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Exam 2
Brain and Behavior 2
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The memory functions of the brain are complex and handled by a number of connected neural systems. To understand the specific functions of the discrete neural systems, it is useful to categorize memories into declarative vs. nondeclarative and declarative memory processes into short term, working, and long term. Declarative memories are memories for facts. There are two types of declarative memories: episodic (life experiences, "what did I do on my birthday?") and semantic (other facts, "what year was the Declaration of Independence signed?"). Nondeclarative memories include procedural memories (skill learning) and memory due to classical conditioning (proprioception and emotional responses).

Another way to categorize declarative memory is by short-term, long-term, and working memory. Short and long term memories are intrinsically linked, as short-term information can be converted into long term through the process of consolidation. Working memory, although still dealing with declarative memory, is thought to be a system separate from the short-long term pairing. Working memory is severely limited in capacity and requires rehearsal.

This web of memory systems is the result of an interconnected set of neuroanatomical substrates. Working memory is thought to be the result of activity in the prefrontal cortex and lateral intraparietal cortex (or area LIP). The specific functions of the prefrontal cortex are as of yet crudely understood relative to the sensory systems, but it is assumed to be involved in higher cognitive tasks such as decision-making, sequencing, planning, and complex problem solving. It is thought that certain cells in the prefrontal cortex may be responsible for working memory. For example, in an animal study, a monkey was shown a food reward, the food was concealed, and the monkey had to choose the location of the food after a short (20 second) delay period. During the delay period, when it is assumed the monkey is holding the location of the food in working memory, the researchers observed a spike of activity in the prefrontal cortex (Fuster 1973). Evidence for LIP involvement comes from observed behaviors in delayed-saccade tasks. Eye movement is directed toward a remembered target stimulus in conjunction with LIP activity (Goldman-Rakic 1982).

Short term and long term declarative memories have the potential to be stored in many regions of cortex due to the multimodal nature of our experience. However, not all regions of cortex contribute to all memories equally. Hebb (1949) proposed a theory of cell assembly, meaning that the memory of an object is made of the network of cells activated by the stimulus. This provided an explanation as to why memory seemed so distributed and intertwined with sensory perception, which guided future inquiry.

The medial temporal lobe is most often cited for involvement with declarative memories. The association areas of the cerebral cortex communicate highly processed information to the medial temporal lobe, first to the rhinal and parahippocampal cortex and then through to the hippocampus. The hippocampus then sends information through the fornix to the thalamus and hypothalamus. Early evidence for the involvement of the medial temporal lobe came from the work of

Penfield (1958) who found that electrical stimulation to the region caused vivid hallucinations of memory. Damages in the area have also been found to disrupt memory. The most notable case is that of H.M., a patient who had most of his medial temporal lobe removed in an attempt to treat seizures. His overall cognitive abilities were not diminished, but his memory was severely impacted. He lives in a continuous vacuum, with no memory from 11 years before his surgery or later. His resulting anterograde and retrograde amnesia made him a famous candidate for many landmark memory studies (Ogden 2005).

Of the structures of the medial temporal lobe, the hippocampus has received the greatest amount of study. Large numbers of neurofibrillary tangles and granulovacuolar organelles in the hippocampus are one of the observed results of Alzheimer's Disease, a type of dementia which severely impacts memory. An example can be found in Ogden's (2005) case study of Sophie. Knowledge of the precise nature of hippocampal function is still developing, but it is assumed it is important for binding sensory information in the consolidation process, it provides spatial memory, and it stores memory for lengths of time. There is also evidence that interactions of the hippocampus and nearby amygdala cause people to have better memories for emotionally charged events (Phelps 2004).

Over a period of time, memories can be moved from the medial temporal lobe to distributed areas across the neocortex in a process called consolidation. The standard model of memory consolidation describes this process possibly being decades long. This poses problems when considered in cases of retrograde amnesia, so an alternative model has been presented, known as the multiple trace model of consolidation. In this model, the hippocampus is always involved, even as memories begin to move into the neocortex. The precise neuroanatomical substrates of long-term episodic memory are still being debated and researched.

Nondeclarative procedural memory is thought to be primarily dependent on the striatum (the caudate nucleus and putamen in the basal ganglia). Studies of humans, rodents, and primates with legions to the striatum or the hippocampus consistently result in different behavioral effects. Legions to the striatum create an inability to learn new habits, while damage to the hippocampus does not. Similarly, hippocampal damage causes issues in declarative memory in ways legions to the striatum do not. For example, patients with Huntington's disease have difficulty learning motor tasks that is disproportionate with the severity of their motor deficits, due to the focused damage the disease does to the striatum.

The many neurophysiologically significant areas that contribute to memory formation and retention are essential to the human experience. Consider Sacks's (1986) example, Mr. Thompson. Superficially, he comes across as quite entertaining to others. However when one considers how he must no longer be able to experience deeper meaning, he appears far more lost than one may think.

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