A PUBLICATION FROM NOLDUS INFORMATION TECHNOLOGY

Why spatial memory is important in rodent research

This is a chapter from the e-book:

Basic behavioral neuroscience in rodents.

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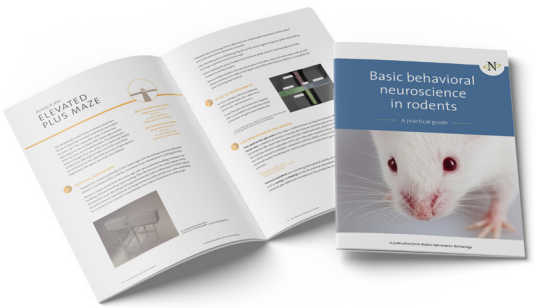

INTRODUCTION

Cognition is defined as 'the mental action or process of acquiring knowledge and understanding through thought, experience, and the senses. In essence, it is the ability to perceive and react, process and understand, store and retrieve information, make decisions and produce appropriate responses. **Memory** refers to the storage and subsequently retrieval of this encoded data/information.

There are multiple forms of cognition and memory, each relating to, and/or responsible for their specific behaviors or actions. These forms are however highly intertwined, making them challenging to distinctly measure. By investigating separate cognitive domains through behavioral batteries scientists are able to tear apart distinct cognitive functions.

Why only talk about mouse transgenic models?

Although the rat has been the animal of choice for drug development and fundamental research for decades, it progressively faded away in favor of mice, a species in which genetic manipulation is much easier and for which there is a greater variety of research reagents available.

Non-transgenic rat models are also studied, but rely (for example) on pharmacological induction of the disease, relating more the sporadic form of Alzheimer's disease. Check out the study from Lecanu and Papadopoulos on that topic.

In animal research, cognition and memory are a popular, though challenging, subject to study. Understanding the development and/or progression of neurodegenerative diseases, like Alzheimer's disease, requires studies in these neurocognitive domains. Pre-clinical studies thus serve as an essential step to better understand the underlying (neural) mechanisms of such diseases. Transgenic mouse models that mimic a specific subset of pathophysiology of Alzheimer's disease for example are amyloid precursor protein (APP), presenilin 1 (PSEN1) and presenilin 2 (PSEN2). These are Alzheimer's disease-linked mutations discovered in humans, which function in the mouse much as they do in humans. Obviously, these mutations on itself do not fully phenocopy the full spectrum of the human disease, but like before (in other models) provide great insight in specific molecular mechanisms which are responsible for specific pathophysiology.

A great overview of animal models of neurodegenerative disease is described by Dawson et al. (2018) in Nature Neuroscience.

FORMS OF COGNITION & MEMORY

ALLOCENTRIC AND EGOCENTRIC SPATIAL MEMORY

Spatial learning refers to the association or representation of an organism in a three-dimensional environment. In animal research terms: An animal learning its position in a given space. This task highly relies on visual cues and/or landmarks. Allocentric refers to encoding information about the location of one object relative to the location of other objects. While egocentric represents the location of objects in space relative to your own body.

Want to read more about the importance of distinguishing allocentric and egocentric search strategies in rodents? This review article by Grech et al. (2018) provides relevant information and additional literature.

WORKING MEMORY

Working memory is generally defined as short term memory for an object, stimulus, or location that is used withing a testing session, but not typically between sessions. In simple terms: keeping in mind everything that is required while performing a task.

SHORT TERM MEMORY

Short term memory is crucial for many basic tasks in life. In animals, short-term memory plays a critical role in understanding new environments, allowing goal-directed behavior, and generally speaking, providing a substantial survival advantage. Without it, animals couldn't successfully avoid predators and search for prey, build nests, and assimilate and understand novel environments within their existing models of the world.

LONG TERM MEMORY

Long term memory is basically information that is retained for a longer period of time, being classified as relevant to store (sometimes indefinitely). Where you live, your name and of your loved ones, where you went to high school, your first kiss etc. Episodic memory is a category of long-term memory, and refers to an *episode* of your past experiences. This usually involves a *when* and a *where*. The latter is quantifiable in rodents, usually involving training to a specific location linked to a reward or aversive event.

ASSOCIATIVE LEARNING

Associative learning is a process in which a new response becomes associated with a particular stimulus. Thus, Pavlovian learning is a form of associative learning, since this is typically induced in subjects that associate stimuli with a negative (aversive) stimulus or situation: such as a light cue followed by a foot shock. Basically, associative learning is the ability of an animal to connect a previously irrelevant stimulus with a particular response which mainly occurs through the process of conditioning. Reinforcement of this response strengthens this behavioral pattern even further.

COGNITIVE FLEXIBILITY / REVERSAL LEARNING

Cognitive flexibility is the ability to rapidly change, or adapt, behavior while facing specific (changed) circumstances. Successful discrimination learning is necessary, since a reversal learning task relies on reversing the two stimuli and assessing whether (or how fast) the subjects learn the new positioning or object or other stimulus. Basically: when a subject is used to a specific situation, how fast can it adapt when specific environmental cues are changed.

Want to read more on the neural basis of reversal learning? Check out this paper by Izquierdo et al. from 2017.