashbulb memories include natural disasters, deaths of notable importance, and significant celebrations.

Implicit (nondeclarative) memory is created indirectly, without conscious effort and can be tested through behavioral responses. This type of memory is considered nondeclarative because it occurs automatically. The categories within implicit or nondeclarative memory are debatable, but they often include priming, conditioned reflexes, and procedural memory. **Priming** occurs when, after being exposed to a stimulus, an individual is unconsciously more likely to be able to recall that same stimulus. *Conditioned reflexes* refer to learned responses such as emotional reactions. **Procedural memory** is the most well-known category of implicit memory and consists of the long-term memory of skills, habits, and cognitive rules involved in particular tasks. Procedural memories for how to do things include solving a puzzle, riding a bike, singing, dancing, throwing a baseball, or driving a car. Unlike other types of memories, procedural memories are processed at least partially in the cerebellum. Certain amnesia patients who have suffered damage to their hippocampus and cannot remember conversations for more than a few minutes or recognize new people no matter how many times they meet, can learn to solve puzzles faster and faster with practice. These patients will protest that they have never seen the puzzle before each time the psychologist brings it, yet they solve it more and more quickly each time. Although their ability to form new episodic and semantic memories has been destroyed due to damage to their hippocampus, they are still able to learn new procedural memories because their cerebellum was unaffected.

STUDY TIP

Semantic (explicit) memories begin with "I remember that . . ."

- Paris is the capital of France.
- my middle name is Diana.
- psychology is the scientific study of the behavior and mental processes of human and nonhuman animals.

Episodic (explicit) memories begin with "I remember this time when . . ."

- I won first place in an art contest.
- I first drove a car.
- my sister smacked me in the face with a bottle.

Procedural (implicit) memories begin with "I remember how to . . ."

- snowboard.
- change a tire.
- do a cartwheel.

Cognitive Processing

Imagine that you are an expert piano player. If you sit down with a new piece, you will play it easily, giving little thought to where each note lies on the keyboard, where your hands are, or how you are moving your fingers. On the other hand, if you are a novice, you may struggle to find each individual note. The experienced pianist is using **automatic (unconscious) processing;** interpreting music takes little effort and almost no conscious awareness of completing the activity. The novice, on the other hand, is using **controlled (conscious) processing;** a conscious decision is being made regarding how and when to play the correct note. Interestingly, if the novice who is utilizing controlled processing is interrupted, the pianist can easily find the correct place again. This is because controlled processing requires a great deal of attention. The automatic-processing expert, if distracted, will have a harder time finding the place because that person is not paying as much attention to the task. Automatic processing, though faster than controlled processing, is best left to tasks that are less important to survival or that are unlikely to go wrong.

Several models of how thinking or processing of memory and learning occur have been presented, often based on analogies between the human mind and computers. One important concept based on how computers work is that of serial versus parallel processing. In **serial processing,** the problem is solved one step at a time and uses the solution of one problem as input for the next problem in much the same way that computers work. In **parallel processing,** many different independent problems are solved all at once. Saul Sternberg theorized that retrieving information from short-term memory involves serial processing, while searches through long-term memory take place in parallel. Serial searches are practical for short-term memory's seven items, but to search the entirety of long-term memory by serial means is impractical. It would simply take too long. Parallel processing takes up much more memory than serial processing, but it is also much faster. At present, computer scientists are trying to program their machines for parallel processing, something the brain already uses effectively in terms of the processes of perception and retrieval of information from long-term memory.

Cognitive psychologists have often wondered just how the process of storage in long-term memory happens. Several theories have attempted to describe the organization of long-term memory, including semantic networks and the connectionist or parallel distributed processing (PDP) model. The **semantic network model** suggests that memories are stored as words connected to associations. For example, the word *psychology* can activate several different associations such as class, job, AP Psychology

exam, review, etc. Each of those associations also has additional associations which can be activated. The time it takes for retrieval reflects the spreading of activation within this large network that can be visualized as a spider web. While this theory provides a great mental representation, it is important to note that it is only an illustration and not an actual brain structure.

The **connectionist** or **parallel distributed processing model** suggests that encoding of memories happens through the building of connections and that retrieval occurs through the spreading of activation within this large network. Memories are not localized and detached from one another allowing them to be recalled one at a time. For example, when Steven first started learning to play guitar he learned specific skills such as how to position his fingers, how to use the guitar pick on the strings, how to read music, etc. Over time, these skills form a network of information that creates a more general understanding of how the guitar works. Neurons are closely connected with one another sending and receiving messages from thousands of different cells. This integrated system of communication is known as a **neural network**. The process in which neural networks function is known as **parallel processing** and involves the activity of a combination of many neurons firing in multiple brain regions at once, rather than individually, in order for the brain to be faster and more efficient.

Retrieval

Once information is ready to enter long-term memory, it must be encoded and stored so that it can be retrieved. **Retrieval** or the recovery of information from memory storage can either occur rapidly with little to no effort or require attention. The first type of retrieval is effortless and often occurs when new information is similar to data that has been previously stored. Word recognition is an example of this type of retrieval. When new information is not similar to previously stored data, memory takes more effort. For example, seeing a familiar face does not guarantee that we will remember the person's name. The new visual information of a face is not close enough and, therefore, does not match the verbal name stored in memory. Information retrieval seems to happen in stages. In response to a trivia question, some people can answer effortlessly, others will require a few clues, and some can say immediately that they do not know the answer. Each of the individuals in the previous example is at a different stage in the process of retrieval. If an individual is struggling to retrieve information, a clue might help them to have complete retrieval.

The process of retrieval can be tested using the methods of recall and recognition. **Recall** is the ability to retrieve information or experiences from memory consciously without clues. The AP Psychology free-response questions require recall. There are no hints to help retrieval beyond the question itself. On the other hand, **recognition** is the ability to remember information consciously through the use of previously learned material. The AP Psychology multiple-choice section utilizes recognition. Each question is followed by a list of five possible answers which can help to trigger a memory for the answer.

Retrieval can be aided by specific methods and also hindered, due to the inability of stored material to be easily retrieved. When items are presented as a list, the location of a particular item on the list can affect how easily it is remembered, based on what is known as the serial position effect. The **serial position effect** states that if we are presented with a list, we will remember best the items at the beginning and the end, and recall for items presented in the middle will be the worst. Sometimes this phenomenon is broken up into two separate concepts and the ability to recall the items presented early in the list is called the **primacy effect,** and the ability to recall the items at the end of the list is called the **recency effect**.

Forgetting, or the inability to retrieve information that has been successfully stored in long term memory, is called **retrieval failure**. An example of retrieval failure familiar to most people is the **tip-of-the-tongue phenomenon** which happens when we cannot locate the desired word in the memory even though we are sure we know it. When we experience this retrieval problem, we have the sense that what we are looking for is just beyond our reach. When something is on the tip-of-the-tongue, individuals use a variety of methods to try and unblock the memory, often by using information from their environment or attempting to trigger other existing memories. Typically the person having trouble remembering a word or name begins by guessing words that are similar to the target. Words that sound like the target word, start with the same letter, have the same number of syllables, or have a similar meaning come to mind. The more a person can narrow down the semantic (meaning) and phonetic (sound) characteristics of a word, the easier recall will be. Interestingly, the person will almost always instantly recognize the word if it is mentioned by someone. There are a variety of retrieval cues or factors in the environment that assist memory recall and several of these are listed in Table 9.2.

Table 9.2. Memory Retrieval Cues

Retrieval Cue	Definition	Example
Priming	Memory retrieval is aided for an individual if he or she has been exposed to a stimulus previously. This prior exposure or priming will make it more likely that the person will recall that same or a similar stimulus later. *Note:* Priming is also a type of implicit memory.	Researchers show subjects a series of incomplete pictures in which each subsequent picture is more finished until finally the complete drawing is visible. If the subjects are then shown the same series of drawings several weeks later, they will identify the completed picture much earlier than the first time. This result is due to the effects of priming because particular aspects of the stimuli triggered an association with the completed drawing.
Mood-congruent	Memory retrieval is aided if an individual is in the same emotional state (mood) when the person is trying to remember something as when he or she first encoded the information.	Individuals who are in a good mood are better able to recall pleasant events, and individuals who are in a sad or angry mood are more likely to recall negative events.
Context-dependent	Memory retrieval is aided when an individual is in an external environment similar to the one where the material was originally encoded.	Before you leave for school, you realize there is no more milk, and you decide that you will stop and get some on your way home. By the time you finish with your busy day, you forget all about picking up the milk. However, once you walk into the kitchen, the context or environment triggers the memory, and you realize you did not pick up the milk.
State-dependent	Memory retrieval is aided if the individual is in the same physical and mental state as when the information was encoded.	An individual who learns material under the influence of caffeine may recall that same information better when under the influence of caffeine again. *Note:* The entire process of memory (encoding and retrieval) works better when a person is not under the influence.

Forgetting

An important early memory researcher, **Hermann Ebbinghaus** is notable for his work on forgetting. Ebbinghaus studied how much individuals forgot over time and what types of techniques could be utilized to reduce forgetting. The research method he used involved creating long lists of what he called **nonsense syllables**, combinations of three letters that did not create words or evoke associations. Ebbinghaus personally memorized lists of nonsense syllables and then carefully tested himself on recall after

intervals of several minutes to many days and recorded the total amount remembered. The result of this research was the identification of what he called the **forgetting curve** or the *graphed representation* of how much information was lost over time. According to Ebbinghaus, the greatest rate of forgetting occurs within the first day after learning. After the initial steep drop-off in recall, the forgetting curve levels off and no more learning is lost. The research also indicated that the speed at which information was forgotten was related to how effectively the material was encoded in the first place. Both the amount of time spent on rehearsal and the depth of processing impact how rapidly information is forgotten. Equally important, Ebbinghaus also recognized that although a great deal of the information initially learned is forgotten, the process of **relearning** the same material would happen in less time than it took to memorize the material in the first place.

The process of **overlearning** or continuing to rehearse material after you have mastered it has been shown to reduce the amount of forgetting and help individuals hold on to material over longer periods of time. For example, when a football team executes a play perfectly the first time in practice, they still continue to rehearse so that the skill becomes automatic. The same is true for studying for exams; after you know the material, you should continue to rehearse so the information will remain in your memory longer in order to do well on the test, your finals, and the AP Psychology exam.

STUDY TIP

To combat the effect of forgetting, Ebbinghaus suggested **spaced practice** or distributed practice. The best way to overcome the forgetting curve is to break up the time you spend studying over several days. In other words, research suggests that if you want to hold onto what you learned longer, spread out your studying and do a little bit each night rather than one long cramming session or **massed practice**.

Brain Damage and Forgetting

Serious problems with memory encoding and retrieval can result from damage to the brain due to degenerative diseases, physical injury, infection, or tumor growth. An example of a degenerative brain disorder that impacts memory is **Alzheimer's disease**, which causes memory loss due to the deterioration of neurons producing acetylcholine. The specific type of memory impairment that occurs in an individual is related to

the area of the brain that is affected. Injury to the hippocampus will lead to problems with encoding new explicit memories (semantic or episodic). Because the cerebellum is involved in both procedural memory and fine motor control, when it is damaged, the result is often a loss of memories related to movement or certain conditioned reflexes including the eye blink reflex and emotional reactions. If the amygdala is damaged, it results in the disruption of the ability to encode and retrieve the emotional aspects of memory. Individuals who suffer injuries to their frontal lobes or prefrontal cortex often have problems with recalling episodic memories and determining the order in which events occurred. Evidence from both studies on animals and evaluation of behavioral changes in people who have suffered brain damage reveal that memory is a complex process involving numerous brain regions.

DID YOU KNOW?

Alzheimer's disease is named after Dr. Alois Alzheimer who, in 1906, studied the brain of a woman who had died of an unusual mental illness. This woman suffered from memory loss, language problems, and unpredictable behavior. Upon examination, Dr. Alzheimer found in the woman's brain many abnormal clumps (called amyloid plaques) and tangled bundles of fibers (called neurofibrillary tangles). Plaques and tangles in the brain are two of the main features of Alzheimer's disease, with the third being the loss of connections between the neurons in the brain. Today, roughly 5.1 million Americans may have Alzheimer's disease.

Repression

Some forgetting is due to motivated forgetting, or the desire to forget events or material that we find upsetting. If thinking about something that has happened to us is stressful or embarrassing, we may try to put it out of our mind because thinking about it is painful. **Suppression** is the term used by Sigmund Freud for motivated forgetting if the individual is conscious of his or her efforts to block painful memories or unacceptable wishes. Sigmund Freud used the term **repression** to refer to unconscious motivated forgetting of upsetting memories or unacceptable urges and desires. According to Freud, both suppression and repression are important defense mechanisms or methods that individuals utilize to reduce stress and anxiety by forgetting their unacceptable thoughts and desires either consciously or unconsciously.

Amnesia

Most of the time when we think of amnesia, what comes to mind is the memory loss that results from injury or illness, but there is also a particular type of amnesia experienced by all individuals known as *infantile amnesia*. **Infantile amnesia** refers to the

fact that individuals cannot remember their early childhood years, or at least accurately, ranging from infancy until about age 5. Neuroscientists suggest that individuals do not have explicit memories from the early years of life because the hippocampus is not mature enough for the memories to be transferred into long-term memory. There are two general types of amnesia involving limited or total memory loss that is either temporary or permanent as the result of biological damage (amnestic disorder) or psychological factors (motivated forgetting). Biological factors resulting in amnestic disorders include damage to brain areas related to memory formation or retrieval due to physical injury, tumor, stroke, or disease.

There are also two subtypes of amnestic amnesia—retrograde and anterograde. **Retrograde amnesia** involves the inability to remember events or information that was stored before the illness or injury that resulted in amnesia. An athlete that suffers a concussion and does not remember the events just prior to getting hurt has suffered retrograde amnesia.

In contrast, **anterograde amnesia** involves the inability to retain memories for events after the injury or disease that resulted in amnesia. An athlete who suffers a concussion and does not remember being examined by the trainer after the injury, but remembers everything that happened before he or she was hurt is experiencing anterograde amnesia. A famous case study of permanent anterograde amnesia involves a man, referred to in scientific journals as patient H.M., who developed temporal anterograde amnesia as a result of a surgery that he underwent in an attempt to treat his epilepsy. During surgery part of his hippocampus, a brain structure buried deep within the temporal lobe, was removed. Although the surgery was successful in treating the epilepsy, the devastating result for this patient was that he would be permanently unable to create new memories. However, scientists have learned a great deal about the biological processes related to memory by studying this patient as a case study. Because patient H.M. could recall items that were placed in his memory before the surgery, scientists were able to determine that the hippocampus is not involved in the storage of long-term memory, but instead was responsible for the transfer of new explicit memories into long-term memory. Scientists were also able to determine that implicit memories are not stored in the hippocampus because these types of memories are unaffected in individuals with hippocampus damage. Testing proved that these individuals retained conditioned responses and that they were capable of learning new motor skills.

STUDY TIP

Be able to differentiate between the two types of amnestic amnesia.

- The prefix "antero" means after, and individuals with anterograde amnesia cannot make memories after the injury or onset of the disease that caused the amnesia.
- The prefix "retro" means before or old, and the term *retro* is associated with old-school music or clothing from the past. Individuals with retrograde amnesia cannot remember what happened before the injury or onset of the disease that caused the amnesia.

Decay

Are memories destroyed, or do they merely fade away? The **decay theory** suggests that memories disappear with time if they are not retrieved. Psychologists relate the decay of memories to muscles weakening over time if they are not exercised. This hypothesis is strengthened by studies showing that neural activity progressively weakens if the connections are not used.

STUDY TIP

To help remember the multiple reasons that people forget information, think of a boy named Brad who is very forgetful. Each letter in his name stands for a different way information can be forgotten. BRAD = **B**rain damage, **R**epression, **A**mnesia, and **D**ecay.

Inteference

Forgetting can also be due to the activities a person engages in during the time between learning and the test of retention. The **interference theory** states that forgetting occurs because two memories are in conflict with one another. Memories are not lost because they have disappeared, but because the brain cannot find them in the clutter of competing alternative responses. In **proactive interference**, previously learned information interferes with the ability to recall a new memory. Anthony experiences proactive interference when he has trouble remembering the new plays his college basketball coach is trying to teach him because he keeps thinking of his high school basketball plays. **Retroactive interference** happens when recently learned information prevents the recall of old memories. Although Rita is a baseball fan, she has a hard time remembering last year's World Series champion team because all she can think of is this season's winner, which is retroactive interference.

STUDY TIP

Be able to differentiate between the two types of interference.

- For proactive interference old information gets in the way of new information and prevents the recall of new information.
- For retroactive interference new information gets in the way of old information and prevents the recall of old information.

Memory Construction

How accurate is our memory for past events? Do you remember what your third-period teacher was wearing yesterday? If you were asked ten minutes later, could you describe the person who stopped you at the mall to ask directions? Maybe, but how accurate would you be? What if the person you were asked to describe was a bank robber or a criminal who fled the scene of a crime? Often witnesses to crimes are very confident about their ability to identify criminals in lineups or give descriptions to the police, but controlled research demonstrates that we do not have as good of a memory as we believe we do. Problems with eyewitness recall have serious social and legal implications because inaccurate witness memory has led to the false imprisonment of innocent people and the acquittal of guilty suspects. Elizabeth Loftus studied the constructive nature of memory or how memory can be affected by the existing knowledge we have about similar events and how information we receive from other sources can become unknowingly added into our original memory. Loftus also investigated how the inaccuracy of human memory affects eyewitness testimony. Contrary to what many people believe, our minds do not work like video recorders that we can simply play back in order to view our memories exactly as they happened.

Elizabeth Loftus demonstrated that memory is not as accurate as we believe it is and that eyewitness testimony is unreliable because false memories or confabulations can be created easily through suggestion. A **confabulation** or false memory is generated when a person's actual memory becomes distorted because the person unconsciously adds or removes information received from other sources. Elizabeth Loftus demonstrated how confabulations can be created using the **misinformation effect** in which researchers give participants subtle misleading information cues that causes them to alter their memories by adding the false information to their recollections. The participants in Loftus's research watched a video of a car crash and were then asked to say how fast they believed the cars were going. Some of the subjects were asked the question, "How fast were the cars going

when they *hit* each other?" and some of the participants were asked the more leading question, "How fast were the cars going when they *smashed* into each other?" The subtle difference of replacing the word *hit* with *smashed* had dramatic results. Participants who heard the word *smashed* in the question estimated the speed of the cars to be significantly faster than those who were asked the same question using the word *hit*. These results show that the way a question is worded can alter a person's memory. This finding has significant implications for how suspects and witnesses should be interviewed by the police and members of the court system. Research on memory indicates eyewitness testimony alone should not be sufficient in criminal cases and that other evidence should be required.

As a result of the constructive nature of memory, individuals may also have difficulty recalling the origin (source) of where a particular memory was acquired, despite having a strong recollection of the actual detail about the memory itself, known as **source amnesia**. Ultimately, our brains are better at storing and retrieving facts and events than determining where that information came from (source). If your friend tells you a joke that you actually told them a week ago, they are demonstrating source amnesia. Your friend remembers the information in the form of the joke, but did not recall the source of the information, which was you.

Brain and Memory

Where are memories created and stored in the brain? Cognitive and biological psychologists continue to debate whether the process of memory is something that is spread out across many areas of the brain or more localized to one specific region. The physiology of how memories are encoded, stored, and retrieved, as well as the locations for the storage of various types of memories, is extremely complex. Evidence from both animal research and case studies of humans who have suffered brain damage to specific regions has revealed that although some regions are specialized for certain aspects of the memory process, memory itself is not located in only one area in particular. It is known for example that the hippocampus is very involved in the process of encoding new explicit memories and transferring them to long-term memory, but that it is not responsible for memory storage. Numerous areas of the brain, including the prefrontal cortex, medial temporal lobe, amygdala, hippocampus, and cerebellum, have all been shown to have specific functions that relate to memory encoding, storage, and retrieval.

Psychologist Karl Lashley contributed to the understanding of the biological aspects of memory through research on where memory is stored in rats. Lashley taught rats to solve a maze and then lesioned (destroyed) a specific area in their brains before having them attempt the maze again. He found that although learning was briefly interrupted,

the rats were ultimately able to complete the maze, suggesting that the area of the cortex that was removed was not where the memory of the maze was stored. Lashley's research provides evidence that memory does not reside in one specific place within the brain, but that memory is in fact spread across many areas of the brain. Lashley began the search for the *memory trace* or the specific physical changes that occur in the brain when a memory is created, which he called the *engram*. Neuroscientists continue today to search for the memory trace, and, although the exact physiological changes that occur when a memory is encoded are still unknown, there is much support for long-term potentiation. According to the theory of **long-term potentiation,** repeated stimulation of neural networks strengthens the connections between neurons and results in the formation of new synapses leading to learning and memory creation.

Memory Improvement

Mnemonic strategies are techniques that are usually effortful, though sometimes automatic, designed to assist in the process of memory. Often these strategies include elaboration by creating connections with other material. The use of **imagery** or creating a mental picture for items or events to be memorized is especially helpful and can be incorporated into a variety of other mnemonic strategies. Imagery is particularly effective if the mental picture that is created is dramatic or unusual. Two mnemonic strategies that depend heavily on the power of imagery are the method of loci and the peg-word system. The **method of loci** involves associating the information that needs to be memorized with a series of locations typically in a familiar place through the use of vivid imagery. Another efficient method for memorizing lists of items in order involves using the **peg-word mnemonic system.** This method requires that the person first memorize a series of words (pegs) connected to numbers. Typical peg-word number combinations are: one is a bun, two is a shoe, three is a tree, four is a door, etc. In order to memorize a list, each new term is associated with the peg-word through the use of imagery. The peg-word system offers the additional benefit of allowing you to be able to go immediately to the part of the list that you are searching for, such as identifying the fifth item on the list without having to list the first four.

Language

Language is a form of communication consisting of symbols that can be arranged to derive meaning. In spoken language, sounds represent objects and ideas, while sign language uses hand motions for communication. Languages enable

individuals to explore actual or potential relationships between parts of the environment. Though most animals communicate, psychologists vigorously debate whether or not they use language. Both chimps and dolphins have been studied, yet the best candidate for the possession of language is the honeybee. When bees return to their hives, they perform complicated dances which may tell other bees where to find honey. However, for reasons described below, most psychologists believe language is unique to humans.

Basic Units of Language

Spoken language is made up of three basic units or ways of conveying meaning: phonemes, morphemes, and grammar. **Phonemes** are the smallest units of sound in a language and are the first sounds infants make. English has forty-five phonemes, including single letters such as *f* and *g* and combinations of letters such as the *th* in the word "think." The Japanese language has fewer phonemes and some languages have more. Other languages also involve phonemes that do not exist in English. The Kung tribe of Africa uses a sort of clicking sound in their language, represented by an exclamation point. One of the most difficult aspects of learning another language, especially as an adult, is learning how to pronounce correctly new phonemes associated with the second language. **Morphemes** are the smallest units of meaning in a language that result from combinations of phonemes. In English, morphemes can be whole words (i.e., rain, dog) or prefixes (i.e., *dis-, ante-)* and suffixes (i.e., *-ing, -ed)*. There are more than 100,000 morphemes in the English language, and this list does not even begin to exhaust all of the possible combinations of the forty-five phonemes.

Grammar consists of the rules that define how a language is used so that people speaking the same language understand each other. The broad overall term *grammar* contains two separate parts: semantics and syntax. **Semantics** is the part of grammar that relates to the meanings of words and their combinations. After constructing meaningful words out of morphemes, a person learning a language would need to be able to create understandable combinations of words. An understanding of semantics is necessary to be truly fluent in a language because understanding a statement may involve more than simply combining the definitions of each of the words involved. **Syntax** is the part of grammar that refers to the system of rules within a language regarding the order of how words can be arranged. Syntax varies among languages; for example, in English it is typical for the adjective to precede the noun "the blue sky," but in Spanish the adjective follows the noun "el cielo azul," reflecting a difference in syntax.

Language Acquisition

Babies are capable of learning their native language or even more than one language effortlessly, quickly, and without any direct instruction (no worksheets or flashcards required). Language acquisition, also called language development, is the process by which children learn to communicate.

Language development is a complex process influenced by the interaction of biology, cognition, and culture. At birth, babies are capable of making noises in order to gain the attention of their caregivers, such as cooing and crying. The first signs of language, babbling, typically appear at about six months and the language acquisition process that follows occurs in a recognized pattern. Language development studies in infants differentiate between **receptive language** (words that babies understand) and **expressive language** (words babies are capable of producing). Similar to other types of development, language acquisition varies among individuals and the ages presented are only approximate. The typical sequence of language acquisition in children is presented in Table 9.3.

Table 9.3. Language Acquisition

Stage	Description	Example(s)
Babbling 4 to 6 months	The first speech-like but meaningless sounds infants make, including phonemes that are not a part of the child's native language. The early appearance of babbling suggests this behavior is "wired in," or biological and that an infant is capable of learning any language.	In English the sounds are typically short consonant vowel combinations, such as "ba, ba, ba," or "la, la, la."
One-word Stage Holophrasic 10 to 18 months	Stage when infants communicate by using only single words, called *holophrases*, to express themselves.	First words are often those that represent important people in the infant's world, such as "mama" or "dada," or significant objects such as "doggy," "milk," or "ball."
Two-word Stage 18 to 24 months	Stage when the child communicates in two-word phrases called telegraphic speech.	"more milk" "give ball" "mama walk"
Telegraphic Speech 18 to 30 months	Type of speech that begins in the two-word stage and continues until about 30 months as children build utterances containing more words. This speech contains only the words essential to meaning, typically nouns and verbs, and lacks other parts of speech.	Two-year-old Marta says merely, "give doll" or "give doll me," rather than the more complete "Give the doll to me."

(*continued*)

Table 9.3 (*continued*)

Stage	Description	Example(s)
Overgeneralization (Overregularization)	Error in language when young children apply rules about grammar to every example before they learn about exceptions.	Julian wants to say that he has two pet mice and overgeneralizes when he says that he has two pet mices instead of mice.
Overextension	Error in language when young children are too broad in their use of a particular word.	Eric refers to all types of moving vehicles as "car." A child that refers to all snacks, including crackers and pretzels, as "cookie."
Underextension	Error in language when young children are too restrictive in terms of how they use a word.	Liza uses the term doll to refer only to her doll and not any other dolls.
Sentences 2+ years	Following the development of telegraphic speech, children quickly begin to create complete sentences and gradually become capable of more sophisticated grammar and sentence construction.	

Cognitive psychologists are interested in how children acquire the complex skills required for language and how nature, nurture, cognition, and culture contribute to this unique human ability. As is the case with other complex human behaviors, the answer is a combination of both nature and nurture, which is best explained by incorporating aspects of several theories that present evidence for each approach.

An early theory that language acquisition was the result of environmental influences was based on the behaviorist approach of B.F. Skinner. According to Skinner, children learn language in the same way they learn everything else, through operant conditioning, imitation, modeling, and association. Children learn the rules of language because they are reinforced with smiles and encouragement when they are correct and punished by being misunderstood or corrected when they are wrong. One major criticism of this approach is that children are likely to be reinforced even when they are incorrect because, although the child says "give cookie me," which is incorrect, they may still be given the cookie. Second, behaviorism does not have an answer for why children overgeneralize by applying grammatical rules more broadly than is appropriate. One example of this linguistic error that children make even though their parents do not make it is adding "-ed" to make words past tense when the rule should not be used, such as saying "holded" instead of "held."

As interest in biological and cognitive psychology grew, psychologists sought a rival explanation for language acquisition which focused more on the influences of biology and genetics. This rival idea is known as the **nativist approach** and contends that language development is the result of a genetically based innate ability. A major proponent of the nativist approach is linguist **Noam Chomsky**, who observed that children learn language much too quickly for it simply to be the result of imitating others or responding to rewards and punishments. Chomsky pointed out that grammar and syntax are acquired even if children are not corrected for the errors in speech they make. He argued that humans, therefore, must come equipped with a **language acquisition device**, or built-in biological readiness to learn the grammatical rules for any language, including syntax, semantics, and pronunciation. Chomsky's language acquisition device is a theoretical idea, but researchers are interested in determining where language development occurs physiologically in the brain. Another important aspect of Chomsky's theory is that language acquisition is the result of a genetic predisposition that he believes is related to the existence of a **universal grammar**, meaning that all human languages have commonalities in terms of their basic underlying structure. As evidence for the biological basis of language, nativists cite the fact that children achieve developmental milestones in linguistics at the same age and in the same order across cultures.

Further support for the biological factors involved in language acquisition comes from evidence regarding critical periods. A **critical period** is a fixed time period very early in life when particular events result in long-lasting effects on behavior. Very young children can easily acquire any language or even more than one language, but as individuals become older, learning a second language becomes increasingly challenging, suggesting a possible critical period when the brain is more receptive to learning language. Similarly, children who are not exposed to normal speech early in their lives have a difficult time learning language later. Ultimately, biological factors also interact with cognitive factors to influence the learning of language.

Language and Thought

Psychologists are interested in how language impacts thought and if thinking is impacted by the particular native language of an individual. Not only does the way we think, such as the grammatical rules we generate, influence the learning of language, the learning of language can also influence the way we think. The most well-known theory regarding how language contributes to thinking was proposed by **Benjamin Whorf** in his theory called **linguistic determinism**. According to linguistic determinism, the

language that a person speaks determines how they think. Whorf cited evidence based largely on Native American languages and how they differed in comparison to English and hypothesized that these differences impacted how members of each culture viewed the world. Psychologists disagree with Whorf's hypothesis that language determines thought, but most agree that language does influence thought in what is now thought of as the **linguistic relativity hypothesis**.

Thinking

Thinking, a type of cognition in terms of psychology, involves the conscious processes involved in reasoning, problem solving, and imagining. Although thinking encompasses the interaction of many various brain regions, the area most directly associated with the complex processes of planning, choice, judgment, impulse control, and even humor is the prefrontal cortex. The building blocks for human thinking consist of imagery, concepts, and prototypes. **Mental images,** or complex cognitive representations for objects and ideas that are not immediately present, are a critical part of the thinking process. **Concepts** are mental categories we create for objects or experiences that are similar to one another, allowing us to represent information about large numbers of specific events, objects, and ideas in an efficient way. Concepts allow us to communicate easily, to remember more, and to solve problems. Examples of concepts used to organize what we know range from simple to more complex, including flowers, trees, action movies, democracy, truth, beauty, and fairness. We typically condense the common features of similar objects by creating a **prototype** or best example of a category. Prototypes can vary among individuals and are even impacted by where people live. For example, the best example of a tree for one person might be an oak tree and another an apple tree, but someone living in a tropical region might immediately think of a palm tree. When faced with new experiences, we solve the problems of identifying them and predicting their impact on us by assessing their resemblance to our prototypes. For example, the more closely your psychology teacher matches your prototype for what a kind teacher is like, the more likely you would be to ask them for extra help. Having assigned them to the category of kind teacher, you would be more likely to remember the characteristics they have that represent kindness and understanding and even recall them having characteristics of the prototype that they may not actually have. For example, you may correctly recall their concern over your sick pet, but also "remember" them allowing you to be exempt from a major assignment when they, in fact, did not do that. Thus, concepts help us remember events, but they also color the ways in which we perceive and remember them.

Problem Solving

The area of cognitive psychology related to problem solving considers the various mental processes involved in generating solutions including both insight and problem solving strategies. **Insight** is the "Aha!" experience people have when a solution to a problem suddenly appears or becomes obvious. Because insight is so startling, it can be used to point out how problem solving entails both conscious and unconscious aspects. The attention and conscious exertion an individual directs toward finding a solution may in turn trigger unconscious sources, resulting in the sudden arrival at a correct answer. Creative solutions to problems do not always flash effortlessly into a person's mind. It is also the case, however, that **metacognitive processing,** or the deliberate and conscious process of talking oneself through a problem, contributes to problem solving. Metacognitive processing essentially allows people to expand their awareness of the problem solving process by watching themselves trying out solutions.

One of the most basic problem solving strategies is using the method of **trial and error** in which individuals attack a problem by making random guesses using little reasoning or analysis. Trial and error is most effective if there are only a small amount of possible solutions to try, but for larger problems this method is often unsuccessful or time consuming. For example, Craig cannot remember the password he used when he signed up for a study-help website and is having trouble logging on. Because Craig uses only four different passwords, he uses trial and error until he figures out the password that works. If Craig had a large selection of possible passwords to choose from, this method would not be effective.

Two general categories of problem solving strategies are algorithms and heuristics. An **algorithm** is a strategy that involves using a set of rules that if followed correctly will guarantee a solution. For example, if you were deciding how to get to a party, you could use an algorithm, or standard procedure, by taking out a map and carefully tracing each possible route you could use to drive there. Potential drawbacks for this method are that a specific algorithm does not exist for every problem, and, while algorithms guarantee a solution, their extensive time commitment may be problematic. A **heuristic** is a problem-solving strategy that is likely to produce a solution quickly, but does not guarantee a correct answer. People often use these mental shortcuts or rules-of-thumb as a way to solve problems, especially those involving estimates of likelihood. (See Table 9.4.) While heuristics are faster and more efficient, they are also more prone to error than algorithms.

STUDY TIP

Algorithms take more time to determine the solution, but are the most accurate way to solve a problem. Heuristics take less time to determine the solution, but are more prone to errors.

Table 9.4. Definitions and Examples of Heuristics

Heuristic	Definition	Example
Representativeness	Judging the likelihood of an event in terms of how well it seems to match a particular prototype, which can result in either a correct or incorrect analysis of the situation.	If you see a man on the street with long hair and tattoos dressed in leather you are more likely to assume that he is a musician than a doctor because his appearance matches your prototype of a rock star. Note: You might be wrong!
Availability	Judging the likelihood that an event will happen in terms of how readily it comes to mind, based on either personal experience or exposure through the media. Events that are more vivid or that have happened more recently tend to be judged as more likely to happen again than those that are less vivid or recent even though this may or may not be true.	Based on how easily an event or solution comes to mind (availability), you might come to the conclusion that judicial trials are relatively common and plea bargains are relatively rare, when the reverse is actually true. News reports of trials tend to be more sensational and, therefore, more memorable than reports of plea bargains, which cause us to expect them to happen more often.

Reasoning

Reasoning is a type of cognition that relates to the processes individuals utilize to reach conclusions based on available information. Two major methods of making conclusions are deductive and inductive reasoning. In **deductive reasoning** individuals start with a premise they have strong reason to believe is accurate and then create conclusions based on that initial premise. Deductive reasoning is used when psychologists create a hypothesis based on an existing and well-established theory. **Inductive reasoning** involves basing a conclusion on what is most likely truth-based on specific examples or determining general principles from analyzing examples. In psychology inductive reasoning is involved when a hypothesis is created based on data obtained through observation. In other words, deductive reasoning goes from established general principle to specific examples and inductive reasoning involves determining general principles based on specific examples. The use of inductive reasoning can lead to a number of potential

biases in thinking including **belief bias** or the error in thinking in which individuals are more likely to agree with conclusions that match up with their existing opinions rather than conclusions appearing to be logically valid.

Obstacles to Problem Solving

Psychologists evaluate how various types of bias or flaws in thinking inhibit individuals from effectively solving problems. **Confirmation bias** involves the tendency to selectively attend to information that is consistent with our viewpoint and ignore or minimize information that challenges our beliefs. If the solution to the problem being investigated is very different from what we believe it will be, this bias can prevent us from looking at every possible alternative. Carmelo is in love and notices only the wonderful positive qualities about his girlfriend and ignores any potential negatives, such as the fact that they have nothing in common, illustrating confirmation bias. **Belief perseverance** is the tendency to hold onto an assumption or belief even after it has been disproven. Cody believes that he is able to drive safely while sending text messages. After reading several articles that present extensive evidence that driving while texting is dangerous, Cody still believes that it is safe when he texts while driving because of the error of belief perseverance. Another error in thinking results from **anchoring bias** that leads an individual to place too great an emphasis on an initial estimate when making decisions under conditions in which one is unsure. Although we realize that we need to modify our original answer, we are so tied to the initial estimate (anchor) that we fail to make a large enough adjustment. Even the way in which problems are worded can make finding solutions more difficult. **Framing effect** results when individuals reach a conclusion to a problem based solely on how it is worded. If potential students read that 75 percent of graduates from Psychology College find a job in their field after graduation, they may be more likely to apply to Psychology College than if they heard that 25 percent of graduates could not find jobs after graduation, due to the effects of framing.

Another obstacle to finding solutions is the idea of **mental set** or the tendency for people to cling to old methods of solving problems even when they are no longer working. A problem related to mental set, **functional fixedness** occurs when the set of ideas people have about the purpose or use of objects prevents them from using objects in new ways. If you have ever sat in a room with a can and no can opener, you know the difficulties involved in trying to find another object that can be used in the same way.

Creativity

Psychologists define the term **creativity** as the ability to generate novel and useful products or solutions to problems. No matter how many other people may have thought of the same idea, a solution is novel if it is new to the person who thinks of it. Another way to think of creativity is in terms of the difference between convergent and divergent thinking. Simple arithmetic is solved by **convergent thinking,** which determines one correct answer through applying consistent rules and categorizing events. **Divergent thinking** produces a variety of solutions to any particular problem. Writing, playing chess, creating pottery, or entertaining children all require divergent thinking because they require the generation of many possibilities. Typically divergent thinking is considered to be more closely related to creativity. A commonly used measurement device for creativity is the Minnesota Test of Creative Thinking. This creativity test asks questions like "How many uses can you think of for an old tire?" or "How can you improve a bicycle?" Creativity tests are often scored in terms of number of original ideas that are generated. These tests have been questioned regarding their construct validity. In other words, it is not clear if they are actually measuring the abstract idea of creativity or not.