The Relationship between Attention and Memory Retrieval

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Abstract. Researchers were trying to explore the relationship between attention and memory retrieval in many different methodologies. This paper aims to clarify the complex relationship between attention and memory. Most early research from the 1900s suggests that memory retrieval is an automatic process that does not require attention. Moreover, in line with intuition, research about implicit memory also suggest that it is an automatic process. However, recent research about explicit memory retrieval suggests otherwise. Neuro-imaging research found that the region that activates during memory retrieval also activates during visual attention. Animal research about attention demand and spatial memory retrieval showed that attention could help memory encoding and retrieval. By studying individuals with attention deficits, it can conclude that attention is crucial for suppressing memory retrieval. Furthermore, behavioral research suggests that divided attention can impair memory retrieval. Thus, memory retrieval is not an automatic process.

Keywords: Attention Demand; Divided Attention; Memory Retrieval.

1. Introduction

The definition of attention can be a fairly diverse term. It can be considered as a mechanism for selecting and prioritizing representations. In this case, attention can be seen as a filter that filtrates the irrelevant stimuli from the mind's representation of the ongoing task and uses the relevant stimuli as input for the cognitive operation. But more commonly, it can be described as limited resources for information processing. In this conceptualization, attention is an energy resource that can be separated to complete different "attention-demanding tasks". The task performance or efficiency will be impaired if less attention was paid [1]. For example, a traffic accident is extremely common when driving car while answering the phone. Because the driver needs to split some of the attention from driving to answering the phone.

If several neurons in your brain that has a very strong synaptic connection because you use those neurons more often than others then those links are the term called long-term memories. Memory retrieval (MR) involves a mechanism that accesses the long-term memory and brings it to the working memory, in another word, consciousness. This mechanism is called 'ecphory'. It correlates the retrieval cues and stored memory traces (or engrams). Engrams are the biological basis of the memory trace. Thus, MR can be conceptualized as using retrieval cues to activate the behavioural expression of the engram [2].

The relationship between MR and attention demand is a fairly new realm of research that generated numerous amounts of inconsistent results from different perspectives. The purpose of this article is to summarize those results and classify them on whether paying attention facilitates or is required by MR, or whether paying attention has no effect on MR.

2. Attention does not affect memory

2.1 Behaviors-based evidence

Baddeley et al. conducted nine experiments to investigate the disrupting effect of divided attention/secondary tasks on MR. For the first experiment, subjects were instructed to learn several stimuli with different characteristics. Then in the recall testing phase, the subject needs to complete a card-sorting task. Subject sort the card into four suits by their characteristics. There are two different conditions: The high processing-load condition has a higher information load and thus requires

different attention demand than the low condition. The accuracy was recorded as evidence. The first five experiments were similar, only different in the types of stimuli. The result showed that the recall accuracy between different conditions did not vary too much. It suggested that MR is not an attention-demanding process[3].

Keele investigated whether MR is an attentive process or not. According to the article, most tasks can be divided into two stages: (1) retrieval stage (retrieval of information from memory), and (2) operation stage (perform the task base on the retrieved information). If two stimuli are presented at the same time, and each requires a different operation, a delay in one of the responses will usually happen. Attention is required to perform a task with interference. However, which stage was causing this delay (In other words, which stage requires attention) was unknown [4].

A classic example of this is the Stroop effect. MR might not be responsible for the Stroop effect, instead, caused by the conflicts of response between the form and color. To test this interpretation, the author set up a modified Stroop task where the stimuli became (1) color-word: Red, Green, Blue, or Yellow. (2) Non-color words: RAT, GLASS, YANKEE, BIRD. And each kind of stimuli has printed in four different ink colors. Participants' job was to classify those stimuli by the color of their ink regardless of its form. The reaction time was recorded as evidence. The results showed the reaction time of group (2) and the control group shows no significant difference. The only condition showing a difference in mean RT is the colour word condition which is slower than the rest of the conditions. This suggests that the interference was not happening in the retrieval stage. Because the non-color word condition must have induced MR for its meaning, the mean RT for this group showed no different than the control group. This implied that interference happened in the operation stage and attention is only required to distinguish one response from another [4]. Thus, memory is a non-attentive process.

2.2 Implicit Memory

Although most previous research has placed its attention mainly on explicit MR, there was a limited amount of research that investigated the effect of attention on implicit MR. Implicit memory exists in our unconscious mind that some suggestions can be retrieved automatically, and it includes a process called priming. Lozito & Mulligan suggested implicit MR can be dissociated into four perspectives: (1) conceptual priming, which is the retrieval of the meaning of concept and knowledge; (2) perceptual priming, retrieval of sensory information of stimuli; (3) identification priming, retrieve information to verify or identify a specific stimulus; (4) production priming, retrieve information that is not uniquely defined to one stimulus, and confined to several answers. For example, if participants were asked to fill the blank 'Sto__', the possible answers are store, stone stole, etc. [5].

Lozito & Mulligan designed four different but similar implicit MR tasks with a secondary task. The implicit memory tasks involve learning the prime and using those learned primes to complete retrieval tasks. During the full attention (FA) task, the experimenter instructed participants to pay full attention to the primary task and try their best to ignore the secondary tasks. During the divided attention (DA) task, participants were asked to do the primary and secondary tasks with equal attention. The goals of that experiment are (1) the role of DA during implicit MR on a general scale; (2) whether variation in the implicit memory retrieval type can be affected by DA differently; (3) whether variation in the secondary task type can have different DA effect. (4) to what extent did the secondary task can impair implicit memory retrieval Those experiments consist of 4 parts. (1) Calibration phase: words will be presented to the screen, then a mask will follow up. Participants need to read the word out loud. (2) Study phase: words will be present on the screen, and participants need to rate their pleasantness on a 1 to 7 scale. (3) Distracter phase: Two tasks will be performed. Participants need to judge whether the number presented now on the slide is identical to the number on the previous slide. Moreover, at the same time, a secondary will be carried out. (4) Test phase: the same task as the Calibration phase [5]. The experiment is only different in the types of priming its use.

The result showed that no matter what kind of implicit task, the priming effect was not decreased by the secondary task. Instead of exerting cost, surprisingly, the implicit MR increase the performance of the secondary task. The result implied that implicit memory retrieval does not require attention. [5].

3. Attention increase memory

3.1 Neuro-based evidence

Previous research has linked episodic MR with activations in the parietal, prefrontal cortex (PFC), thalamic region, and anterior cingulate [6]. However, some brain research involving neuro-imaging suggested that those regions can be activated by visual attention (VA) [7]. Thus, Cabeza et al. hypothesized that there might be an overlap between the activations of those regions during episodic MR and VA. This might imply that MR is an attention process instead of mnemonic processes

To test this idea, Cabeza et al. use fMRI to record the brain activity while letting them complete ER and VA tasks. Participants studied a list of words in a specific amount of rate. While the participant was in the scanner, they viewed a screen through the reflection of a mirror. In episodic MR test, Subjects responded to the cue word by answering several questions: (1) Did you read those words in the study? (2) Can you remember any details of it? (3) Is this word not in the list? In VA test, participants fixate their attention on a letter symbol for 12s to determine how many times it disappear (or never) [8].

Consistent with Cabeza's prediction, there are significant overlapping activations in the right PFC, dorsal parietal, anterior cingulate, and thalamic regions during episodic MR and VA. Surprisingly, cerebellar, and basal ganglia regions showed similar overlapping activations during episodic MR and VA. The fact that these regions' overlapping activation indicates that attention can have a crucial role in MR [8].

3.2 Animal-based evidence

Previous research showed that the rat's hippocampus encodes information beyond the single sensory modality. It also registers details on surrounding space, which requires combining different sensor information. The summation of that information will become the cognitive representation of a spatial map. Animals navigate themselves by actively retrieving data from the spatial map. If the animals were in a particular place in an specific environment, the place cell in its hippocampus will fire. And the biological foundation behind the spatial map is the place cell's stabilities of firing [9] .

Muzzio et al. hypothesized that an increase in attention demand to the environment can increase the accuracy and stability of the place field and spatial memory. He us rats as his test subjects and set up four tasks with increasing attentional demand. (1) No-task condition: animals explore the environment freely. (2) Foraging condition: rats collect random food pieces from all over the environment (3) Discriminating condition: the same task as the foraging condition, but after it completes one foraging session, it will be placed back into the old environments and do the foraging task again (4) Spatial task condition: there will be an electric shock that constantly applies to the animals, and it must find the buttons in the environment to turn that off. The firing rats of the place cell will be recorded as evidence. The result fits the hypothesis that animals in the no-task condition showed fewer stabilities and accuracy than in the other 3 conditions. And the spatial condition showed the exact opposite pattern to the other 3 conditions. [10]. This suggests that the animal needs to place enough attention to retrieve the spatial map in order to help them stabilize and accurately navigate in the environment. Spatial memory retrieval requires attention.

3.3 Abnormal psychology

ADHD (attention deficit hyperactivity disorder) is a psychological disorder that recently get popular by its symptoms: inattentiveness (difficulty concentrating and focusing) hyperactivity, and

impulsiveness [11]. Unable to pay attention to the inhibitory control process might cause problems in several domains, such as memory retrieval.

A previous study that involves neuroimaging indicated prefrontal cortex and frontal gyri are primarily responsible for motor response inhibition [12]. However, ADHD patients showed a significant reduction in these regions when doing motor tasks. As these regions also activate during MR and VA, it is reasonable to assume that ADHD individuals can have impairments in inhibiting memory retrieval [8]. To test this idea, they hypothesized that, due to the reduction of neuroactivities of the prefrontal cortex and frontal gyri, ADHD individuals would have impairment in inhibiting memory retrieval. [11].

The participants are sixteen young adults with ADHD and 16 healthy controls all between 18 and 23 years of age. Their brain activities will be measured before the experiments. The experiment consists of three phases: (1) Training phase: participants need to learn 40 pairs of "face" and "picture". During the learning, they were constantly being tested to indicate whether this was the correct pair. The learning phase stops when they reach an accuracy of 97.5 percent. (2) Experiment phase: the participant will learn to associate the "red" background color of the pairs to the "No-Think conditions"; and "green" to the "Think condition". These conditions will be used in the test phase. Participant must try their best not to let these associations enter their consciousness during the no-think condition. And they were encouraged to think about the picture that was previously paired with this face at the think condition. (3) Test phase: the faces will be presented to the participants, and a description of the picture pair need to be written. The accuracy and the brain activities were recorded as evidence [11].

The brain scan showed that there is a reduction in activities of the prefrontal cortex and frontal gyri in ADHD individuals than in the control group. Moreover, the behavioural test result showed that there are no significant differences between the performance of Think and no think condition, which implied that ADHD individuals showed impairment in inhibiting the MR [11].

3.4 Behaviors based-evidence

Much behavior-based research used the contrast between the FA condition and Divided Attention DA to demonstrate the empirical discrepancy of an operation that contains primary and secondary tasks. Many of these kinds of research have shown that DA can have a decremental effect on memory encoding tasks, but only a slight impact on memory retrieval. Some early research even conceptualized memory retrieval as an automatic process that does not require attention [3]. Some research implied that memory retrieval under DA condition is confounded and meaningless in which the participants label those words as 'old' because they have seen them recently. If that is the case, there are MR was not involved in this process [13].

Craik et al. set out to investigate: (1) whether MR under DA is due to fam or recollection; (2) whether retrieval can be significantly affected by DA to the same degree as memory encoding. The experiment has two phases. During the first phase, participants needed to encode the details of the words. The details include the first letter, rhyme characteristics, and meaning. Then is the retrieval phase, in which participants need to label the word as old or new (whether they saw it in the encoding phase or not) and whether can remember any details or not. There were nine lists of words. 3 of the lists were encoded under FA and recalled under FA; 3 of them under encoded under FA and retrieved under DA; 3 of them were encoded under DA and recorded under FA. The secondary task is auditory where participants listen to a series of three numbers and identified the first number by saying it out loud. At the DA condition, the secondary task will be considered as crucial as the retrieval task [14].

The result showed that there was a significant effect on both encoding and retrieval. Both performances showed a significant drop in DA than FA condition. Suggesting that memory retrieval does not draw attentional resources; retrieval is not a process of familiarity; retrieval is not an automatic process[14].

4. Conclusion

For the research that suggests that there is no obvious correlation or causation in memory retrieval, early behavioural research usually indicated that memory retrieval does not require attention and it is an automatic process. Implicit memory that exists in our subconsciousness does not need attention to help recall.

For the research that suggests memory retrieval is an attentive process, brain-imaging-based evidence suggests that the brain region that activates during memory retrieval is also activated during visual attention, and divided attention during retrieval will reduce the activity of those regions. Moreover, individuals that have attention deficits have trouble suppressing memory retrieval. The animal-based experiment suggested that spatial memory retrieval requires attention. Moreover, despite previous behavioral research suggesting memory retrieval is an automatic process, more recent research that tests the subject using a secondary task to divide attention suggests that memory retrieval does not draw attentional resources and is not automatic.

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