

Helplessness and Spatial Memory in Swimming Rats

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Our study describes behavioral procedures for inducing a form of learned helplessness in swimming rats and also explores long-term spatial memory. Male Long-Evans rats participated in a spatial mapping replication study from 76-80 days of age. They were required to escape from a large circular pool of cloudy water onto a small hidden platform. At 514 days of age, the rats were assigned to either a control group (C rats) or a learned helplessness group (LH rats). During a learning phase, C rats swam from the West position to the hidden escape platform in the Southeast quadrant while LH rats received helplessness conditioning. Each LH rat was yoked in terms of swimming time to a C rat counterpart, being required to swim in the pool sans platform and experiencing random quadrant retrieval. During a testing phase, all rats swam from West to Southeast with platform present. Latency data for both phases evidenced no deficits in long-term spatial memory for C rats. Escape latencies of LH rats were significantly impaired and their performance failed to improve during testing, suggesting that a form of helplessness had been induced.

Seligman (1975) describes learned helplessness as "the psychological state that frequently results when events are uncontrollable." Whether this helplessness results from natural life occurrences or is experimentally induced, organisms learn that they have no control over their environment, that their actions do not matter. Helplessness has been observed in a variety of species including chickens, cats, dogs, fish, mice, and rats (Maser & Seligman, 1977; Seligman & Beagley, 1975) and is a prevalent psychogenic explanation for reactive depression in humans. According to Seligman (1975), evidencing helplessness in rats requires two critical components: a voluntary response task and response-outcome independence. We previously observed behavior reminiscent of learned helplessness in swimming rats (Wiebers, 1988; Wiebers & Cook, 1998; Wiebers & Hothersall, 1989) and hypothesized that a level of helplessness could be induced in laboratory rats using a modified place task version of Morris' (1981) swimming pool paradigm.

For reference purposes, Kolb (1989) includes an informative schematic of the swimming task. Essentially, the animal is required to escape from a large circular pool of cloudy water onto a small submerged platform. Although rats are natural swimmers (Barnett, 1975; Morris, 1981), they are highly motivated to get out of the water. This paradigm generates clean and rapid measures of performance, contributes to the overall health of laboratory rats, and is relatively noninvasive; perhaps offering an alternative to traditional shock paradigms used in helplessness studies (Wiebers, 1992; Wiebers, 1994). Because the animals cannot see, hear, or smell the platform's location, they must rely on cognitive maps to escape the water (Morris, 1981; Tolman, 1948). We believe a task requiring cognitive map formation satisfies the first of Seligman's criteria. Further, removal of the platform and random quadrant retrieval during helplessness conditioning should satisfy the second criterion because the swimming response is dissociated from escaping the water.

Herein, we describe an experimental procedure for inducing a form of learned helplessness in swimming rats. Because our rats were engaged in a developmental study of swimming behavior, we also provide data relevant to long-term spatial memory in rats and possible immunization against helplessness. Unlike the classic studies of Richter (1957) and Galef & Seligman (cited in Seligman, 1975) who instilled a severe helplessness in their wild rats, our intent was to induce a milder form of helplessness in laboratory rats. We hypothesized that such helplessness would reflect impaired cognitive performance and perhaps be a better parallel for commonplace reactive depression in humans.

Method

Subjects

Twelve male Long-Evans hooded rats participated. They were housed in pairs since weaning and received a variety of foods to supplement the standard laboratory diet. Between daily care and cohabitation, they had extensive inter- and intra-species socialization experience.

Apparatus

A large circular animal watering trough (173 cm diameter) served as the swimming pool, with a small escape platform (12 cm diameter) fabricated from PVC pipe. We rendered the water opaque with the addition of a nontoxic white powdered paint and maintained a temperature of approximately 22° C. The apparatus was situated in a corner of our laboratory in alignment with designated compass directions (N, S, E, & W) and surrounded by a number of salient distal cues.

Procedure

At 76 days of age, we examined the swimming behavior of the rats in a partial replication study of Morris (1981) and Wiebers (1988). After an initial adaptation swim on the first day, rats received six escape trials per day for three days. Rats were required to swim from the West position and escape onto the submerged platform located in the center of the Southeast quadrant. Rats did receive differential experiences on the last three trials on the last day of testing (see Morris, 1981). On every trial, the rat handler timed escape latency with a stopwatch while the other experimenter traced the swim path onto a map of the pool, noted the latency, and recorded the number of rears while the rat was on the platform during a thirty second inter-trial-interval (ITI). Behavioral observations such as stereotypic swimming styles and diving were noted throughout the course of the study. All rats were thoroughly dried at the end of each swimming session and returned to their living quarters. This initial replication study was part of an undergraduate research project and was important for establishing the reliability of our behavioral procedures.

Over the next 434 days, rats were tended to daily, and other than handling and periodic cage cleaning, received no other outside experiences. Our helplessness and spatial memory study began when the rats were 514 days of age. We assigned six rats to a control group (C rats), with the other six being designated as the learned helplessness group (LH rats). We made sure that the differential test experiences from the replication study were equally represented in the two

groups. Methods of data collection paralleled those of the replication study.

On the first day, all rats received an individual two-minute adaptation swim in the pool sans platform to assure that the animals were still healthy, capable swimmers. During an acquisition phase spanning the next four days, C rats swam six trials per day, always starting from the West position with the submerged platform located in the center of the Southeast quadrant. Each LH rat was yoked to a control counterpart during this acquisition phase. They started from the West position and swam in the pool sans platform for the same amount of time as their yoked counterparts on any given trial and corresponding day. For example, if a C rat escaped in 60 seconds on trial two of the third day, his yoked LH rat swam for 60 seconds on his trial two of the third day. Whereas C rats were retrieved by the handler from the platform for the commencement of the next trial, LH rats experienced random quadrant retrieval (SE, NE, SW, or NW). In other words, they were never able to predict which quadrant the handler would go to for retrieving them from the water. Their corresponding ITI was spent in a holding cage outside of the pool. These four days constituted the learned helplessness conditioning for the LH rats, indicative of Seligman's response-outcome independence. Days 6 and 7 were testing days designed to examine whether helplessness was present in the LH rats. During this testing phase, all rats swam from the West position with the platform located in the Southeast quadrant.

Results

Figure 1 presents mean escape latency data in seconds \pm SE for C and LH rats across trial blocks for each phase of our study. Individual rat data for every three successive trials were averaged to form a trial block score for purposes of analysis. For clarity in presenting the helplessness and spatial memory data, trial block six from the replication study has been omitted; although, the test data did successfully replicate the Morris (1981) findings. One LH rat was withdrawn from the study early in helplessness conditioning because of recurring nosebleeds. All other rats completed the study. To control for the heterogeneity of variance and nonnormal distributions inherent in escape latency swim data, we have found it appropriate to calculate log transformations for use in our analyses of variance (Aron & Aron, 1999; Wiebers, 1988; Winer, 1962).

We reanalyzed the original replication data (omitting trial block six) by subsequent group assignment to assure that there were no group differences prior to the helplessness phase. A two-factor ANOVA with trial block being treated as a repeated measures factor confirmed this expectancy (group and group \times trial block were both ns). The analysis did yield a significant effect of trial block [$F(4,36) = 4.73, p < .004$], indicating that the rats were learning the location of the hidden platform.

For the helplessness phase of the study, we first conducted a repeated measures ANOVA for C rat data across their first eight trial blocks (ns). This finding implies that C rats retained their original learning and is of particular interest because of the implications for long-term spatial memory in rats.

Finally, we conducted a two-factor ANOVA (group \times trial block, with trial block as a repeated measures factor) for the last four trial blocks when all rats had the platform present.

This was essentially a testing phase designed to detect any helplessness in LH rats as a result of their experiences. Trial block and group x trial block were both ns. However, there was a significant group effect [$F(1,9) = 8.43, p < .02$] indicating impaired escape latency for LH rats across all trial blocks.

Discussion

Results suggest that our behavioral procedures for inducing a form of helplessness in swimming rats, manifested by impaired cognitive performance, were effective. LH rats were significantly slower than C rats to escape the water and failed to improve across trial blocks. However, we further suggest that these data should be interpreted with a certain degree of caution. First, performance of LH rats was not all that different from the initial two trial blocks of C rats during the helplessness phase of our study. Second, prior experience with the swimming task may have provided partial immunization against a more severe helplessness in LH rats. Third, we expect that the effect would have dissipated eventually had we continued swimming the LH rats with platform present. Nevertheless, we did evidence a form of helplessness. It is curious to note that one LH rat was removed from the study due to recurring nosebleeds during helplessness conditioning. Further, two of the 12 rats developed tumors before their death: Both were LH rats. We suggest that further studies utilizing our procedures to instill helplessness in swimming rats might necessitate a behavioral therapy phase contingent on the severity of helplessness induced.

A second interesting result of our study is the demonstration of significant long-term spatial memory in C rats. Our 17-month-old rats were able to resume their previous level of performance after a 14.5-month hiatus from the swimming task, results indicating that no significant new learning was required. While we have great respect for the learning and memory abilities of rats, we did find this result surprising, expecting at least a mildly significant learning curve for the beginning of the helplessness phase. Admittedly, our rats would not be considered senescent at the time of testing. Gage, Dunnett, & Björklund (1984) and Rapp, Rosenberg, & Gallagher (1987) both reported impaired spatial memory in 24-month-old swimming rats. Though younger, our C rats evidenced no deficits in either short-term or long-term spatial memory, and these data may be of interest to researchers attempting to isolate a temporal window of memory decline in aging rats.

Additional laboratory work is necessitated to assess helplessness in swimming rats and the usefulness of our behavioral procedures. However, as long as we rely on animal models of human psychopathologies, we believe our helplessness study provides a unique alternative to traditional shock paradigms. A helplessness manifested by impaired cognitive performance may at times be a more practical parallel than one resulting in a more severe helplessness or sudden death.

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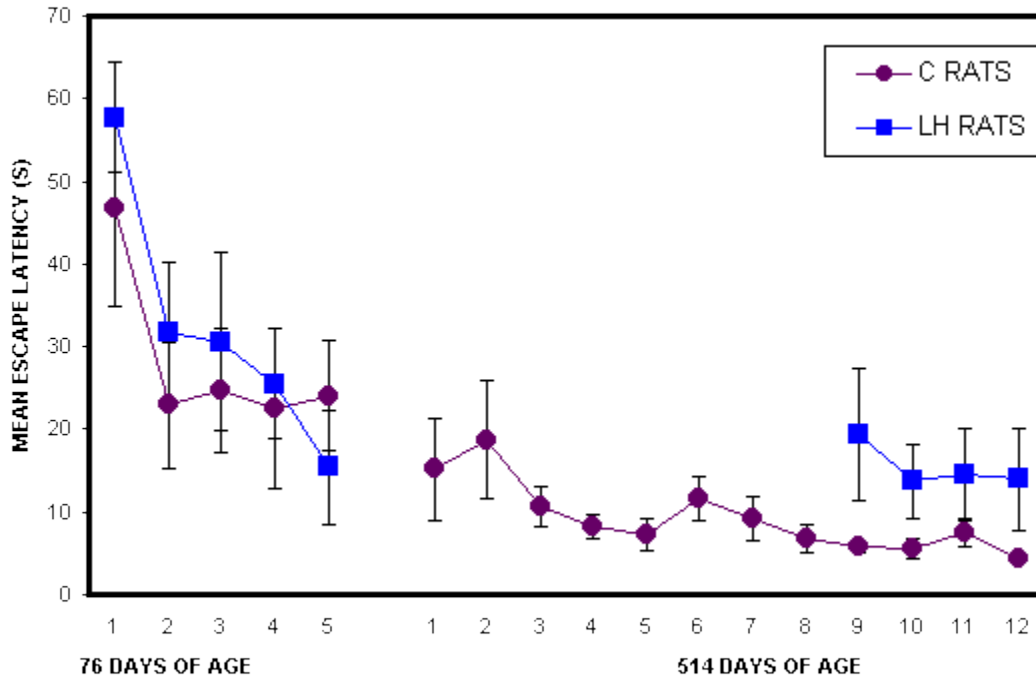


Figure 1. Mean escape latency in seconds \pm SE across successive trial blocks for C and LH rats at 76 days of age (replication study) and 514 days of age (helplessness and spatial memory study).

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Biographical Sketch

Brandy Cook graduated with honors from Henderson in May 2000. She is currently attending veterinary school at Colorado State University. Todd Wiebers is currently professor & chair of psychology at Henderson.

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