At the end of this unit, you will be able to:

1. Describe the nature and basic forms of learning.
2. Describe the relationship between learning and synaptic plasticity.
3. Discuss the mechanisms responsible for the increase in synaptic strength that occurs during long-term potentiation.
4. Differentiate between long-term potentiation and long-term depression.
5. Review the connections between relational learning and anterograde amnesia.
6. Discuss how the reinforcement system may detect reinforcing stimuli and strengthen synaptic connections.
7. Describe the nature of human anterograde amnesia and the type of brain damage that causes it.
8. Discuss research on how learning affects neural structures, the induction of long-term potentiation, and the role of NMDA receptors.
9. Explain the distinction between remembering and forgetting.
10. Discuss the role of the medial temporal lobe in spatial memory and memory retrieval and the role of the prefrontal cortex in confabulation.
11. Outline a possible explanation of the role of the hippocampal formation in learning and memory.
9.1 THE NATURE AND TYPES OF LEARNING

Learning is the acquisition and development of memories and behaviors, including skills, knowledge, understanding, values, and wisdom. It is the product of experience and the goal of education.

Learning is the process by which experiences change our nervous system and hence alters future our behavior. Memory is the substrate for storing information about those experiences.

Learning ranges from simple forms of learning such as habituation and classical conditioning seen in many animal species, to more complex activities such as play, seen only in relatively intelligent animals.

Thus, learning does not occur if there is no change in the amount of knowledge even for a long time. Learning can be negative, if the amount of knowledge is decreasing over time.

Figure 9.1: A simple neural model of classical conditioning. When the 1000-Hz tone is presented just before the puff of air to the eye, synapse T is strengthened.

Hebb rule: The hypothesis proposed by Donald Hebb that the cellular basis of learning involves strengthening of a synapse that is repeatedly active when the postsynaptic neuron fires.
Classical conditioning

A learning procedure; when a stimulus that initially produces no particular response is followed several times by an unconditioned stimulus that produces a defensive or appetitive response. This type of learning involves:

- Unconditioned stimulus
- Unconditioned response
- Conditioned stimulus
- Conditioned response

Instrumental conditioning

A learning procedure whereby the effects of a particular behavior in a particular situation increase (reinforce) or decrease (punish) the probability of the behavior. It is also called operant conditioning:

- **Reinforcing stimulus**: An appetitive stimulus that follows a particular behavior and thus makes the behavior become more frequent.

- **Punishing stimulus**: An aversive stimulus that follows a particular behavior and thus makes the behavior become less frequent.

Neural Circuits Involved in Reinforcement

- **Medial forebrain bundle (MFB)**: A fiber bundle that runs in a rostral-caudal direction through the basal forebrain and lateral hypothalamus; electrical stimulation of these axons is reinforcing.

- **Ventral tegmental area (VTA)**: A group of dopaminergic neurons in the ventral midbrain whose axons form the mesolimbic and mesocortical system; plays a critical role in reinforcement.

- **Nucleus accumbens**: A nucleus of the basal forebrain near the septum; receives dopamine-secreting terminal buttons from neurons of the ventral tegmental area and is thought to be involved in reinforcement and attention.

Types of learning

- **Perceptual learning**: The ability to learn to recognize stimuli that have have been perceived before. The primary function of this type of learning is the ability to identify and categorize objects and situations.

- **Stimulus-response learning**: Learning to automatically make a particular response in the presence of a particular stimulus. It is the ability to learn to perform a particular behavior when a particular stimulus is present. It includes classical and instrumental conditioning. The behavior could be an automatic behavior such as a defensive reflex or it could be a complicated sequence of movements that was learned previously.
Figure 9.2: A simple model of instrumental conditioning.

Figure 9.3: An overview of perceptual, stimulus-response (S-R), and motor learning.
Motor learning: Learning to make a new response; a component of stimulus based learning; differs from other forms of learning in the degree to which new forms of behavior are learned; the more novel the behavior, the more neural circuits in the motor system must be modified.

Relational learning: Involves learning the relationships among individual stimuli such as becoming familiar with the contents of a room.

Spatial learning: Learning about the relations among many other stimuli.

Episodic learning: Remembering sequences of events that we witness.

Observational learning: Learning by watching and imitating others.

Synaptic plasticity is the ability of the connection, or synapse, between two neurons to change in strength. There are several underlying mechanisms that cooperate to achieve synaptic plasticity, including changes in the quantity of neurotransmitter released into a synapse and changes in how effectively cells respond to those neurotransmitters (Gaiarsa et al., 2002).

Since memories are postulated to be represented by vastly interconnected networks of synapses in the brain, synaptic plasticity is one of the important neurochemical foundations of learning and memory.

Two known molecular mechanisms for synaptic plasticity were revealed by research in laboratories such as that of Eric Kandel:

- The first mechanism involves modification of existing synaptic proteins (typically protein kinases) resulting in altered synaptic function (Shi et al., 1999).
- The second mechanism depends on second messenger neurotransmitters regulating gene transcription and changes in the levels of key proteins at synapses. This second
mechanism can be triggered by protein phosphorylation but takes longer and lasts longer, providing the mechanism for long-lasting memory storage.

Long-lasting changes in the efficacy of synaptic connections (long-term potentiation) between two neurons can involve the making and breaking of synaptic contacts. If the strength of a synapse is only reinforced by stimulation or weakened by its lack, a positive feedback loop will develop, leading some cells never to fire and some to fire too much.

### 9.2.1 Induction of Long-Term Potentiation

**Long-term potentiation**: A long-term increase in the excitability of a neuron to a particular synaptic input caused by repeated high-frequency activity of that input.

**Hippocampal formation**: A forebrain structure of the temporal lobe, constituting an important part of the limbic system; includes the hippocampus proper (Ammon’s horn), dentate gyrus, and subiculum.

![Figure 9.4](image)

**Figure 9.4**: Connections of the components of the hippocampal formation. (a) shows a pictomicrograph of a horizontal section through the hippocampal formation of a rat brain. (b) Shows its intrinsic connections.

**Entorhinal complex**: A forebrain structure of the temporal lobe constituting an important part of the limbic system; includes the hippocampal proper (Ammon’s horn), dentate gyrus and subiculum.

**Granule cell**: A region of the limbic cortex that provides the major source of input to the hippocampal formation.
Dentate gyrus: Part of the hippocampal formation; receives inputs from the entorhinal cortex and projects to the field CA3 of the hippocampus.

Perforant path: The system of axons that travel from cells in the entorhinal cortex to the dentate gyrus of the hippocampal formation.

Field CA3: Part of the hippocampus; receives input from the dentate gyrus and projects to the field CA1.

Pyramidal cell: A category of large neurons with a pyramid shape found in the cerebral cortex and Ammon’s horn of the hippocampal formation.

Population EPSP: An evoked potential that represents the EPSPs of a population of neurons.

ACTIVITY 9.1

iii) What is a long-term potentiation?
iv) Describe the brain structure that are involved in the induction of long-term potentiation.

Figure 9.5: The procedure for producing long-term potentiation.
**Associative long-term potentiation**: A long-term potentiation in which concurrent stimulation of weak and strong synapses to a given neuron strengthens the weak ones.

**Figure 9.6**: Population EPSPs recorded from the dentate gyrus before and after electrical stimulation that led to long-term potentiation.

### 9.2.2 Role of NMDA Receptors

**NMDA receptor**: A specialized ionotropic glutamate receptor that controls a calcium channel that is normally blocked by Mg$^{2+}$ ions; involved in long-term potentiation. Found in the hippocampal formation especially in field CA1.

AP5: 2-Amino-5-phosphonopentanoate; a drug that blocks NMDA receptors.

AMPA receptor: An ionotropic glutamate receptor that controls a sodium channel; when its open, it produces EPSPs.

**Dendritic spike**: An action potential that occurs in the dendrite of some types of pyramidal cells.

### 9.2.3 Mechanisms of Synaptic Plasticity

Research indicated that at least two types of modifications occur when a synapse becomes strengthened: Individual synapses are strengthened and new synapses are produced.

Strengthening of an individual synapse appears to be accomplished by an increase in the number of postsynaptic AMPA receptors present in that synapse.

**CaM-KII**: Type II calcium-calmodulin kinase, an enzyme that must be activated by calcium; may play a role in the establishment of long-term potentiation.

**Nitric oxide synthase**: An enzyme responsible for the production of nitric oxide.
Figure 9.7: A hypothetical model that describes the insertion of new AMPA receptors into postsynaptic membrane of dendritic spines after long-term potentiation. The presence of glutamate and membrane depolarization open NMDA receptors. Calcium ions enter and activate molecules of CaM-KII by attaching phosphate groups (P), a process known as phosphorylation. Linking proteins attach to the activated CaM-KII, and AMPA receptors, brought to the postsynaptic membrane in vesicles, attach to the linking proteins. The addition of new AMPA receptors results in larger postsynaptic potentials when the terminal buttons release glutamate.

Figure 9.8: A hypothetical series of changes that synapses undergo following long-term potentiation.
The findings were based on earlier work identifying the amygdala as a site at which neural changes that underlie auditory fear learning occur. Current theories suggest that memories are processed by our brain initially as fragile short-term memories (stm) and then get stored more permanently as long-term memories (ltm).

The transition from stm to ltm is mediated by the production of proteins. Nader found that fear experiences stored in the amygdala, when retrieved, return to a state that again requires protein synthesis in order to be restored. If you reactivate the fear memory and block the production of protein in the amygdala immediately afterwards, the memory is lost.

9.2.4 Long-term Depression (LTD)

A long-term decrease in the excitability of a neuron to a particular synaptic input caused by stimulation of the terminal button while the postsynaptic membrane is hyperpolarized.

Long term depression involves a decrease in the number of AMPA receptors in the postsynaptic membrane of dendritic spines. Disorders characterized by extreme and unwarranted disturbances in emotion or mood.

9.3 RELATIONAL LEARNING AND ANTEROGRADE AMNESIA

Amnesia is a condition in which memory is disturbed. The causes of amnesia are organic or functional. In simple terms it is the loss of memory.

Organic causes include damage to the brain, through trauma or disease, or use of certain (generally sedative) drugs. Functional causes are psychological factors, such as defense mechanisms. Hysterical post-traumatic amnesia is an example of this.

Amnesia may also be spontaneous, in the case of transient global amnesia. This global type of amnesia is more common in middle-aged to elderly people, particularly males, and usually lasts less than 24 hours.

Another effect of amnesia is the inability to imagine the future. A recent study shows that amnesics with damaged hippocampus cannot imagine the future. This is because when a normal human being imagines the future, they use their past experiences to construct a possible scenario.
9.3.1 Human Anterograde Amnesia

**Anterograde amnesia:** Amnesia for events that occur after some disturbance to the brain, such as head injury or certain degenerative brain diseases. A person with anterograde amnesia can remember events in the past and those that occurred just prior to the trauma. However, they cannot retain information encountered after the trauma.

Alzheimer’s disease patients lose recent memories first and retain oldest memories until the final stages of the disorder. The final stages of Alzheimer’s disease are associated with severe memory impairment, intellectual decline and incontinence.

**Retrograde amnesia:** Amnesia for events that preceded some disturbance to the brain, such as a head injury or electroconvulsive shock. People with retrograde amnesia may not be able to recall events in the past or events that occurred just prior to the brain trauma.

**Korsakoff’s syndrome:** Permanent anterograde amnesia caused by brain damage resulting from chronic malnutrition (thiamine). Korsakoff’s syndrome is associated with severe alcoholism or, more specifically, vitamin B<sub>1</sub> deficiency. Since there is general progressive decline in this disorder, it is difficult to sort out the specific types of amnesia.

**Confabulation:** Refers to the tendency of an amnesic patient to make up a false memory; unintentionally reports a memory of an event that did not take place.

It is a common symptom noted in Korsakoff’s syndrome; damage to the prefrontal cortex can result in confabulation. Active confabulation showed frontal lobe hypoactivity.

**Short-term memory:** Immediate memory for events, which may or may not be consolidated into long-term memory.

**Long-term memory:** Relatively stable memory of events that occurred in the more distant past.

**Consolidation:** The process by which short-term memories are converted into long-term memories.

*Declarative and Nondeclarative Memory*

Clearly there are two major categories of memories:

**Declarative memory:** Memory that can be verbally expressed, such as memory for events in a person’s past.

**Nondeclarative memory:** Memory whose formation does not depend on the hippocampal formation; a collective term for perceptual, stimulus-response, and motor memory.

**Episodic memory:** Memory of a collection of perceptions of events organized in time and identified by a particular context.
9.3.2 Anatomy of Anterograde Amnesia

**Perirhinal cortex:** A region of limbic cortex adjacent to the hippocampal formation that, along with the parahippocampal cortex, relays information between the entorhinal cortex and other regions of the brain.

**Parahippocampal cortex:** A region of limbic cortex adjacent to the hippocampal formation that, along with the perirhinal cortex, relays information between the entorhinal cortex and other regions of the brain.

**Place cell:** A neuron that becomes active when the animal is in a particular location in the environment; most typically found in the hippocampal formation.

**Hippocampal Region:** A part of the limbic system which includes the hippocampus and underlying cortical areas. Involved in the formation of semantic memories.

Memories can be retrieved without the hippocampus involvement. Specific types of memory handled by the hippocampus in the context of spatial location, such as working and reference memory. The Hippocampus is especially important in forming episodic memories. It is involved in creating intricate neural spatial maps.

Major theories of hippocampal function are presented, such as providing a cognitive map, handling configural learning, and encoding spatial arrangements of stimuli.

**Semantic Memories:** A memory of facts and general information; involve the hippocampus and other parts of hippocampal region; other long and short-term memories usually are intact.

![Figure 9.9: The posterior (rear) hippocampus of an experienced London taxi driver, shown in red in the MRI scan on the left, is significantly larger than the posterior hippocampus of a research participant who was not a taxi driver, shown in red in the scan on the right.](image)

**Neuronal Changes and Memory**

*Aplysia* sea snail study mapped neural circuits formed as the animal learned and remembered. Donald Hebb argued in 1940’s that learning and memory must involve the enhancement of transmission at the synapses between neurons.

**Long-term Potentiation (LTP):** An increase in the efficiency of neural transmission at the synapses that lasts for hours or longer. It does not take place unless sending and receiving
are activated at the same time by intense stimulation. Receiving neuron must be depolarized (ready to fire) when the stimulation occurs.

Hormones and Memory

Strongest and most lasting emotions are usually fueled by emotion. Cahill and McGaugh two pathways for forming memories:

(a) Ordinary information.

(b) Memories fired by emotion
   i) Adrenal glands release epinephrine and norepinephrine into bloodstream.
   ii) Fight or flight response imprint powerful and enduring memories surrounding threatening situations.
   iii) Amygdala activates during emotional episodes and may explain the intensity and durability of flashbulb memories.
   iv) High levels of stress hormone cortisol interferes with memory.
   v) Estrogen improves working memory efficiency and the development and maintenance of synapses in the brain.

9.4 REMEMBERING

Remembering is a form of recollection or a retrieval of memory. It is not a passive process; people employ metacognitive strategies to make the best use of their memory, and priming and other context can have a large effect on what is retrieved. When we try to remember information there are several different techniques we can employ. These are called Measures of Retention.

There are several ways to classify memories, based on duration, nature and retrieval of information. In order to remember, memory must first be formed. Memory formation is an organism's ability to record, store, retain, and subsequently retrieve information. From an information processing perspective, there are three main stages in the formation and retrieval of memory:

- **Encoding** or registration (processing and combining of received information)
- **Storage** (creation of a permanent record of the encoded information)
- **Retrieval or recall** (calling back the stored information in response to some cue for use in a process or activity)

Encoding: transforming information into a form that can be stored in memory.

Storage: The process of keeping or maintaining information in memory.

Retrieval: bringing to mind information that has been stored in memory.

Information-processing theory uses computer models and computer terminology to describe human cognitive functioning.
9.4.1 Atkinson-Shiffrin model

**Sensory:** Sensory memory corresponds approximately to the initial 200 - 500 milliseconds after an item is perceived. The ability to look at an item, and remember what it looked like with just a second of observation, or memorization, is an example of sensory memory.

It holds information from the senses for a period of time ranging from only a fraction of a second to about 2 seconds. Sensory memory holds a visual image, like a lightening bolt, for a fraction of a second – just long enough for you to perceive a flow of movement. It codes information according to sound and holds about seven items for less than 30 seconds without rehearsal.

**Short term memory:** Some of the information in sensory memory is then transferred to short-term memory. Short-term memory allows one to recall something from several seconds to as long as a minute without rehearsal. Its capacity is also very limited.

George A. Miller conducted experiments showing that the store of short term memory was 7±2 items. Modern estimates of the capacity of short-term memory are lower, typically on the order of 4-5 items.

Memory capacity can be increased through a process called chunking. For example, if presented with the string:

| FBIPHDHTWAIBM |

people are able to remember only a few items.

However, if the same information is presented in the following way:

| FBI PHD TWA IBM |

people can remember a great deal more letters. This is because they are able to chunk the information into meaningful groups of letters.

Beyond finding meaning in the abbreviations above, Herbert Simon showed that the ideal size for chunking letters and numbers, meaningful or not, was three. This may be reflected in some countries in the tendency to remember phone numbers as several chunks of three numbers with the final four-number groups generally broken down into two groups of two.

Short-term memory is believed to rely mostly on an acoustic code for storing information, and to a lesser extent a visual code. Conrad (1964) found that test subjects had more difficulty recalling collections of words that were acoustically similar (e.g. dog, hog, fog, bog, log).

Memory strategies include:

1. **Chunking:** Grouping or organizing bits of information into larger unites.
2. **Rehearsal:** Purposely repeating information to maintain it in short-term memory.
3. **Maintenance Rehearsal:** Repeating information over and over again until it is no longer needed. May lead to storage of information in long term memory.

**Displacement:** The event that occurs when short-term memory is filled to capacity; each new, incoming item pushes out an existing item which is then forgotten.
Long-Term Memory (LTM): The memory system with virtually unlimited capacity that contains vast stores of a person’s permanent or relatively permanent memories.

The storage in sensory memory and short-term memory generally have a strictly limited capacity and duration, which means that information is available for a certain period of time, but is not retained indefinitely. By contrast, long-term memory can store much larger quantities of information for potentially unlimited duration (sometimes a whole life span). For example, given a random seven-digit number, we may remember it for only a few seconds before forgetting, suggesting it was stored in our short-term memory.

On the other hand, we can remember telephone numbers for many years through repetition; this information is said to be stored in long-term memory. While short-term memory encodes information acoustically, long-term memory encodes it semantically: Baddeley (1966) discovered that after 20 minutes, test subjects had the greatest difficulty recalling a collection of words that had similar meanings (e.g. big, large, great, huge).

Short-term memory is supported by transient patterns of neuronal communication, dependent on regions of the frontal lobe (especially dorsolateral prefrontal cortex) and the parietal lobe. Long-term memories, on the other hand, are maintained by more stable and permanent changes in neural connections widely spread throughout the brain.

The hippocampus is essential to the consolidation of information from short-term to long-term memory, although it does not seem to store information itself. Rather, it may be involved in changing neural connections for a period of three months or more after the initial learning.

One of the primary functions of sleep is improving consolidation of information, as it can be shown that memory depends on getting sufficient sleep between training and test, and that the hippocampus replays activity from the current day while sleeping.

Types of long term memory includes:

- **Episodic Memory**: Records events as they have been subjectively experienced.
- **Semantic Memory**: Stores general knowledge or objective facts and information
- **Elaborative Rehearsal**: A memory strategy that involves relating new information to something that is already known.

9.4.2 Three Kinds of Memory Tasks

1. **Recall**: producing required information by searching memory
   - **Retrieval Cue**: Any stimulus or bit of information that aids in retrieval

2. **Recognition**: Identifying material as familiar or as having been encountered before. Only requires that you recognize it, not recall all the information

3. **Relearning**: Retention expressed as the percentage of time saved when material is relearned.
9.4.3 The Nature of Remembering

Memories are usually reconstructed, shorter, and more consistent with an individual’s viewpoint. Puzzling features are adapted to fit expectations or familiar objects.

- **Reconstruction:** An account of an event pieced together from a few highlights; may or may not be accurate.

- **Schemas:** Integrated framework of knowledge and assumptions about people, objects, and events; affect how the person encodes and recalls information; may or may not be accurate.

- **Positive Bias:** Pleasant events are remembered more than unpleasant events; aids with current emotional well-being.

**Eyewitness Testimony**

Is highly subject to error and should be viewed with caution. U.S. Department of Justice prepared national guidelines for collecting eyewitness evidence in 1999.

Minimize identification of suspects errors by first describing the perpetrator and then searching for photos to match the description. Lineup errors are minimized through sequential viewing. Viewing members of lineup one at a time rather than all together. Mistakes are more likely if person is of another race or if a weapon was used in the crime.

Misinformation Effect is misleading information supplied after the event confounds a witness’ memory. Stress of the event does not lessen ability to remember critical details while less important details may be lost. Confidence of eyewitnesses has much to do with ease of recall not accuracy of information.

**Recovering Repressed Memories**

Repressed memories may be false “recovered” memories influenced by suggestions. APA & AMA both agree repressed memories exist and that false memories can be constructed.

Hypnosis techniques often used to aid in recovery of memories. Hypnosis does not improve the accuracy of memory only the confidence in what was remembered.

Persons asked to imagine a fictitious event develop a false memory of the event. Repeated exposure to suggestions of false memories can create them. Individual differences in suggestibility may also play a role.

**Infantile amnesia:** The inability to recall events from the first few years of life likely due to limited language and hippocampus development.
Flashbulb Memories

An extremely vivid memory of the conditions surrounding one’s first hearing the news of a surprising, shocking, or highly emotional event.

Easily recalled due to high:
   1. Emotionality
   2. Consequentiality (importance of the consequences of the event)
   3. Rehearsal (how often people think or talk about the events afterward)

Appear to be forgotten at about the same rate and ways as other kinds of memories. Strong emotions present when the flashbulb memories are formed interfere with accurate encoding.

Memory and Culture

The matter and manner of recall are often predominantly determined by social influences.

Swazi herdsman can recall minute individual differences of every cow or a history of a tribe preserved orally by specialist are impressive memory feats possible because it is an integral and critically important part of the culture in which they live.

Other memory components usually no different, stories set in own cultures more easily remembered than those set in other cultures. Culturally based schemas may also influence memory and recall.

9.4.4 Serial Position Effect

The finding that, for information learned in a sequence, recall is better for the beginning and ending items than for the middle items in the sequence

Primacy effect: The tendency to recall the first items in a sequence more readily than the middle items

Recency effect: The tendency to recall the last items in a sequence more readily than those in the middle.

Poorer recall of information in the middle of a series because it is no longer in short-term memory. Serial position effect supports notion of separate systems for short and long-term memory.

Context dependent memory: Information is easier to recall when a person is in the same environmental context they were in when they learned it. Elements of the physical setting where information is learned are encoded along with the memory

State dependent memory: The tendency to recall information better if one is in the same pharmacological or psychological state as when the information was encoded

Mood dependant memory: The finding that what we remember when while in a given mood may be determined in part by what we learned when previously in that same mood.
FORGETTING

Forgetting (retention loss) refers to the apparent loss of information already encoded and stored in an individual's long term memory. It is a spontaneous or gradual process in which old memories are unable to be recalled from memory storage. It is subject to delicately balanced optimization that ensures that relevant memories are recalled.

Forgetting can be reduced by repetition and/or more elaborate cognitive processing of information. Reviewing information in ways that involve active retrieval seems to slow the rate of forgetting.

Forgetting functions (amount remembered as a function of time since an event was first experienced) have been extensively analyzed. The most recent evidence suggests that a power function provides the closest mathematical fit to the forgetting function.

Figure 9.10: Ebbinghaus’s Curve of Forgetting Cause of Forgetting
Ebbinghaus’s Curve of Forgetting: After memorizing lists of nonsense syllables retentions was measured after varying intervals of time using the relearning method. Forgetting was rapid at first (58% after 20 minutes and 44% after 1 hour) then tapered off.

9.5.1 Causes of Forgetting

Encoding failure: Information is not put into long-term memory

Decay theory: Memories not used will fade with time and ultimately disappear

Interference: Information or associations stored hinder the ability to remember it
  • Proactive Interference: Information or experiences already stored hinder memory
  • Retroactive Interference: New learning interferes with ability to recall previous learning

Consolidation Failure: Any disruption in the consolidation process that prevents a long-term memory from forming.

Retrograde Amnesia: A loss of memory for experiences that occurred shortly before a loss of consciousness

Motivated Forgetting: Suppression or repression in an effort to protect from material that is painful, frightening, or otherwise unpleasant

Intentional forgetting: We sometimes forget information we believe to be inaccurate or useless, only to find that we do need it at a later time.

Repression: Removing unpleasant memories from one’s consciousness, so that one is no longer aware that a painful event occurred

Amnesia: A partial or complete loss of memory due to loss of consciousness, brain damage, or psychological cause
  Prospective Forgetting: Not remembering to carry out some intended action; forgetting to do something that is unimportant or unpleasant.

Retrieval Failure: Not remembering something one is certain of knowing

Tip-of-the-tongue phenomenon: Trying to recall some bit of information knowing you knew it but not able to come up with it.

9.5.2 Improving Memory

Over-learning: Practicing or studying material beyond the point where it can be repeated once without error. People remember material better and longer if they over-learn it.

Massed Practice: Learning in one long practice session without rest periods
Spaced practice: Learning in short practice sessions with rest periods in between; more effective with learning than massed practice. Applies to motor skills, learning facts and information.

Method of Loci: The Method of Loci or is a technique for memorizing many things. It is a type of mnemonic link system based on places (loci, otherwise known as locations), used most often in cases where long lists of items are concerned.

The First-Letter Technique: Take the first letter of each item to be remembered and form a word, a phrase, or a sentence with those letters.

Pegword System: A peg system is a mnemonic technique for memorizing lists. It works by pre-memorizing a list of words that are easy to associate with the numbers they represent (1 to 10, 1-100, 1-1000, etc). Those objects form the "pegs" of the system. Then in the future, to rapidly memorize a list of arbitrary objects, each one is associated with the appropriate peg.

<table>
<thead>
<tr>
<th>Item Number</th>
<th>Pegword</th>
<th>Peg Image</th>
<th>Item to Be Recalled</th>
<th>Connecting Image</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>bun</td>
<td><img src="image1.png" alt="image" /></td>
<td>milk</td>
<td><img src="image2.png" alt="image" /></td>
</tr>
<tr>
<td>2</td>
<td>shoe</td>
<td><img src="image3.png" alt="image" /></td>
<td>bread</td>
<td><img src="image4.png" alt="image" /></td>
</tr>
</tbody>
</table>

**Figure 9.11:** The pegword system

**ACTIVITY 9.3**

(a) Explain the various causes that have been proposed to explain forgetting.
(b) Describe various techniques for improving memory.
SELF TEST

1. In which type of conditioning is an association formed between one stimulus and another?

2. Any event or object in the environment to which an organism responds is a ________________.

3. ______ involves transforming information into a form that can be stored in memory.

4. ______ occurs when information stored in memory is brought to mind.

5. Virtually everything we see, hear, or otherwise sense is held briefly in:

6. Short-term memory usually codes information according to:

7. This process can result in items being pushed out of short-term memory and forgotten.

8. ______ is a person’s vast storehouse of permanent or relatively permanent memories.

9. There are two main subsystems within long-term memory. These are:

10. ______ consists of motor skills, habits, and simple classically conditioned responses.

11. In ______ a person must produce required information by searching memory without the help of retrieval.
12. The tendency to recall things that are presented at the end of a sequence is called:

13. When Jacob was 2 years old, he and his family narrowly escaped death when their house was destroyed by a tornado. Despite the significance of this event, Jacob could remember nothing of it. This is called:

14. Recent research supports the hypothesis that ______ is especially important in episodic memories.

15. In the study of memory, LTP stands for:

16. This is a hormone that is released into the bloodstream when a person is emotionally aroused

17. ______ improves working memory efficiency and plays a role in the development and maintenance of synapses in memory areas of the brain, such as the hippocampus.

18. This researcher introduced the “curve of forgetting.”

19. This assumes that memories, if not used, fade with time and ultimately disappear entirely.

20. A term that would be used to describe “cramming” or learning in one long session without rest is:
Suggested Text and References

Required Reading:


Suggested Readings


Suggested Web Sites

Neural Plasticity and LTP Page
http://hallux.medschool.hscklyn.edu/~eric/#Plastica

Medial Temporal Lobe and Memory
http://thalamus.wustl.edu/course/limbic.html

Learning and Memory
http://brembs.net/

Tutorials on Learning and Memory
http://psy71.dur.ac.uk/Education/memory/index.html
Self-check

Answers:

1. classical conditioning
2. stimulus
3. Encoding
4. Retrieval
5. sensory memory
6. sound
7. displacement
8. Long-term memory
9. declarative memory and nondeclarative memory.
10. Nondeclarative memory
11. Recall
12. the recency effect.
13. infantile amnesia
14. the hippocampus
15. long-term potentiation
16. epinephrine
17. Estrogen
18. Ebbinghaus
19. decay theory
20. massed practice.