Science Education Collection

Balance and Coordination Testing

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Abstract

Balance and coordination are critical components involved in the control of movement. Many sensory receptors and neural processing units are required to help individuals maintain balance while performing various activities. Deficits in balance and coordination occur in patients suffering from movement disorders or due to aging. Therefore, scientists are trying to understand the pathophysiology behind these conditions. One way to do that is by using rodent models and testing them on behavioral paradigms such as the rotarod or balance beam.

This video discusses the currently known neurophysiology behind balance and coordination. Then, we go over protocols to run balance tests in rodents using the rotarod and balance beam. Finally, we'll discuss some current studies utilizing these methods to investigate aging, muscular dystrophy and Parkinson's disease.

Transcript

Balance and motor coordination are critical components involved in control of movement. We currently understand the basic mechanisms of the numerous sensory and processing systems that help us maintain our balance while performing various activities. To our advantage, laboratory animals, such as mice, use similar systems for maintaining balance and motor coordination. Scientists can therefore use mice to model different physiological conditions to observe their effect in balance and motor coordination tests.

This video will briefly discuss the neurophysiology behind balance and coordination, followed by the general protocols for the most commonly used behavioral tests, namely the rotarod and balance beam. Lastly, we'll review some current experiments being conducted using these behavioral paradigms.

Before delving into the protocols of behavioral tests, let's take a look at the neurophysiological inputs and processing units that determine our balance and motor coordination.

Visual cues combined with the innate sense of our body's position in space, also known as proprioception, are the main sensory inputs determining our balance. The receptors involved in this phenomenon, called proprioceptors, are found in muscles and joints, and they provide information about our physical status to the central nervous system. This information, combined with input from the vestibular system, which is housed in our inner ear, make up the rest of our "proprioceptive sense." The vestibular system is made up of three semicircular ducts capped by an ampulla, which together are known as canals. Contained within these canals is a fluid called endolymph. A specialized structure known as the cupula, located within the ampulla of each canal, contains hair cells that produce cilia. It is these cilia that are bent by moving endolymph and transmit that information to the vestibular nuclei, which are located in the brainstem. In the brainstem, inputs from the eyes, joints, and vestibular system are sorted and prioritized.

Finally, all these sensory inputs travel to the cerebellum, which subconsciously coordinates proprioceptive and visual information to fine-tune motor commands to increase muscle precision and coordination. Although, a lot has been discovered about the neurological basis of balance and coordination, scientists are still trying to understand the pathophysiology of various movement disorders. One of the tools used by researchers to do that is the rodent behavioral test examining balance and coordination.

Let's discuss the most commonly employed test for this phenomenon-the rotarod.

The rotarod apparatus is composed of three components. First, the spinning dowel, which comes in various sizes. Second, lanes with divisions: the apparatus may be composed of multiple lanes, which allow researchers to test up to five animals at once, or just a single lane for testing one animal at a time. Third, the platforms located beneath each lane that provide a safe landing zone for the animal if they fall from the spinning dowel. In more modern equipment, these platforms can sense animal falling, and automatically record the "time to fall."

Prior to training or experimentation, a period of acclimatization ensures that animals are in a calm state before testing. Training sessions involve animals walking on an accelerating rotarod for several sessions per day over a series of days, and is considered complete once the animals' average "time to fall" begins to plateau. Initially, the rotarod is set to a low speed while animals are placed on the dowel, and rotation is then gradually increased to a maximum speed. Mice should be allowed to rest in-between training runs, and during that time the apparatus should be thoroughly cleaned.

Following training, experimental interventions, such as drug treatment, surgically induced lesions, or other physical manipulation, can be performed. For testing, follow the same protocol as the training session where dowel speed is gradually increased and the data are recorded as "time to fall." A maximum testing time should be defined so as to not overexert the animals. "Time to fall" for each mouse is recorded and averaged over different numbers of trials depending on the experiment.

The second common behavioral assay that tests balance and coordination uses a beam. Numerous distinct balance beams exist including simple, complex, and slanted beams, but the basic set-up is composed of a one-meter-long beam suspended 50-100 centimeters above a table or surface. Motion sensors or video recorders are present to measure animal beam traversal time. An enclosed box containing nesting material located at the end point serves as an attraction for the mouse, while illumination at the start point would act as an aversive stimulus.

Training on the balance beam usually occurs up to three times per day over several days. Training continues until average beam traversal time begins to plateau; however, overtraining can lead to increased stalling and turning on the beam. Following experimental modulation, the testing phase begins, and data are recorded as "time to traverse." Usually, results are obtained by averaging at least two crossings in which the tested animal did not stop or require prodding.

Now that we've seen the experimental set-ups of commonly employed behavioral tests, let's look at some specific applications of these methods.

Aging is a normal biological process, one consequence of which is the degradation of the vestibular system as hair cells produce fewer cilia, and also begin to die. The result of this is loss of balance that can result in increased falls in the elderly. In this experiment, mice of varying ages went through a vestibular challenge in which they were spun in a rotator for 20 seconds and immediately after that asked to traverse a slanted beam. Researchers observed that older mice are more dramatically affected by vestibular challenge than the younger mice.

Rotarod testing is useful in studying gross motor deficits and fatigue resistance, making it ideal for studying a disease like muscular dystrophy. The hallmark of muscular dystrophy is muscle damage that ultimately results in deficits in mobility, coordination, and balance. In this experiment, researchers compared rotarod running times between wild type mice and mouse models of muscular dystrophy.

Parkinson's disease is characterized by the death of dopaminergic neurons in substantia nigra, and often presents with motor deficits and loss of coordination. In this experiment, a challenging beam test was performed. Comparing wild type mice to a genetically engineered Parkinson's model, it was observed that Parkinson's mice had increased errors per step and increased errors per beam width.

You've just watched JoVE's video on balance and coordination testing. This video discussed the neural correlates of balance and coordination, some prominent methods to test balance, and finally a few applications of these behavioral tests in neuroscience labs today. As always, thanks for watching!