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Male Long Evans rats' retention of a place memory acquired during a single massed training session in a water plus maze is short lived

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ABSTRACT

While rats can retain a place memory acquired across several training days in the Morris water maze task (MWM) for long periods of time, retention of a place memory acquired during a single massed training session does not last very long (Bolding & Rudy, 2006). We hypothesized that reducing the searching area in the MWM by inserting a water plus-maze (WPM) might affect retention of a rapidly acquired spatial location. In Experiment 1, male Long Evans rats were given 10 trials on a place problem over a single massed training session in a WPM, followed by a 30-s no-platform probe trial given at 1 of 4 retention intervals: 30 min, 4 h, 24 h, or 48 h. Only the 30-min group showed a spatial bias, spending more time in the correct arm compared to the next preferred arm. In Experiment 2, the same rats were retrained on the spatial problem to determine if spatial bias would be evident at longer retention intervals when the duration of the probe trial was manipulated. No significant spatial bias was evident at the 4-h or 24-h retention intervals when rats were given 20-s or 60-s probe trials. Interestingly, in both experiments, first arm choice during the probe trials did not correlate with searching behaviour. The results from the present study extend Bolding and Rudy's (2006) findings in the open field MWM to the WPM and suggest that in a WPM first arm choice alone is not a representative measure of place memory retention.

Introduction

The place version of the Morris water maze task (MWM) is a hippocampal dependent task that can be retained for long periods of time (D' Hooge & De Deyn, 2001; Morris, 1981; Morris, Garrud, Rawlins, & O'Keefe, 1982; Sutherland, Kolb, & Whishaw, 1982; Sutherland & Rudy, 1988; Spreng, Rossier, & Schenk, 2002; Zelinski, Hong, & McDonald, 2014; Zelinski, Tyndall, Hong, & McDonald, 2013). In the MWM, rats typically receive anywhere from four to eight trials a day for five to six consecutive days (subsequently referred to as the distributed MWM; Morris, 1984; Vorhees & Williams, 2006). This version of the MWM requires the dorsal hippocampus, but not the ventral hippocampus (Moser, Moser, Forrest, Andersen, & Morris, 1995). Animals with ventral hippocampal lesions are initially impaired in the distributed MWM, but by the end of training they are indistinguishable from control animals (Ruediger, Spirig, Donato, & Caroni, 2012).

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There are variants of the MWM task that involve a single massed training session consisting of typically 10–16 trials (subsequently referred to as the massed training MWM; Bolding & Rudy, 2006; Morris, 1984; Warren, Castro, Rudy, & Maier, 1991), or a novel platform location each day (delayed matching-to-place task (DMP); da Silva, Bast, & Morris, 2014; Ferbinteanu, Ray, & McDonald, 2003). These versions of the MWM involve the rapid acquisition of spatial information and some of these versions require both dorsal and ventral hippocampus (Ferbinteanu et al., 2003). Rapid acquisition MWM tasks are useful paradigms because in contrast to the distributed MWM version, these tasks place such a high demand on hippocampal processing that the ventral hippocampus is necessary for task completion (Ferbinteanu et al., 2003). Thus these paradigms are especially sensitive to hippocampal damage (Craig, Hong, Kopp, & McDonald, 2008a, 2008b, 2009a, 2009b; Ferbinteanu et al., 2003; McDonald, Craig, & Hong, 2008).

Although rats can retain spatial information acquired in the distributed MWM for many days (Spreng et al., 2002; Zelinski et al., 2014, 2013), they cannot retain spatial information acquired in the massed training MWM for very long (Bolding & Rudy, 2006; Morris, 1984; Spreng et al., 2002; Warren et al., 1991). For example, Bolding and Rudy (2006) observed in their first experiment that rats only retained spatial information for 30 min after training on a single massed session consisting of 10 trials.

As in the vast majority of studies utilizing the MWM, Bolding and Rudy (2006) used an open field MWM. Plexiglas walls can be inserted into the water tank to create a water plus-maze (WPM) (Skinner et al., 2001; Wahlsten, Cooper, & Crabbe, 2005) or water T-maze (Cahill, Fifield, Thorpe, Martin, & Skinner, 2014; Peckford, McRae, Thorpe, Martin, & Skinner, 2013; Whyte, Martin, & Skinner, 2009). Wahlsten et al. (2005) demonstrated that some mouse strains perform better in the WPM compared to the MWM, while the opposite is true for other strains. One possible explanation for differential performance in the two tasks is that a WPM reduces the exploration area of the tank. It has been suggested that the MWM might provide an overestimated measure of place retention because the quadrants used for analysis are so large that thigmotaxic behaviour and swimming through the target quadrant are scored as if the animal is searching for the platform in that quadrant (Blokland, Geraerts, & Been, 2004). Alternatively, a WPM might be easier to acquire because the number of possible trajectories is greatly reduced. Thus, it is conceivable that retention for a spatial location acquired during a single massed training session could be better in the WPM compared to the MWM. In addition to the configuration of the water maze, the length of the probe trial can also influence the interpretation of a rat's retention of spatial information, with shorter probe trials typically offering a better representation of the place memory (Blokland et al., 2004). The present study investigated rats' retention of a place memory acquired during one massed training session comprised of ten trials in a WPM.

Experiment 1

The aim of the first experiment was to determine how long rats can retain a rapidly acquired place memory in a WPM. The rats received ten training trials in a single massed training session and were then given a 30-s probe trial at 30 min, 4 h, 24 h, or 48 h after the training session.

Methods

Subjects

Thirty-two adult male, experimentally naïve, Long Evans (LE) rats, weighing 183–243 g at the start of the experiment and obtained from the Charles River Company (St. Constant, Quebec, Canada), were used. The rats were housed individually in clear plastic cages (45 cm × 25 cm × 21 cm) with secured metal lids. The rats were kept in controlled laboratory conditions and maintained on a 12-h/12-h light/dark cycle with lights on at 0800. For the entire duration of the experiment, rats were given free access to food and water, while in their home cages. Animal care and all procedures used in the present experiment were approved by Memorial University's Institutional Committee on Animal Care and followed the Canadian Council on Animal Care guidelines.

Apparatus

The training room (528 cm × 464 cm × 267 cm) had windows covering the entire north wall. There were many distal cues throughout the room, such as several doors, cabinets, a sink, a coat rack, and stacks of boxes. The location of these cues remained constant for the entire duration of the experiment.

The water maze consisted of a plus maze inserted into a circular metal tank (120 cm diameter × 31 cm high). This apparatus was placed on a metal frame with wheels. Clear Plexiglas (31 cm high) walls extended around the circumference of the tank. The walls of the plus maze were also made of clear Plexiglas and extended 31 cm above the top of the tank. The arms of the plus maze were 52.5 cm long and 11.5 cm wide. The water level was maintained at 2.5 cm below the top of the metal tank and kept at room temperature (approximately 20 °C). Also, the water was rendered opaque by adding approximately 250 ml of non-toxic white Tempera paint (Rich Art Color Company, Northvale, NJ). A platform (11.5 cm diameter × 26.5 cm high) positioned 1–2 cm below the surface of the water was placed at the end of one of the arms of the plus maze. It was made of white plumbing tubing, filled with sand, topped with a non-slip drawer liner and attached to a Plexiglas base for stability. The position of the platform was changed manually by lifting it off of the bottom of the tank.