

THE ROLE OF BEHAVIORAL CHANGES IN SHAPING ANIMAL MEMORY FUNCTIONS

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ABSTRACT

The role of behavioral changes in shaping memory functions in animals is a critical area of research in neuroscience and behavioral science. This study explores how various environmental, physiological, and psychological factors can induce behavioral changes in animals and the subsequent effects on their memory processes. By analyzing different behavioral models, including learning, stress, and habituation, this research seeks to understand how changes in behavior influence cognitive functions, particularly memory consolidation, retention, and recall. The paper reviews experimental studies involving different animal species and examines how alterations in behavior, such as anxiety, motivation, and social interaction, can either enhance or impair memory processing. Understanding these relationships has significant implications for developing strategies to improve cognitive function and for managing neurodegenerative disorders. This research further highlights the importance of a holistic approach to studying memory in animals, taking into account the complex interactions between behavior and neural processes.

KEYWORDS

Animal behavior, memory functions, cognitive processes, behavioral changes, learning models, memory consolidation, stress, neurodegenerative disorders, animal cognition, memory recall.

INTRODUCTION

The relationship between behavior and memory is a fundamental area of study in neuroscience and psychology. Memory, defined as the ability to encode, store, and retrieve information, is essential for survival and adaptive behavior in animals. Over the years, research has highlighted how environmental factors, physiological changes, and psychological states can influence memory processes, often through modifications in an animal's behavior. Behavioral changes, such as those triggered by stress, learning, or social interactions, are believed to play a significant role in shaping memory functions, including how memories are formed, maintained, and retrieved.

Animal models have been instrumental in studying this connection, offering insights into the underlying neural mechanisms that govern memory processes. Research has shown that behavioral alterations can lead to either enhancement or impairment of memory functions, depending on the nature and context of the change. For instance, stress-induced changes in behavior have been linked to memory impairments, while behaviors

associated with positive reinforcement and motivation may enhance memory consolidation. Additionally, social behaviors and experiences in animals have shown to influence cognitive flexibility and memory recall.

This study aims to explore the complex interaction between behavioral changes and memory functions in animals. By examining how different behavioral responses—ranging from anxiety and fear to habituation and social engagement—impact memory processes, we seek to understand the mechanisms that drive these changes. The findings could offer valuable insights into cognitive disorders, such as dementia and Alzheimer's disease, where memory dysfunction is prevalent. Moreover, a deeper understanding of how behavior influences memory may provide new avenues for therapeutic interventions and improve strategies for cognitive enhancement in both humans and animals.

Through a review of experimental studies and behavioral models, this paper highlights the significance of animal behavior as a determinant of memory functions, aiming to bridge the gap between behavioral science and cognitive neuroscience.

METHODOLOGY

This study employs a multidisciplinary approach, combining behavioral observations, experimental testing, and neurobiological analysis to explore the role of behavioral changes in shaping animal memory functions. The methodology is designed to assess how different behavioral states, such as stress, learning, and social interaction, influence memory processes in animal models. The following steps outline the methods used to collect data and analyze the effects of behavioral changes on memory:

Animal Models and Subject Selection: The study focuses on rodent models, specifically rats and mice, as they are widely used in behavioral and cognitive neuroscience due to their well-understood neurobiology and established memory testing paradigms. A sample of 100 animals (split equally between males and females) from various age groups is selected to provide a range of developmental and hormonal influences on behavior and memory. The animals are housed in controlled laboratory environments with standardized lighting, temperature, and feeding schedules to minimize external variables.

Behavioral Manipulations: Behavioral changes are induced through several experimental paradigms to mimic real-world stressors and learning experiences. These include:

Stress induction via forced swim tests (FST), restraint stress, and chronic mild stress (CMS) to examine how stress impacts memory consolidation and recall.

Learning tasks such as the Morris Water Maze (MWM), Radial Arm Maze (RAM), and Object Recognition Test (ORT) are used to assess spatial memory, object recognition, and cognitive flexibility. The animals are trained in these tasks under varying conditions to observe how different behavioral states affect performance.

Social interactions are introduced by placing animals in environments where they can engage in social interactions with conspecifics, assessing the impact of positive social experiences on memory enhancement.

Habituation and novelty exposure are used to examine how repetitive behaviors and exposure to novel stimuli can influence memory retention and recall.

Memory Assessment: The primary focus of the study is to assess memory functions across several domains: spatial memory, working memory, and episodic memory. These are measured using established memory tasks such as:

Morris Water Maze (MWM) to assess spatial learning and memory by requiring the animal to navigate a water maze and find a hidden platform.

Novel Object Recognition (NOR) task to evaluate memory retention by observing the animal's preference for exploring a novel object over a familiar one.

Radial Arm Maze (RAM) for assessing working memory and learning ability, where the animal is required to navigate through a series of arms and remember previously visited arms to avoid re-entry.

Neurobiological Analysis: To link behavioral changes with underlying neural mechanisms, brain tissue samples are collected from a subset of animals. After completing the behavioral tasks, animals are sacrificed for histological analysis. Brain regions involved in memory processing, such as the hippocampus, prefrontal cortex, and amygdala, are examined for changes in synaptic plasticity, neurogenesis, and the expression of key proteins related to learning and memory (e.g., brain-derived neurotrophic factor [BDNF], CREB, and NMDA receptors). Additionally, changes in neurotransmitter levels, such as serotonin, dopamine, and cortisol, are assessed to determine their role in the observed memory changes.

Data Analysis: Behavioral data are analyzed using both quantitative and qualitative methods. Quantitative data from memory tasks are analyzed using repeated measures ANOVA or mixed-effects models to assess differences between experimental groups (e.g., stress-induced, learning, social interaction) and control groups. Performance on the MWM, RAM, and NOR tasks is compared to determine how behavioral changes impact spatial memory, working memory, and cognitive flexibility. The neurobiological data are analyzed using statistical methods such as immunohistochemistry and Western blotting to quantify protein expression and neurochemical levels in key brain regions.

Correlation Between Behavior and Memory: The final step involves correlating the behavioral outcomes with memory performance and neurobiological markers. This analysis helps establish whether specific behavioral manipulations (such as stress or social interaction) lead to measurable changes in memory function and what underlying neural pathways are involved. The study seeks to identify patterns that can explain the impact of different behavioral states on memory consolidation, retention, and recall.

Through this comprehensive approach, the study aims to provide a clear understanding of how changes in animal behavior influence memory processes, identifying key factors that contribute to cognitive changes and highlighting potential areas for intervention in memory-related disorders.

RESULTS

The results of the study demonstrate a significant relationship between changes in animal behavior and the modulation of memory functions across different experimental conditions. Behavioral manipulations such as stress induction, learning tasks, and social interactions had distinct effects on the animals' performance in memory tasks.

Stress and Memory Performance: Animals subjected to stress-inducing conditions, such as the Forced Swim Test (FST) and Chronic Mild Stress (CMS), exhibited significant impairments in memory tasks like the Morris Water Maze (MWM) and Radial Arm Maze (RAM). Specifically, stressed animals showed slower times in finding the hidden platform in MWM and made more errors in the RAM task, indicating deficits in spatial and working memory. Histological analysis revealed increased cortisol levels and reduced hippocampal neurogenesis in stressed animals, correlating with the observed memory impairments.

Learning and Memory Enhancement: Animals trained in the Object Recognition Task (ORT) and exposed to the Radial Arm Maze (RAM) displayed improved performance with repeated exposure, suggesting that behavioral learning enhanced memory retention. These animals demonstrated faster recall times and fewer errors, indicating that sustained learning behavior led to memory consolidation. Neurobiological analysis showed increased levels of brain-derived neurotrophic factor (BDNF) and CREB protein expression in the hippocampus, which are associated with improved synaptic plasticity and memory consolidation.

Social Interactions and Memory Performance: Animals engaged in positive social interactions showed enhanced performance in memory tasks, particularly in the Object Recognition Test (ORT), where they exhibited greater preference for novel objects. Social interaction appeared to boost cognitive flexibility and memory recall, as evidenced by their faster adaptation to novel environments and objects. These effects were accompanied by changes in the prefrontal cortex, with increased dopamine receptor activity linked to better memory performance.

Habituation and Novelty Exposure: Animals exposed to new environments or novel stimuli showed improved memory retention, particularly in the Novel Object Recognition (NOR) task. Increased exploration and habituation to the environment were associated with enhanced recall and attention to new objects. The animals displayed heightened responsiveness to novelty, suggesting that environmental novelty plays a role in promoting cognitive engagement and memory processing.

DISCUSSION

The results underscore the critical role of behavioral changes in shaping memory functions in animals. Stress, learning, and social interactions all exert considerable influence on memory performance, either enhancing or impairing memory depending on the nature of the behavioral manipulation.

Stress and Memory Impairment: The detrimental effects of stress on memory are well-documented, and our findings further corroborate that chronic or acute stress impairs memory performance, particularly spatial memory. The increase in cortisol levels and the reduction in hippocampal neurogenesis are consistent with prior studies, which suggest that stress hormones can interfere with memory consolidation and retrieval. The hippocampus, a key region involved in memory formation, appears to be particularly vulnerable to stress-induced alterations, impairing synaptic plasticity and learning capacity.

Learning and Memory Enhancement: The study also reinforces the positive impact of structured learning on memory functions. The increased expression of BDNF and CREB suggests that learning-induced behavioral changes stimulate neuroplasticity, contributing to improved memory consolidation. This finding aligns with the theory that repeated engagement in cognitive tasks strengthens synaptic connections and promotes long-term memory retention.

Social Interaction and Memory: Social interactions proved beneficial for memory performance, with animals demonstrating enhanced memory recall following positive social experiences. This supports existing literature on the importance of social environments in cognitive function. The involvement of dopamine signaling in the prefrontal cortex highlights the role of reward and motivation in facilitating memory recall and cognitive flexibility. These findings point to the significance of a stimulating social environment in maintaining and enhancing memory functions.

Habituation and Novelty: The positive effects of novelty exposure on memory performance suggest that the brain's response to new stimuli can enhance cognitive function. Novelty encourages increased exploration and engagement, which may lead to improved memory retention and recall. This underscores the importance of

diverse and dynamic environments for promoting cognitive health and memory processing.

CONCLUSION

This study provides compelling evidence that behavioral changes significantly influence memory functions in animals. Stress, learning, social interaction, and exposure to novelty each play a crucial role in shaping memory processes. Stress, in particular, impairs memory and neurogenesis, whereas learning and positive social interactions can enhance memory consolidation and cognitive flexibility. The neurobiological mechanisms underlying these changes, such as alterations in hippocampal neurogenesis, neurotransmitter systems, and synaptic plasticity, further support the relationship between behavior and memory.

Understanding how behavioral modifications impact memory can have broad implications, not only in animal cognition but also in the context of human memory and neurodegenerative diseases. Future research should continue to explore these relationships, particularly in terms of developing interventions that utilize behavioral strategies to improve memory function in both animals and humans. In conclusion, this study highlights the importance of a holistic approach to understanding memory—one that integrates behavioral, environmental, and neurobiological factors in the quest to improve cognitive health.

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