

Impact of stress on rats' spatial learning and memory



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Abstract

Stress has been shown through varying literature to disrupt learning and memory. Exposure to stress has been identified as anything that threatens to disrupt or disturb homeostasis. When an individual is exposed to prolonged stress it can affect them cognitively, impairing their spatial learning and memory that this review looks at. Specifically, this review investigates the spatial memory of rats when exposed to chronic or acute stress and how these stressors in turn effect their performance on the Morris Water Maze (MWM) or Radial Arm Water Maze (RAWM); assessments designed to test for spatial memory in rats. The literature on stress has been inconsistent coming to conclusions that stress impairs while others showing that stress enhances spatial memory and learning depending on a variety of factors such as the duration of the stress or the nature of the stressor that are investigated in this review. This review was done to organize the thoughts and finding to find other underlying factors that might be playing a role in these inconsistent results in the literature.

Introduction

Stress is a change that disrupts or threatens to disrupt the body's homeostasis to an unusual degree. Anything that can induce a significant disturbance in homeostasis is called the stressor that can be defined as chronic or acute depending on it's duration. Acute stress is a form of short term stress that causes the stress system to turn on but will go back to baseline, this common form of stress can be exciting or thrilling but if extended for longer periods of time can be exhausting. Chronic stress, on the

other hand is a kind of stress that is prolonged and causes the homeostatic stress system to be tipped out of balance in which an individual feels as if they have little to no control over it as the stress system is turned on for quite a while and won't go back to baseline. Exposure to the stressor causes the body to respond in a certain way to adapt to the stress, unfortunately at certain times the stress may prolong causing an individual to enter a stage of exhaustion whereupon the body can no longer adapt to the stress thus causing deleterious effects on learning and memory.

Extensive research has supported this, but there are also positives of stress on learning. Stress has been found to not only impair learning, but can enhance it as well. Across many studies looking at stress there are inconsistent data either supporting the impairing quality of stress or the improving quality of stress, but these data all are dependent on varying attributes from the duration of the stress, to the type of stress used. (Chaby, Sheriff, Hirrlinger, Lim, Fetherston, & Braithwaite, 2015) This review considers the effects of stress whether impairing or enhancing on rats' spatial learning and memory which is defined as the ability to retain and cognitively manipulate information about the spatial environment to able to navigate in one's surroundings and help in minimizing or escaping danger. (Chapy et, al. 2015) Specific tasks that assess rats' spatial learning and memory are the Morris Water Maze (MWM) and the radial arm maze (RAM). MWM is a circular pool consisting of spatial cues located outside of the pool and a platform submerged in water. The rat must find the submerged platform but using the different spatial cues found surrounding the pool. (Vorhees & Williams, 2006)

This review discusses the negative impairment, but also including the positive enhancement of stress on learning and memory. This review will further look at the different factors of stress and how independently they influence learning and memory to broaden our knowledge on stress and find other underlying factors that may be playing a role in these inconsistent results.

The primary focus of this review is to show evidence that proposes how stress can enhance or impair learning by drawing current research from the animal literature to organize the thoughts and knowledge to find possible missing gaps in the literature that need further investigation. This paper reviews 1) Chronic versus Acute Stress 2) Duration of Stressor and 3) Nature of the stressor.

Chronic vs Acute Stress

Gouirand et. al investigated the role of chronic, unpredictable stress on the spatial memory of rats by exposing rats to various stressors such as cold temperatures for 50 minutes, lights on and food deprivation overnight and so on. (Gouirand & Matuszewich, 2005) These stressed rats then performed on MWM and results found to be that these mice had shorter latencies when locating the platform submerged in the water. Meaning there was a facilitation in the spatial memory acquisition of the MWM affecting these stressed mice search strategies in this spatial learning task. (Gouirand & Matuszewich, 2005) This experiment showed that chronic stress was beneficial in learning as the mice were performing better on the task, the stress must have helped these stressed rats learn a better search strategy <https://assignbuster.com/impact-of-stress-on-rats-spatial-learning-and-memory/>

than that of the controls making them find the platform faster and swim a less distance to get there. However, another study examined chronic stress by having rats placed in wire mesh restrainer for 6 hours a day for 28 days and see the affects on the RAWM performance. (Mika, Mazur, Hoffman, Talboom, Bimonte-Nelson, Sanabria, & Conrad, 2012). It was found that the chronically stressed rats don't remember and forget to avoid arms that were previously visited and could only avoid arms that were never visited. (Mike et al., 2012) This shows that spatial working memory was impaired, but reference memory stayed intact when these rats were exposed to the chronic stress. But as the trials persisted on the chronically stressed rats who had this working memory deficit could quickly recover and perform just as well as the control rats. (Mike et al., 2012) This is questionable as further research should be done to investigate if it is the deficits that truly were improved upon or was it other structures or memory systems compensating for this stress induced deficit. Both studies show that chronic stress can both enhance or impair learning, but there must be more to the story. As with the first study the rats were exposed to various stressors differing in their nature and for distinct durations that may be effecting that certain learning and memory systems in a different way, compared to the other study that had only one type of stressor and longer duration lasting for 6 hour per day for 28 days. This reveals that stress is complex and we must take into consideration other factors that can impact the enhancing or impairing of learning.

Investigating the effects of chronic stress in these experiments seems to show both impairment and enhancement in spatial working memory.

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To investigate the effects of acute stress, Passecker explored the role of acute stress, exposure of bright light on rats in a small round bucket, that were then put into their cages before testing on the MWM. (Passecker, Barlow, & O'Mara, 2014) It was found that the stressed group of rats performed worse than the control group by having an increased latency and swam greater distances to get to the platform. (Passecker et al., 2014) This is questionable as to why in this scenario the rats didn't do as well when exposed to the acute stress while previously mentioned in the Gouriand experiment the rats performed well when exposed to chronic stress. This striking difference might be due to the fact both experiments used different strains of rats; Passecker used Wistar rats while Gouriand used Sprague-Dawley rats. (Gouirand & Matuszewich, 2005) (Passecker et al., 2014) This raises a question that stress may be effecting the rats' strain differently either impairing, enhancing or having no effect on their learning. So, there is a gap in the literature, so research must look at the same types of rat exposed to different types of stress to control for individual differences. So, to be sure stress effects different strains of rats differently there needs to be more research done in this field.

Duration Matters

Green & McCormick looked at chronic restraint stress that was 1 hour each day for 15 days compared to Wright & Conrad who also looked at chronic restraint stress but the duration was different the stress lasted 6 hours a day for 21 days. (Green & McCormick, 2013) (Wright & Conrad, 2008) It was found that stressed rats had impairment in acquisition; taking longer to locate the hidden platform than the controls. (Wright & Conrad, 2008) While <https://assignbuster.com/impact-of-stress-on-rats-spatial-learning-and-memory/>

in Green and McCormick found that stressed rats were found to have improved performance on water maze across trials within days compared to controls but had less retention of learning between days. (Green & McCormick, 2013) This shows that 15 days of restraint stress for 1 hour wasn't enough to impair the rat's performance on the MWM as they did better than the controls, but retaining learning was less, meaning this stress may have just impacted the memory retention but not the memory acquisition. So, stress seems to be effecting memory processes differently impairing one and enhancing another. On the other hand, Wright and Conrand found that after 21 days of restraint stress the rats had impaired acquisition meaning it might take about 21 days to impact acquisition and see observable deficits in the water maze. To investigate if the 6 hours per day is causing the impairment another study looked at chronic stress for 21 days but for only 3 hours a day and found the same results as Wright et. al suggesting that the prolonged 21 days of chronic stress is what is causing the impairment in performance of MWM. (Meng, Chen, Jiang, & Zhang, 2013) But more research should be done using various ranges of durations to find out where in fact the borderline between enhancing and impairing learning is as 15 days didn't cause any impairment but what about the numbers between 15 days and 21 days. It could be in fact that 17 days may cause an impairment but that can't be concluded as the literature hasn't used a wide range of durations to see the effects on spatial learning.

Nature of Stressor

The nature of the stressor plays a role in the learning and memory as researcher looked at the effect of social instability stress where rats were

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isolated. They were then tested on the MWM and found the distance taken to travel and find the platform decreased from the first trials to second trials indicating better short term spatial learning while the measurement in long term spatial learning the socially stressed rats were swimming longer distances to get to the platform between first and second sessions. (Green & McCormick, 2013) Which suggests that long term spatial memory in the MWM was impaired. This experiment indicates that exposure to social instability stress only impaired long term spatial memory and not short term spatial memory in the MWM. In addition, this current study had the rats that were exposed to the stress placed back into their housing with another rat that was also exposed to the stress procedure, this type of exposure may be used as some sort of coping mechanism for the rats and that might be as to why the stress didn't effect short term spatial memory. As well this study is focusing on social stress by isolating the rats but by having the rats exposed to another rat in the same housing may make the rats bond as they both were exposed to the stress which could mitigate the prior stress exposure as well as they are getting social exposure after being socially isolated so would it would make the rats want to interact with rats even more after they were isolated.

Looking at another stressor, predation, male and female rats were exposed to a cat for 30 minutes before learning acquisition of location of the hidden platform in the radial-arm water maze. (Park, Zoladz, Conrad, Fleshner, & Diamond, 2008) There was found to be impairment in memory indicated by an increased number of entry errors but there was greater impairment in the male rats than females. (Park et al., 2008) This suggests that not only does

stress may have impairing effects but may also effect genders differently. Future studies should look at gender differences as they may be playing a role in causing these differences in stress effects. This may also show that predation may be a stronger stressor that leads to impairments in performing the RAWM as exposure to the cat must have caused the rats to be traumatized inducing high levels of anxieties that could have caused this effect. This can be related to humans who experience PTSD who exposed to a traumatic event like with these rats exposed to the cat causing heightened stress response that in turn has effects in deficits in learning.

Physical stress was also analyzed looking at acute versus chronic forced exercise on a treadmill and were then tested on the MWM. The rats were submitted to acute physical exercise for 2 weeks or chronic physical exercise for 8 weeks on a treadmill. (Mello, Benetti, Cammarota, & Izquierdo, 2008). It was found that chronic physical stress caused a decrease in latency to swim to a previous location where the escape platform was. (Mello et al., 2008) This study operationalizes 2 weeks as being the acute condition and 8 weeks as being the chronic condition which may cause some questioning as why did the researchers decide on those number of weeks to be designated with either acute or chronic stress. More should be considered by having stressors that defer in how long they last by indicate how long the stressor is present each day as chronic stressed is prolonged it should have be lasting for around the longest hours in the day compared to acute which should be present for a brief amount then dissipate.

Conclusion

In summary stress, can't be exclusively thought of as to only impair learning but can also enhance learning depending on multiple attributions stress has such as duration, the nature of the stressor, type of stressor that were discussed. It was found through this review that increased duration of the stress around 21 days has impairing effects but if the duration is smaller around 15 days the performance on the water maze isn't impaired. Each of the attributes discussed have their own effects on stress and therefore the literature is inconsistent, all coming up with different conclusions. The research is lacking in looking at individual effects of stress as it effects everyone differently as seen in the discussion where that rats are of different strain and this may be a contributing factor on how stress affected them differently even when both were exposed to the same stress. Future studies should look at all the factors of stress such as duration or type of stressor on one specific strain of mice and compare it's results to that of a different strain of mice to see if there are any differences.

In addition, further investigation should look at the effects of stress on gender as it was found through this review that the females performed better than the males suggesting that stress may not have effected the females on such a destructive level as the male rats. In addition, the literature in stress should look at the effects of different ages of rats on the effect of stress. As the research hasn't really looked at this, as well children and adolescence may be more vulnerable to stress as their brain is more vulnerable compared to adults.

Also, the review also found that one type of memory was effected and the other enhanced or lack of effect. This may allow for future studies to look at <https://assignbuster.com/impact-of-stress-on-rats-spatial-learning-and-memory/>

how stress effects different components of memory and its effects on learning and performance to get closer to answer as to why the literature on stress conclude inconsistent results.

Altogether, stress is a complex concept that deals with a lot of factors that all play a different role on learning but it may not only be the factors of stress but the factors of the individual that is exposed to the stress that designates the effect stress will have on them whether it be impairing or enhancing.

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