Science Education Collection

The Morris Water Maze

URL: http://www.jove.com/science-education/5211

Abstract

The Morris water maze is one of the most widely used behavioral tests for studying spatial learning and memory. In the initial phases of this task, rodents must swim to a platform to escape from a pool of water. The platform is then hidden under the water's surface, so that the animal is required to remember it's location in order to escape.This simple yet powerful maze design can be used to assay cognitive function, study animal models of neurodegenerative disease, and test potential drug therapies.

This video provides an introduction to the Morris water maze and the principles surrounding its use, including a discussion of the different types of memory tested in the maze, important points to consider when designing and conducting this experiment, and the procedures for setup and running of the test. Several applications of the maze are examined, such as investigating how radiation treatment may lead to memory impairment. Finally, other types of water mazes, such as the 8-arm radial maze, are introduced to show how this paradigm can be adapted to engage different types of memory.

Transcript

The Morris water maze is a valuable tool to study learning and memory in rodents. These critters are good swimmers, but they generally prefer to be on land. The water maze takes advantage of this preference to train animals to use a small platform as an escape from a pool of water. After training, the platform is hidden beneath the surface requiring the rodent to remember its location with respect to distant visual cues.

This video will summarize principles of Morris Water Maze testing review procedures for setting up and running the test and highlight some ways that this and other water tests are used in lab studies.

Let's dive right in to some basic concepts behind experimentation using the Morris water maze! As previously mentioned, rodents will find their way to a hidden platform by referencing visual cues, like high contrast posters arranged around the room. This depends upon specific regions of the brain, including the hippocampus, whose function is important in memory formation. Changes in the time it takes the rodent to find the platform in a series of successive trials can be used as a measure of spatial learning and memory.

To help quantify memory, the pool is conceptually divided into four quadrants so that the tendency of the animal to explore the region near the platform can be assessed.

The conceptual quadrants are also useful in the probe trial, where the animal is tested in a pool containing no platform. If performed at least 24 hours after the completion of training, the tendency of the animal to explore the formerly correct quadrant is an indication of long-term or "reference" memory formation.

Similarly, reversal trials involve a change in platform location and measure the cognitive flexibility of the rodent to recognize that the platform is gone and look somewhere else. Since all of these data are collected over many trials and with many animals, variability between trials and subjects will have a big impact on your results.

Factors that can affect animal performance include temperature, humidity, or time of day. Additionally, visible investigators can become unintentional visual cues during testing, so the presence and visibility of investigators in the test room are important considerations.

Variability also exists between animals and can be a source of error. As a result, rodent age and sex must be carefully matched between experimental groups. Finally, measurements from animals with mobility problems, injuries, or bad vision will not accurately reflect learning and are not ideal for testing in the water maze.

Now that you have considered important experimental factors, let's jump in to setting up the test. Begin with a pool filled with cool, not cold, water. Pool size can vary depending on if you are using rats or mice. Next, place non-motile visual cues around the room, with at least one cue per quadrant.

The learning trials begin by putting an escape platform into the pool. Next, gently place the subject into the water, taking care not to submerge its head. Allow the animal to explore the maze and record the amount of time it takes to find the platform. If the rodent does not locate the platform within approximately 60 seconds, guide it there and allow it to stay for 10 - 20 seconds before removing, drying, and placing it into a warmed cage.

To complete the training, repeat this procedure multiple times, with the animal beginning each successive trial from a different entry point.

Now it's time to test the animal's ability to find a hidden platform. Start by raising the water level to about an inch above the top of the platform and adding powdered milk or non-toxic paint to the water. In these trials, record the time the rodent spends in each quadrant and the time it takes to find the hidden platform.

Again, if the animal doesn't succeed in 60 seconds, guide it to the platform and allow it to remain for a short period before removal. Repeat this procedure at least twice more on the same day, with the animal beginning each successive trial from a different position.

24 hours after the completion of the hidden platform trials, perform a probe test by removing the platform and allowing the animal to explore the maze for another 60 second trial. Monitor and record time in each quadrant.

You have learned the basics of the Morris water maze, so let's discuss how it's used in behavioral neurobiology experiments.

First, behavioral tests like the water maze are extremely useful for studying the molecular biology of learning and memory. For instance, scientists can use techniques like stereotaxic surgery to manipulate the expression of specific genes in the brain and directly test the impact on learning. Furthermore, testing rodent models of genetic disorders affecting memory, like Alzheimer's, can be used to characterize molecules that could either be risk factors or potential therapeutics for the disease.

Behavioral tests are also important for studying the impacts of brain injury on learning and memory in the context of head trauma, oxygen deprivation, or lesions in specific brain regions. For example, certain medical therapies, like radiation, can damage the brain and negatively impact memory. In this experiment, irradiated animals perform poorly in the water maze when compared to controls. By simultaneously testing different treatments, researchers can explore interventions that could prevent cognitive impairment in humans undergoing radiotherapy.

Since water is very effective in encouraging rodents to explore a maze, it's no surprise that many water-based maze variants exist. Some variants seek to reduce animal stress during testing, like this paddling maze, which alleviates the need for swimming and provides exits at the edges, where rodents naturally prefer to be. Other swimming variations, such as the 8-arm maze, have a more complex configuration demanding that the rodents integrate more information to reach the escapes. This layout allows for simultaneous testing of both reference memory and shorter-term working memory.

You've just watched JoVE's introduction to the Morris water maze. Water mazes are one way for us to test how animals learn and remember and help us understand the relationship between biology and behavior.

Thanks for watching!