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Spatial memory in rats after 25 hours ☆

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ABSTRACT

We investigated the time course of spatial-memory decay in rats using an eight-arm radial maze. It is well established that performance remains high with retention intervals as long as 4 h, but declines to chance with a 24-h retention interval (Beatty, W. W., & Shavalia, D. A. (1980b). Spatial memory in rats: time course of working memory and effect of anesthetics. *Behavioral & Neural Biology, 28*, 454–462). It is possible that 24 h reflects a genuine retention limitation of rat spatial memory. Alternatively, it may be possible to identify factors that might support memory performance even after very long delays. The current experiment was conducted to test the above two hypotheses. We evaluated performance using two intertrial intervals (24 and 48 h) and two retention intervals (1 and 25 h). Increasing the intertrial interval produced an approximately constant increase in performance for both retention intervals. This improvement is consistent with a trial-spacing effect (i.e., the superiority of spaced over massed trials). Rat spatial memory apparently lasts at least 25 h.

The radial arm maze (Olton & Samuelson, 1976) has been used extensively to explore the mechanisms of spatial cognition in rats. For example, initial behavioral studies focused on the basic psychological processes responsible for the highly accurate levels of performance that are typically observed (e.g., Brown, 1992; Roberts, 1981, 1992; Timberlake & White, 1990). Subsequent experimental efforts using this approach have explored the anatomical (Davidson & Jarrard, 2004), pharmacological (Myhrer, 2003), and genetic (Ammassari-Teule, Hoffmann, & Rossi-Arnaud, 1993; Ammassari-Teule, Mil-

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haud, Passino, Restivo, & Lassalle, 1999; Mineur & Crusio, 2002; Prior, Schwegler, & Ducker, 1997) bases of spatial cognition. In addition, performance on the radial maze has been useful for assessing hormonal and developmental contributions to spatial cognition (Jonasson, 2005; Luine, Luine, & Harding, 1994; Meck & Williams, 2003).

In the classic version of this method, eight equidistantly-spaced runways are connected to a central area, and the distal end of each arm is baited with a small piece of food. The rat is placed in the central area and permitted to explore the maze and eat the food. Optimal performance is to visit each arm once because each arm is depleted of food when a visit occurs and food is not replaced. In most experiments of this type, the rat is returned to the maze after a day and the next trial (with new food at each arm) is conducted.

The extensive use of the radial maze stems from the observation that rats are quite efficient at visiting each arm once without revisits (Olton & Samuelson, 1976; Timberlake & White, 1990). A basic method for studying spatial cognition in the radial maze involves interrupting the rat part way through the trial and then continuing the trial after an intervening event. For example, the initial phase of the trial might consist of presenting the rat with four randomly selected accessible arms (*study phase*), and the continuation of the trial consists of returning the rat to the maze with all arms accessible (*test phase*). Many intervening events have been shown to leave memory for the study phase locations unimpaired. For example, changes in visual, auditory, and olfactory stimuli and food consumption do not interfere with memory (Maki, Brokofsky, & Berg, 1979). More remarkably, performance on another radial maze does not interfere with memory (Beatty & Shavalia, 1980a) even when they are located in the same room (Roberts, 1981).

However, a limited number of events have been found to produce retroactive interference. For example, if the intervening events are at the exact spatial locations that were used in task, then performance declines, and performance also declines if many interpolated events occur (Roberts, 1981). Delivering electroconvulsive shock a couple of hours after the study phase is an additional effective interfering event (Beatty, Bierley, & Rush, 1985; Shavalia, Dodge, & Beatty, 1981). These observations suggest that events that reduce spatial memory in the radial maze are primarily limited to events that occur at the exact position in space or that disrupt consolidation of recently formed memories.

Consistent with the overall finding of resistance to interference in radial maze performance, memory for earlier locations appears to be uninfluenced by relatively long retention intervals between study and test. In particular, Beatty and Shavalia (1980b) showed that accuracy was uniformly high for retention intervals between 0 and 4 h. Performance declined gradually with longer retention intervals, and was not significantly different from chance[1] when the retention interval was 24 h. It is possible that 24 h reflects a genuine limitation of rat spatial memory. Alternatively, it may be possible to identify factors that might support memory performance even after very long delays. The current experiment was conducted to test the above two hypotheses.

One potential explanation for chance-level performance with a 24-h retention interval is as follows. Training procedures typically involve one trial per day, as was the case in Beatty and Shavalia's (1980b) experiment. Consequently, it is possible that the rats treated the 24-h retention interval as a cue to reset spatial memory for locations in the earlier study phase. Indeed, accurate performance in the earlier parts of the experiment generally required resetting of spatial memory from day to day in order to maintain high levels of accuracy. The radial-maze experiment is an example of a recency discrimination because all locations have been visited in the past; therefore, accurate performance requires that the subject discriminate which locations have been visited most recently, which would be facilitated by resetting spatial memory each day. Importantly, in earlier experiments, confusion between retention interval and intertrial interval would produce chance performance with retention intervals that are approximately a day. The confusion proposal outlined above is similar to Zentall's recent observations regarding temporal processing, which focus on the potential confusion between retention intervals and intertrial intervals (Zentall, 2006, 2007).

[1] The percent correct in the first four choices in the test phase of this experiment is 45% based on chance; this value is based on the conservative assumption that a rat does not enter the same arm twice in succession (Olton & Samuelson, 1976); see Beatty and Shavalia (1980b) for a brief discussion of the chance calculation.