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The Effects of Enriched and Typical Laboratory Environments on Object Investigation in Old Sprague Dawley Rats

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Abstract

The purpose of this study was to observe the differences in object investigation between two groups of aged Sprague Dawley rats reared in an enriched and a typical laboratory environment. Research has shown that enrichment has a positive effect on behavior of young and mature rats. Our research question was: Will this positive effect on behavior be retained into old age? Object investigation was measured by recording exploratory activity and overall time spent with objects in an open field. Twelve rats were tested with six in each group. There was no significant difference found in bouts of behavior between the typical and enriched group on Day 1 or Day 2. However, there was a significant difference between the time engaged with objects on Day 1 but not on Day 2. Overall, the results of the study did not support the hypothesis that the enriched group would engage in significantly more object investigation, measured by bouts of behavior and time duration, than the typical laboratory group. Further research on the effects of environment on behavior of the old is important to understand how to maximize functioning through environmental stimulation in old age.

Introduction

Dating back to the time of Darwin, there has been a fascination with the general curiosity of animals and humans alike (Renner & Seltzer, 1991). Darwin studied this curiosity by "placing a live snake in a bag into the cages in the monkey house and the London Zoological Gardens" (as cited in Renner, 1987). Darwin's description of the monkey's reactions was that "they could not resist taking a momentary peak" (as cited in Renner, 1987). Over time, psychologists have further investigated curiosity and have called it animal exploration or investigation.

Thinus-Blanc et al. (1987) investigated exploratory behavior in hamsters placed in an open field by manipulating the distances between objects and topological relationships. The results indicated a renewal of exploration after the experimenters affected the spatial relations of the objects but not after they affected the distance. Similarly, a study done by Dubois et al. (1999) measured behavioral bouts of Wedge-capped Capuchin monkeys directed toward objects to address whether location affects activity. Overall, results showed a great deal of between- and within-subject variability. Renner and Seltzer (1991) defined several exploratory and investigative behaviors in rats in terms of their molar characteristics (e.g., large units of behavior) and studied how these change as a result of repeated opportunities to explore the same environment. The results indicated the activity levels remained the same over the period of observation, and the amount of time spent interacting with objects increased initially followed by a decrease. In an additional study, Renner and Seltzer (1994) suggested that behavioral grammars can be used to predict individual animals' interactions with stimulus objects. They defined behavioral grammars as the bouts of specific object interaction observed in different rats. Overall, they found there were no stereotypical object-investigation behaviors. Rather, they observed many individual differences in the rats' behaviors.

Many neuroscience studies have used exploration as a dependent variable for their research in order to look at brain functions (Patra, Mohanty, & Das, 1984; Ricceri, Calamandrei, & Berger Sweeney, 1997; Young, Wintink, & Kalynchuk, 2004). Todorovic et al. (2003) examined both behavioral and immunological functions to find a possible link between the two during the aging process. The study found a significant correlation between age-related reduction in exploratory activity and reduced capability of the immune system, suggesting such a link exists.

Increased object exploration has been studied in relation to enriched and typical laboratory environments. Enrichment generally consists of housing animals together in a complex and stimulating environment, which has been shown to enhance interactions with littermates and objects. "The behavioral activity of interactions with objects in the enriched condition has been shown to lead to a relatively enduring change in behavior, that of alteration in exploratory behavior" (Renner & Rosenzweig, 1987, p. 89). Renner (1987) studied the plasticity of exploratory behaviors in adult male rats raised either in a typical laboratory environment or an enriched environment and found that rats from the enriched environment participated in a greater diversity of behaviors related to objects, as well as longer interactions with the objects, than the typical laboratory group. Also, the enriched subjects climbed more than the typical laboratory group on the objects that were nonmanipulable.

Enrichment studies have focused on the effects of enrichment on the developing brain and behavior in the young or mature rat but not in the old rat. A computerized literature search located 30 articles using a keyword search of "rats" <and> "exploration" <and> "enriched" in the following data bases: PsycINFO *(Psychological Abstracts)*, (1887 to present); EBSCOhost, (1985 to present); and Wilson Web, (1983 to present). However, when using the keywords "old rats" or "aged rats" along with "exploration" <and> "enriched," no articles were located, which indicates a gap in the literature knowledge base about how enrichment in young life affects behavior in the old rat.

In this study, one aspect of exploratory behavior was investigated—object investigation. The purpose of this study was to observe the differences in object investigation between two groups of aged Sprague Dawley rats reared in either an enriched or typical laboratory environment. Research has shown that enrichment has a positive effect on behavior of young and mature rats. Our research question was: Will this positive effect on behavior be retained into old age? In order to examine the positive effects of an enriched environment on aged rats, object investigatory behavior of an enriched group and a typical laboratory group was recorded and compared. These observations were conducted in an open field where each subject was allowed free rein of the field which consisted of manipulable and nonmanipulable objects. It was hypothesized that the enriched group would engage in significantly more object investigation, measured by bouts and time duration, than the typical laboratory group.

Method

Participants

The subjects used in this study were 12 female Sprague-Dawley rats (*Rattus norvegicus*). Of these 12 rats, 6 served as the control group raised in a typical laboratory environment, and 6 served as an experimental group raised in an enriched environment. During the course of this experiment, all subjects had access to food and water ad lib, except during the brief observation periods. Lights were on from 0700 to 1900 hr daily, until two weeks prior to testing when the light-dark cycle was changed to 0500 to 1700 hr daily for testing purposes.

Apparatus

Observation Area

The observation area, known as an open field, was a 111.76 cm circle surrounded by 43.18 cm high wooden walls. Subjects were transported to the observation area individually in a Plexiglas® cage and placed in the center of the circular area as determined by the pre-measured diameter. The arena was illuminated by a red light, which is virtually undetectable to rats, allowing the researchers to view the rats' activities.

Stimulus Objects

Objects were classified as either manipulable or nonmanipulable depending upon the rat's ability to move each object. Objects consisted of random household items such as a spoon, a sock, and a textbook. A total of four different objects, two manipulable and two nonmanipulable, were present in the open field area during each testing block. Each of the eight objects was replaced by a similar object for Day 2 of testing.

Videotaping Equipment

Behaviors were videotaped on a Sony 990-Handycam Camera, serial number 308928901, which was placed directly above the area of observation.

Procedure

The rats used in this study were subjects of a prior study. Although there was a clear difference between the enriched rats and the typical rats as seen in their interactions with humans, the enrichment condition would have been constant if there had been control of their environments since weaning for this study. At 32 days the enriched rats (n = 6) were placed in a Plexiglas® cage measuring 70 cm x 70 cm x 46 cm. It was filled with wooden toys, nibble bars, a running wheel, and golf balls. The typical laboratory rats (n = 6), also at age 32 days, were housed in pairs in 28 cm x 21 cm x 19 cm empty metal cages. All rats were tested four times in a six-unit T-maze during the prior study (Rauscher, 2005). At age 62 days the enriched rats were housed in the same conditions as the typical laboratory rats until the conclusion of the study. At this time the enriched rats were returned to their previous enriched condition. All rats were held daily during the previous study to accustom them to human contact, which ended at age 122 days.

It is important to note for this study that there was a difference in the ages of the enriched and typical laboratory rats. The typical rats were born approximately

September 13, 2004, and the enriched rats were born approximately January 7, 2005. Despite the age difference, both groups were considered to be old rats, as supported by rat study literature. Throughout the present study, the typical laboratory rats were housed in empty metal cages. The enriched rats were housed in the communal Plexiglas® cage and were exposed to spontaneous bouts of interactions with humans lasting no more than 20 minutes at any one time.

Rats in both groups were held for 2-minute intervals for 8 days. Three days before testing, all rats were acclimated to the open area three times for 5 minutes each and held for 2-minute intervals each. Each rat was tested on two separate consecutive days for 10-minute blocks each day between the hours of 1800 and 2100. The 10-minute block began when we left the observation room. After 10 minutes, we reentered the room and the recording stopped. The testing area was cleaned as necessary to remove waste, but no solvents were used during the 2-day testing period. Operational definitions used to code behaviors are listed in Table 1.

During testing, we were blind to whether we were observing the enriched or typical laboratory rats to eliminate the possibility of experimenter bias. Additionally, coding of the recorded tapes did not begin until a 90% interrater reliability was established using practice rats.

Results

The total bouts of behavior were tallied for each rat in the typical laboratory and enriched condition. Bouts on Day 1 were calculated independent of Day 2. The means of the typical laboratory and enriched groups on Day 1 were analyzed with a one-way analysis of variance; there was no significant difference: $F(1, 11) = 0.06$, $p > .05$, as seen in Table 2 (see the Appendix for an explanation of statistical abbreviations and symbols). Similarly, as shown in Table 3, the means on Day 2 were not significantly different: $F(1, 11) = 0.52$, $p > .05$. The total time engaged with objects was also recorded. The means of the typical laboratory and enriched groups on Day 1 were analyzed with a one-way analysis of variance, and these means were found to be significantly different: $F(1, 11) = 5.96$, $p < .05$, as seen in Table 4. However, as seen in Table 5, a difference was not observed on Day 2: $F(1, 11) = 0.52$, $p > .05$.

Discussion

Despite previous research findings indicating that enrichment had a positive effect on behavior of young and mature rats, the results suggested that the behaviors observed in the typical laboratory old rats and in the enriched old rats did not significantly differ. Although there was a significant difference between the groups in time spent interacting with the objects on Day 1, that difference disappeared on Day 2. Overall, the results of the study did not support the hypothesis that the enriched group would engage in significantly more object investigation, measured by bouts of behavior and time duration, than the typical laboratory group.

Our unique research question was: Will this positive effect on behavior be retained into old age? Given the results of this study, two plausible explanations exist. It is plausible that any gains in behavior as a result of an enriched environment are lost in old age. This would suggest that cognitive slowing occurs regardless of what environment a rat is in for the duration of its life. Alternatively, given that there was a

significant difference in time duration between the groups on Day 1 which disappeared on Day 2, it is plausible that the plasticity of the typical laboratory old rat's brain can account for the lack of differences in behavior bouts and time duration on Day 2. This explanation would suggest that although old rats were subjected to a typical laboratory environment for the duration of their lives, there remained sufficient brain plasticity for them to show as high a level of exploratory behavior as the enriched rats on Day 2. The results could also indicate that the dependent variables were not sensitive to the treatment and that other dependent measures should have been chosen, which could have revealed findings more in agreement with literature on the positive effects of enriched atmospheres. Future research is needed to test these possible explanations.

There are several limitations of this study and suggestions for further research. As mentioned in the procedure, the rats used in this study were subjects of a prior study. Although there was a clear difference between the enriched rats and the typical laboratory rats as seen in their interactions with humans, it would be advisable to have constant control over the environments of both groups of rats from weaning. Also, there were only six rats in each treatment condition. To further generalize the results, a larger *n* should be used. Furthermore, a within-groups calculation was not conducted in this study, which limited the analysis. This information may have provided further explanation for the results found in the present study and would allow for individual differences to be analyzed in future studies. A specific suggestion of additional research on enrichment would be to raise a group of rats all in a typical laboratory environment until old age and then divide the group equally between the typical laboratory and an enriched environment to see if enrichment in later life only has an effect on object investigation.

Past studies focused primarily on enrichment environments for young or mature rats and failed to compare old rats raised in enriched and typical laboratory environments with respect to object investigation. This study has contributed to the science of psychology by expanding the body of research on enrichment to find out if positive effects on behavior are retained into old age. Additional studies on the topic of aging in relation to environment are needed to determine the most adaptive environment for older individuals. Research on the effects of environment on behavior is important to understanding how to maximize functioning through environmental stimulation in old age. The results could indicate how a stimulating nursing home environment can impact behavior. Overall, this type of research has increasing importance as age demographics change and the baby boomer cohort moves into older adulthood.

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Appendix

Table 1
Behaviors Used in Interactions With Objects

Behavior	**Description**
Sniff	Nose contact with object
Single paw contact	One paw contacts object
Two paw contact	Two paws contact the object
Four paw contact	All four paws on the object
Bite	Teeth contact the object
Lick	Tongue contacts the object
Drag	As rat moves backward, object moves with it
Push	As rat moves forward, object moves with it
Collide	Bodily contact with object (not paw or teeth) resulting in movement of object

Note. All descriptions are derived from Renner and Seltzer (1991).

Table 2
Analysis of Variance Summary Table

Day 1 Bouts

Source of variance	*SS*	*df*	*MS*	*F*	*p*
A	6.75	1	6.75	.06	$p > .05$
S/A	1060.17	10	106.02		
Total	1066.917	11			

Note. Was not significant at $p = .05$ alpha level. A = Enriched v. typical groups; S/A = Variability within groups.

Table 3
Analysis of Variance Summary Table

Day 2 Bouts

Source of variance	*SS*	*df*	*MS*	*F*	*p*
A	102.08	1	102.08	.52	$p > .05$
S/A	1956.83	10	195.68		
Total	2058.92	11			

Note. Was not significant at $p = .05$ alpha level. A = Enriched v. typical groups; S/A = Variability within groups.

Table 4
Analysis of Variance Summary Table

Day 1 Time

Source of variance	*SS*	*df*	*MS*	*F*	*p*
A	12675	1	12675	5.96	$p < .05$
S/A	21270.67	10	2127.07		
Total	33945.67	11			

Note. Was not significant at $p = .05$ alpha level. A = Enriched v. typical groups; S/A = Variability within groups.

Table 5
Analysis of Variance Summary Table

Day 2 Time

Source of variance	*SS*	*df*	*MS*	*F*	*p*
A	140.08	1	140.08	.05	$p < .05$
S/A	25730.83	10	2573.083		
Total	25870.92	11			

Note. Was not significant at $p = .05$ alpha level. A = Enriched v. typical groups; S/A = Variability within groups.

Statistical Abbreviations

Abbreviation	Definition
df	Degrees of freedom
F	Fisher's *F* ratio
MS	Mean square
p	Probability
SS	Sum of squares

Confusion for Cheeseheads: How Contradictory Expert Opinions Have Stalled Wisconsin's CCW Legislation

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Abstract

This study argues that Wisconsin's failure to pass any concealed carrying of weapons (CCW) legislation stems from the multitude of differing opinions and findings on CCW. This assertion is made by focusing on three studies on CCW with contradictory conclusions, coupled with a history of CCW in the United States. I show that the multitude of opinions and findings offered by the experts has delayed Wisconsin in passing CCW legislation.

Introduction

Twice in the last three years, in 2004 and more recently in 2006, a concealed-carry weapons (CCW) law has passed both the Wisconsin state Assembly and Senate—only to be vetoed by Governor Jim Doyle. In 2006, though, the Senate overrode the veto, and the Assembly nearly overruled the veto, failing by only two votes. In the United States, Wisconsin and Illinois are the only two states that do not have laws on record that allow individual citizens to carry a concealed handgun in most public areas. With its tradition of hunting and shooting sports, Wisconsin is on the short list of states without a CCW law. For much of the rest of the United States, CCW appears less controversial in the recent political climate, and after years of discussion, the debate may soon reach a close in much of the United States.

Concealed carry hardly qualifies as a new idea. New Hampshire enacted CCW law in 1923, and Georgia, Vermont, and Washington followed suit (Squires, 2001, p. 82). However, by 1986 only eight states had shall-issue concealed carry laws (citizens with no criminal record and adequate training can carry a concealed weapon), and 21 states did not allow concealed carry at all (NRA, 2006). In the past 20 years, states with shall-issue CCW have increased more than fourfold to 35, and only Wisconsin and Illinois lack any form of CCW (NRA, 2006).

CCW has expanded for many reasons. For instance, many interest groups have spent much time and money on influencing states to adopt CCW. According to Packing.org (2006), a group dedicated to the passage of CCW, national groups such as the National Rifle Association have voiced and financed their support for CCW, while groups such as the American Association of Retired Persons (AARP) and the American Bar Association have opposed its passage. Grassroots groups also have played a large role in supporting and opposing CCW legislation. In Wisconsin, groups like the Wisconsin Concealed Carry Association have pushed for the passage of CCW legislation, while groups like the Wisconsin Grassroots Democrats have remained strongly opposed. The involvement of such groups makes it obvious that CCW has remained a highly contested issue for some time.

Economist John Lott poses one rationale for passing CCW legislation. In his controversial book *More Guns Less Crime: Understanding Crime and Gun Control*