Science Education Collection

An Introduction to Behavioral Neuroscience

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Abstract

Behavioral neuroscience is the study of how the nervous system guides behavior, and how the various functional areas and networks within the brain correlate to specific behaviors and disease states. Researchers in this field utilize a wide variety of experimental methods ranging from complex animal training techniques to sophisticated imaging experiments in human subjects.

This video first offers a historical overview of some of the major milestones that lead to our current understanding of the brain's control over behavior. Then, some of the fundamental questions asked by behavioral neuroscientists are presented, which all involve the study of neural correlates, or specific brain regions whose activation is responsible for a given function. Next, prominent methods used to answer those questions are reviewed for both human and animal subjects, such as operant conditioning and functional neuroimaging. Finally, experimental applications of these techniques are presented, including animal training using a Skinner box, and the use of electroencephalography to investigate human neurological disease.

Transcript

Behavioral neuroscience is the study of how the nervous system guides behavior in humans and animals. Researchers in this field utilize a variety of methods, from animal training techniques to neuroimaging experiments, to study how the functional areas and networks of the brain correlate to specific behaviors and related disease states.

This video will review a brief history of behavioral neuroscience, go over the key questions asked by investigators in this field, review some of the prominent methods used to answer those questions, and provide a glimpse into the types of experiments performed in behavioral neuroscience labs today.

Let's begin with an overview of some of the major milestones in the history of behavioral neuroscience. In ancient Greece, Hippocrates and his followers were among the first to believe that the brain controlled human thought.

Then, in 1662, René Descartes developed one of the first models to describe how the brain controls behavior - he speculated that the soul controlled the body through the pineal gland.

The next few centuries produced a lot of evidence that Descartes was wrong. For example, in 1848, railroad foreman Phineas Gage was involved in an accident that drove an iron rod through his skull. He lived, but exhibited severe personality changes, demonstrating that damage to the frontal lobe has a profound impact on behavior.

Then, in the late 19th century, Paul Broca and Carl Wernicke studied patients who had lost their ability to read and/or speak, and discovered areas of the brain responsible for language, now known as the Broca and Wernicke areas.

Later, in 1890, William James declared that psychology should be studied via biology, and many major discoveries in behavioral modification followed. In the 1930's, following James' advice, BF Skinner developed an apparatus called the Skinner box, which is still used to study how punishment and reward can reinforce behavior in animals.

Then, in the late 1900's, advanced neuroimaging techniques became available, such as magnetic resonance imaging, or MRI. In 1990, Seiji Ogawa developed the method now used for functional MRI, which revolutionized the field of neuroscience by allowing researchers to visualize brain activity over time during simple cognitive tasks.

Now that we've discussed some of the major events in the history of behavioral neuroscience, let's review some of the fundamental questions asked by the folks who neurobiology of behavior today. These questions all involve the study of neural correlates, or specific brain regions whose activation is responsible for a given function.

For example, a scientist interested in nervous system control of movement might investigate the mechanisms that control balance and coordination. Although it has been established that these functions map to the primary motor cortex, premotor cortex, cerebellum, and the substantia nigra, scientists are still investigating how the circuitry within and between each region enables locomotion.

Alternatively, researchers may investigate how the nervous system evaluates stimuli and guides behavior based on these stimuli. Here, researchers may ask how different types of reward can impact animal behavior. Understanding when and why certain rewards are motivating could help us address problems like addiction. Neural correlates for motivation and reward are the limbic system and the ventral tegmental area.

Other behavioral neuroscientists study how the nervous system allows for learning and memory formation. For example, one may investigate how the brain creates and retains memories related to fearful stimuli, which is important for the treatment of post-traumatic stress disorders. These functions generally map to the hippocampus and the amygdala.

Additional key questions focus on higher cognitive processes, such as facial recognition. Here, a researcher may investigate how a subject responds to familiar versus novel faces. In humans, a neural correlate specific for face recognition is the fusiform face area in the fusiform gyrus.

Now that we've gone through a few of the major questions asked by behavioral neuroscientists, let's delve into some of the prominent methods used when trying to answer them. Many approaches in this field involve behavioral experiments in animals, which are performed after manipulating certain brain regions, in order to study the link between neurobiology and behavior.

Processes such as locomotion can be studied in animals using specialized equipment such as the rotarod, which is a rotating rod that requires the animal to move continually to avoid falling off, or chambers that require the animal to reach for food to test dexterity.

Methods involving behavioral modification include operant conditioning, and may utilize the Skinner box for self-administration experiments involving rewarding or aversive stimuli, such as food or drugs.

Methods to investigate learning and memory often utilize mazes, such as T-arm or Morris water maze designs, in which animals have to find, and then remember, the path to exit the apparatus.

As the complexity of the behavior under investigation increases, so does the need for human subjects. For example, studying higher cognitive processes, like language, may involve methods that measure neural activity through the scalp, such as electroencephalography, which can be applied as a subject performs a specific cognitive task.

Functional imaging methods are also used to study human cognition, such as Functional Magnetic Resonance Imaging or fMRI. This method measures a signal, which is correlated to blood flow, and can in turn be linked to task based neuronal activation thereby resulting in a statistical map of active brain regions.

Now that we've gone over some of the prominent methods in behavioral neuroscience, let's have a look at some applications of those techniques.

In this experiment, a mouse is taught that repeatedly pressing a lever in a Skinner box will result in a food reward. The animal is then treated with neuroactive substances, like the hormone leptin, to assess how the resulting changes in brain activity influence the motivation to obtain food.

In humans, functional MRI is often used to study higher cognitive processes such as decision-making. In this study, participants were asked to decide if a pattern of dots is moving quickly or slowly during an fMRI scan.

Electroencephalography, or EEG, is a non-invasive technique that can be used to study disease states, such as dementia and Alzheimer's disease. For these experiments, participants wear non-invasive electrodes on the scalp that measure the brain's electrical activity as a function is performed. Analysis may reveal abnormal patterns correlated with neurologic or psychiatric diseases.

You've just watched JoVE's introduction to behavioral neuroscience. We've reviewed a brief history of this field of study, went over some if its key questions, discussed some prominent methods used to answer those questions, and examined some specific application of those methods.

Thanks for watching!