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Review

The pharmacology, neuroanatomy and neurogenetics of one-trial object recognition in rodents

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Abstract

Rats and mice are attracted by novel objects. They readily approach novel objects and explore them with their vibrissae, nose and forepaws. It is assumed that such a single explorative episode leaves a lasting and complex memory trace, which includes information about the features of the object explored, as well as where and even when the object was encountered. Indeed, it has been shown that rodents are able to discriminate a novel from a familiar object (one-trial object recognition), can detect a mismatch between the past and present location of a familiar object (one-trial object–place recognition), and can discriminate different objects in terms of their relative recency (temporal order memory), i.e., which one of two objects has been encountered earlier. Since the novelty-preference paradigm is very versatile and has some advantages compared to several other memory tasks, such as the water maze, it has become a powerful tool in current neurophamacological, neuroanatomical and neurogenetical memory research using both rats and mice. This review is intended to provide a comprehensive summary on key findings delineating the brain structures, neurotransmitters, molecular mechanisms and genes involved in encoding, consolidation, storage and retrieval of different forms of one-trial object memory in rats and mice.

Keywords: Alzheimer's disease; Behavioral genetics; Dopamine; Episodic-like memory; Hippocampus; Knockout; Mice; NMDA receptors; Object exploration; One-trial learning; Perirhinal cortex; Rats; Serotonin; Spatial learning; Temporal order memory

Contents

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1. Introduction

1.1. The novelty-preference paradigm

Rodents naturally tend to approach and explore novel objects, which are assumed to have no natural significance to the animal and which have never been paired with a reinforcing stimulus. They also show an innate preference for novel over familiar objects. Rodents readily approach objects and investigate them physically by touching and sniffing the objects, rearing upon and trying to manipulate them with their forepaws (Aggleton, 1985). This behavior can be easily quantified and utilized to study simple recognition memory as well as more complex spatial-, temporal- and episodic-like memory in rodents. The standard one-trial object recognition task measures spontaneous behavior. A large advantage over food-rewarded maze learning tasks and classical delayed matching- or non-matching to sample tasks is that it does not require spatial learning, food or water deprivation, the application of reinforcing stimuli (food or electric shock delivery), the learning, retention and application of rules, or the learning of response–reward associations. It, therefore, requires little training and is also, by far, less stressful and arousing than tasks based on negative reinforcement of behavior, such as the hidden platform version of the water maze, the inhibitory and active avoidance, or fear conditioning tasks, which have been widely used to study the neurobiology of learning and memory in rodents. The object recognition paradigm is especially suited to test the effects of pharmacological and genetic interventions on learning and memory. Whenever experimental manipulations such as the administration of a drug or the knockout of a gene, are known to or presumed to affect either weight regulation, food palatability and intake, or processes of reward and reinforcement, then food-rewarded paradigms might not be the best choice of task. In such the novelty-preference paradigm, would probably yield results, that can more safely be related to changes in learning and memory. Similarly, known or suspected effects of drugs or gene interventions on pain perception, stress susceptibility, anxiety and thermoregulation, preclude the use of shock-motivated or water-maze navigation tasks. Since the novelty-preference paradigm, in comparison to other animal models of learning and memory, does not require lengthy training and does not induce high levels of arousal and stress, it is more closely related to conditions under which human recognition memory is measured (Ennaceur and Delacour, 1988).

Furthermore, variations of the novelty-preference paradigm can be used to measure different forms of object memory, such as recognition of a familiar object (Ennaceur and Delacour, 1988), one-trial object–place recognition (Mumby et al., 2002a), temporal order memory (Hannesson et al., 2004; Mitchell and Laiacona, 1998) and recently, episodic-like memory in rats and mice (Dere et al., 2005a, b; Kart-Teke et al., 2006, 2007). Since the learning and test situations in these different versions of the novelty-preference paradigm are very similar; i.e., the animal is placed into a familiar arena containing objects, it is possible to investigate the effects of experimental manipulations, such as a knockout of a gene, on these different forms of recognition memory, avoiding confounding influences of paradigm-specific demands on the animal's performance. For example, if a genetic manipulation disrupts motor or sensory systems required to explore and encode objects, the animals should be equally impaired in the one-trial object recognition, one-trial object–place recognition, temporal order memory and episodic-like memory versions, while impairments in one, but not the other versions, i.e., experimental dissociations, would suggest a specific involvement of the gene in a specific type of object memory.