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Assessing Dexterity with Reaching Tasks

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Abstract

Reaching tasks are employed in behavioral neuroscience to investigate motor learning and forelimb dexterity. Much like human hands, rodents have dexterous forepaws, which are necessary for executing coordinated and precise motor movements. Experimenters may utilize food rewards to train rodents to reach and for testing their reaching abilities. These tasks help behavioral neuroscientist in understanding how CNS injuries, such as a stroke, may impair reaching ability and dexterity in humans.

This video begins by discussing the principles and neurobiology of forelimb use in rodents, and then explains a protocol on how to conduct reaching experiments using different types of food rewards. Applications section reviews studies that involve reaching and food handling in animal models of CNS injury.

Transcript

Reaching tasks are used in the field of behavioral neuroscience to assess forelimb dexterity and motor learning. Animals are motivated to reach for appetizing food rewards, such as pasta or seeds. Aiming, grasping, breaking, and retrieving are some novel skills that animals acquire and refine while learning these tasks.

This video covers the reasons why behavioral neuroscientists study skilled reaching, and discusses a protocol for conducting reaching experiments. Lastly, the video will also review some specific behavioral experiments involving skilled forelimb use in various models of brain injury.

Before jumping into the reaching task protocol, let's talk about forelimb use, which is what reaching tasks measure. Rodents have extremely dexterous forepaws, which they use in ways similar to how we use our hands. Reaching tasks allow scientists to observe how rodents use their paws to grasp and retrieve food pieces. This provides a quantifiable measure of forepaw dexterity.

These tasks require that animals learn new sequences of movements, such as flexion and extension, pronation and supination, and rotation.

This motor learning is associated with activation of specific areas of the brain. Neural signals for gross, as well as fine, motor skills are initiated in motor areas consisting of primary motor and premotor cortices, and sent via the spinal cord to the appropriate muscles, which produce desired movements.

Rodents are a good model for translational motor studies because their motor system is organized similarly to that of humans. Damage to these motor areas perturbs hand use in people, and forepaw use in rodents, the latter of which can be measured using reaching tasks.

Since you now know why scientists use reaching tasks, let's see how these studies are done. Prior to testing, animals should be handled and exposed to the apparatus and food rewards, in order to limit stress and fear responses. Usually, animals are fed a restricted diet, with food provided at the end of daily reach training sessions. This ensures that the animals are not sated at the time of testing.

Reaching tasks are conducted in a specially designed chamber that has three slits. Let's talk about the task involving rodents reaching for seeds. For this type of experiment, the central slit is used to determine the limb preference and this process is called shaping. In order to do this, mice are allowed to reach for seeds with both limbs for a limited number of times in one session. Shaping sessions are conducted daily until animals exhibit prererential reaching with one limb 70% of the time. Then, their preferred limb is trained to skillfully reach for individual seeds placed in the divets for the side slits on the reaching stage. Each reach attempt is scored as either a success, a drop, or a fail. Reach training must be conducted over many days in order for the animals to learn the task. Mice generally reach a plateau within a few days.

In cases where animals are trained to reach for pasta rather than seeds, the experimenter utilizes only the central slit for both, training and testing. The pasta matrix, a plastic block with holes drilled through the entire depth, is filled with dry pasta and placed in front of the chamber. The preferred limb is determined by allowing mice to reach with both limbs. Then, training is conducted by filling only the half of the matrix opposite to the preferred limb. The number and location of pasta pieces broken per reaching session is recorded. Over the course of a few weeks, mice learn to clear larger and more distant portions of the matrix.

Now that we've reviewed the basic protocol for testing forelimb use, let's discuss some current experiments using these tasks.

Reaching behaviors are significantly impaired after a stroke and the type of rehabilitative training can affect how well the stroke-affected limb regains function. Here, scientists show that in a mouse model of stroke, compensatory training with the non-paretic or "good" limb impairs the ability of the paretic or "bad" limb to regain reaching ability. However, directly training the paretic limb results in improvements over time after stroke.

Other than reaching tests, there are other tests of forelimb use in rodents, such as pasta or cereal handling tests that provide different, more varied measures of forelimb dexterity. After stroke, rodents show deficits in paw movements used to handle pasta during eating. In a model of spinal cord injury, cereal handling patterns, including forepaw contact, wrist movements, and digit contact, are altered.

Similar to reaching tasks in rodents, the modified Brinkman board can be used to test hand dexterity in non-human primates. In this test, monkeys grasp food pellets placed in holes on an angled board. Following a spinal cord injury that impairs the use of one arm, the number of pellets retrieved by the affected hand decreases and does not improve over time. In contrast, after a stroke in the motor cortex, the number of pellets retrieved by the affected hand initially decreases, but improves over time.

You've just watched JoVE's introduction to reaching tasks. This video covered the principles and neural correlates associated with skilled forelimb use, the general protocol of conducting reaching tests, and some experiments using forelimb dexterity assessment in brain or spinal cord injury models. As always, thanks for watching!