Science Education Collection

An Introduction to Learning and Memory

URL: http://www.jove.com/science-education/5416

Abstract

Learning is the process of acquiring new information and memory is the retention or storage of that information. Different types of learning, such as non-associative and associative learning, and different types of memory, such as long-term and short-term memory, have been associated with human behaviors. Studying these components in detail helps behavioral scientists understand the neural mechanisms behind these two complex phenomena.

JoVE's overview on learning and memory introduces common terminologies and a brief outline of concepts in this field. Then, key questions asked by behavioral scientists and prominent tools such as fear conditioning and fMRI are discussed. Finally, actual experiments dealing with aging, eradication of traumatic memories, and improvising learning are reviewed.

Transcript

Learning and memory are two closely related cognitive functions that are fundamental to our ability to interact with the world in a meaningful way. Learning is the process of acquiring new information about the world. Memory is the retention or storage of such information, like a series of numbers.

This video presents a brief outline of concepts in learning and memory, introduces key questions asked by scientists in this field, describes some prominent methods, and finally discusses actual experiments in these fields.

Let's begin by exploring some of the concepts that distinguish different types of learning and memory.

Research has shown that learning can be divided into two main classes. First, there is non-associative learning, where properties about a stimulus are learned through either single or repeated exposures. This type of learning usually takes one of two forms.

The first form, habituation, is when a response to a stimulus is decreased or lessened after repeated presentations. In this example, the mouse exhibits a diminished response to a loud noise after hearing it many times.

The second form, called sensitization, is the increased response to a wide variety of stimuli after an intense or noxious stimulus. In this example, the mouse is also exposed to a loud, noxious sound, and continues to be startled in response to soft, more pleasant sounds. It has learned to react as if all sounds are unpleasant.

The second main class of learning is associative learning, during which association between two stimuli, or a behavior and a stimulus, is established.

The first form, operant conditioning, uses reinforcement and punishment to alter the stimulus-behavior association. In this example, a pigeon has learned to peck a box to the right whenever the green stimulus is shown for a food reward. In other words, the correct pecking behavior is positively reinforced.

The second form, classical conditioning or "Pavlovian" conditioning, is when a neutral stimulus, such as a sound, is paired with an intense stimulus, like a shock, to produce a stereotyped behavior. In this example, the mouse learns to associate the neutral stimulus, a loud noise, with the intense shock stimulus, which makes the mouse jump.

After conditioning, the mouse responds to the neutral tone stimulus alone by stopping movement, or freezing, in anticipation of a shock. In this graph, the black line illustrates that mice conditioned with the tone-shock pairing freeze more when later exposed to just the tone than mice that only heard the tone.

Research into memory has also shown that it can be divided into two main types. Short term, or working memory, works like a scratch pad where information, such as a learning a sequence of numbers, is held long enough to carry out a task-like reciting the numbers-and then discarded.

Long term memory is for storing information for days, weeks, or even a lifetime. One subtype of long term memory is explicit or declarative memory. These memories are conscious recollections that can be either episodic memories of specific events, like a party, or semantic memories of specific knowledge about a subject you have learned.

The second sub-type is implicit or procedural memories that are unconsciously expressed. An example would be motor memory of a difficult motion such as balancing on a balance beam.

Now that we have reviewed some of the concepts in learning and memory, let's examine some key scientific questions asked by behavioral scientists.

Some scientists are interested in how learning and memory are affected by one's environment. Scientists may ask how emotions influence learning and memory performance. Emotional images have been shown to be remembered better than neutral images. Scientists may also ask if sleeping helps with remembering. In this study, participants that slept after training were better at remembering than those that did not sleep, as shown by the difference between the red and gray lines.

Other researchers are interested in determining the functional and molecular mechanisms of learning and memory. They may ask what brain regions are active, shown in yellow, during specific learning and memory tasks, and what is the relationship between the regions.

Some researchers study learning and memory in other animals such as rodents, birds, and flies. By studying animals, insight is gained into the physiological processes, like neuronal activity, and specific molecule involvement that govern learning and memory formation in humans.

One important question in learning and memory research is to figure out the changes that occur as we age. It is well known that memory performance and retention diminishes with age. For this reason, scientists are actively working to uncover ways to lessen the effects of aging on learning and memory.

Now that you have a feel for some of the key questions asked about learning and memory, let's look at some of the prominent methods that are used by behavioral scientists.

There are many behavioral tests used to investigate learning and memory in humans, and rodents. One popular test used to study classical conditioning is fear conditioning, where, in the example shown here, a mouse learns to associate a sound with a foot shock.

Mazes, either in the water or on tracks, are used extensively to study operant conditioning and spatial memory. Here a rat has learned to move to the appropriate spot in the maze depending on the cue.

Short term memory, or working memory, can be assessed using what is called a N-back task, where the subject indicates whether or not the current image appeared n-images previously. The more images between repeats, the harder it is to remember.

Behavioral scientists are also interested in the brain mechanisms that enable learning and memory.

Today there exists a variety of non-invasive methods to investigate the neural correlates. Functional magnetic resonance imaging, or fMRI, tracks blood oxygen levels as a proxy for brain activity. Magnetoencephalography, or MEG, maps brain activity by recording changes in magnetic fields produced by the electrical activity in the brain.

Another method used by behavioral scientists to assess brain activity during learning and memory tasks is electroencephalography, or EEG, which uses electrodes on the skull to monitor electrical activity across the brain.

Now that you have a feel for the prominent methods used to study learning and memory, let's look at some actual experiments.

One area of investigation is to figure out the effects and possible treatments of aging on learning and memory. For this investigation, some scientists use a route-learning task in a maze with mice of varying ages. The time and the routes taken to complete the maze are recorded. Results show that older mice, represented by the black bar, took nearly twice as many days to learn the correct route through the maze than the younger mice.

A second area of exploration is to see if memories, especially traumatic memories, can be manipulated or erased after they have been formed. One approach is to investigate whether there are critical time periods after an event in which the memory can be diminished or erased. In this study, subjects learn to associate a specific colored square with a mild shock to the fingers in what is called fear conditioning. Next, various inhibitory learning protocols are used to create new, safe memories of the shock-associated color. The results demonstrate that, if safe memories are created ten minutes after fear conditioning, then the fear memory can be extinguished.

A third area of investigation is to make learning more efficient. Recently, video game technology has been used to investigate learning and memory in conjunction with EEG brain activity recordings. The subject's brain activity at different time points of the game can then be analyzed for insight on how learning and memory are implemented during gameplay.

You've just watched JoVE's introduction to learning and memory. We presented a brief outline of concepts in learning and memory, introduced key questions asked by scientists in this area, described some of the prominent methods, and finally, discussed applications of these fields. Thanks for watching!

