P.G Department of Psychology

NEUROPHYSIOLOGICAL BASE OF MEMORY

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NEUROPHYSIOLOGICAL BASE OF MEMORY

- Neuropsychologists have contributed both through the study of those individuals with brain damage and by use of neuroimaging procedures with healthy volunteers across life span through the of study neurophysiology of memory. Memory refers to our ability to acquire, retain, and retrieve information. This information is stored in the brain, and thus analysis of those who have sustained damage to the brain, or techniques that allow us to image brain activity, provide us with means by which we can understand memory.

- The fact that memories are stored somewhere in the brain, *and* that they consist of activities involved in acquiring, storing, and retrieving information, points to two general theoretical approaches that have provided guiding frameworks in the study of memory.

- The *systems* approach takes the view that different types of memory are located within different regions of the brain.
- The *process* approach takes the view that memory is composed of different processes that may recruit similar or different neural regions.
- Depending on the task facing the individual, the memory consists of both systems and processes and that both views are important for a comprehensive understanding.

SHORT-TERM MEMORY AND WORKING MEMORY

- Atkinson and Shiffrin (1968) Modal model of memory distinguishes between a sensory memory store (which stores sensory impressions for very brief periods of time), a short-term memory store (which can hold information over longer periods through mental rehearsal), and a long-term memory store (into which information is passed following processing by the short-term store). The model proposes that the memory stores (systems) are essentially unitary: that is, indivisible into separate subcomponents.

- This multi-component model, referred to as working memory, is most closely associated with the work of Alan Baddeley and colleagues The structure of working memory consists of a central executive whose function is to direct and regulate the flow of information, and allocate attention and processing operations within the two "slave" systems, so-called because they are essentially controlled by the central executive. These slave systems are the visuo spatial sketchpad (which serves the function of integrating and processing spatial and visual information over short periods) and the phonological loop (which serves the function of storing and processing verbal auditory information over short periods). Although the model was initially proposed on the basis of research with individuals without brain damage, the study of both neuropsychological patients and the use of neuroimaging with healthy controls have been useful in its subsequent testing and development.

NEUROPSYCHOLOGICAL EVIDENCE FOR COMPONENTS OF WORKING MEMORY

- The visuospatial sketchpad is the subsystem responsible for the temporary storage and manipulation of visual and spatial information. One particular neuropsychological test used to assess visuospatial memory is the Corsi block test. In this task nine identical blocks are arranged in front of the participant in such a manner that there is no apparent order or pattern to their placement. Following this, the experimenter taps the blocks in a particular sequence (e.g., touches block 3 followed by 5, 2, 8, etc.). The participant is then required to immediately reproduce this sequence. This measures visuo spatial working memory, as the participant has to retain the spatial sequence in order to achieve accurate reproduction.
- DeRenzi, Faglioni, and Previdi (1977) found that patients with damage to the right posterior parietal region were significantly impaired on this task. However, the parietal regions do not act by themselves in terms of processing spatial information—the right frontal cortex is also important.
- Pigott and Milner (1994) tested performance on a task that required short-term memory for chequerboard-like patterns. In this, participants were presented with a random array of black and white squares. After a short delay the participant was shown the same pattern with one of the squares missing. It was found that those with right frontal damage were impaired at remembering the spatial position of the missing square.

- Neuroimaging work also suggests a role for frontal regions in visuospatial working memory.

- Smith, Jonides, and Koeppe (1996) presented to participants arrays of dots on a computer screen for 200 ms. Following a 3-second delay, a circle appeared either in the same or in a different location to one of the dots. Participants were asked to decide if the circle would have covered one of the dots if it had been present at the same time. It was found that this task led to activation in the right frontal lobe.

- The label "visuospatial" suggests a combination of both visual and spatial processing. In everyday life most visual perceptions contain both visual and spatial information, which may in turn suggest that such features are processed together in the brain. However, it is now becoming clear that the visual and spatial components of working memory can be dissociated.

- Owen et al. (1995) reported that damage to the anterior temporal lobes impairs visual working memory, while leaving spatial working memory intact.

- Levine, Warach, and Farah, (1985) reported that damage to the parietal lobes selectively impairs spatial memory tasks. This double dissociation provides strong evidence that the visuospatial sketchpad needs to be subdivided into separate visual and spatial components. The visual component is important for processing the identity of the object, while the spatial component is important for processing the relative location of objects or features of object.

- Overall, these studies testify to the importance of neuropsychological research in advancing our understanding of this component of working memory. Neuroimaging with healthy controls has also revealed that separate regions are implicated in the processing of visual and spatial information, with visual working memory associated with activations in inferior occipitotemporal regions and spatial working memory associated with activations in parietal regions.

LONG-TERM MEMORY

- **Amnesia** refers to a particular cognitive deficit in which long-term memory is selectively impaired. There are two classes or subtypes of global memory impairments referred to as anterograde and retrograde amnesia

- **Anterograde amnesia** is essentially a memory deficit for the acquisition of new information or new learning since the time of the brain damage. Thus those with anterograde amnesia will have problems remembering what they did the previous day or even a few moments ago. It can be considered a deficit in the ability to update memory, and in many respects those with this form of amnesia effectively live in the past as no (or very few) new memories are laid down. This type of amnesia is typically associated with damage to the medial temporal lobe (MTL) and associated structures, namely the hippocampus, the dentate gyrus, the entorhinal cortex, the perirhinal cortex, and the parahippocampal cortex. Some of these structures are connected to other neural regions important for memory such as the thalamus, mamillary bodies, and prefrontal cortex.

- **Retrograde amnesia** refers to impairment in remembering information from the time prior to the onset of the damage. In terms of neuropsychological research, these two types of amnesia are often investigated separately, with theoretical emphasis and empirical studies designed to assess or characterise the nature of one or the other form.

ANTEROGRADE AMNESIA AND NON-DECLARATIVE MEMORY

- Perhaps the most famous case of anterograde amnesia is that of patient HM. He was unfortunate enough to suffer from severe epilepsy, and efforts to treat this conventionally (with medications) were unsuccessful. The decision was made to remove the focus of his seizures and this entailed the surgical removal of much of the medial temporal lobe regions in both hemispheres. The operation took place in the early 1950s and left HM with a very severe form of anterograde amnesia. As a consequence of being unable to update his memory, HM was mentally "stuck" in the 1950s. Thus he failed to recognise people he had recently encountered even when these individuals had been in frequent contact with him. He also reread magazines and newspapers because he failed to recognise the fact that he had read them before.

- The reverse of what is found in those without retrograde amnesia, who display superior memory for more recent events. The temporal extent of the retrograde impairment can vary quite widely. For some individuals the impairment may be for the previous few months or years. For very severe cases, the extent of impairment can be across the whole lifespan.

- In addition, individuals with retrograde amnesia can often display a range of

deficits in recalling pre-morbid memories. These can include:

(1) Memory for personal episodes and events from their lives such as a birthday party or holiday,

(2) Personal semantic information such as who they are, their characteristic traits and preferences,

(3) Public and news events, such as who won the general election on some particular date, and also famous people and personalities, such as politicians and TV stars.

NEUROIMAGING OF AUTOBIOGRAPHICAL MEMORY

- Autobiographical retrieval leads to the activation of a network of areas including temporal and parietal regions, the medial frontal cortex, the cerebellum, and the hippocampus.

- Different experimental studies often reveal different activations. Maguire claims that this is likely to be due to a number of factors such as the variety of means by which autobiographical memories are elicited, the relative recency of the memories, differences in the amount of effort required to recall a memory, and the amount of time allowed for each recall and response.

- According to some researchers, the reason for this is that following the encoding of an event, memories undergo a slow consolidation process and this is dependent on the hippocampus. Thus, initially, a newly formed memory is actually quite unstable. Consolidation processes work to make the memory stable and increase its strength and resistance to forgetting. More specifically, it has been proposed that the hippocampus is responsible for retrieving only relatively recent memories. Following the passage of time, and the consolidation process, it becomes possible to retrieve memories independently of the hippocampus. This idea has received support from research with animals and humans.

Thus neuropsychological research tells us about the *systems* and *processes* underlying short-term/working memory and long-term memory. Through the careful analysis of individuals with brain damage, and with the use of neuroimaging procedures, it will be appreciated that the concept of memory does indeed encompass and support the idea of multiple memory systems and subsystems with multiple component processes.