Proceedings of the 4th International Conference on Educational Innovation and Philosophical Inquiries
DOI: 10.54254/2753-7048/12/20230834

The Mechanisms of False Memory and the Factors Contributing to It

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Abstract: False memories are unavoidable and occur in creatures' lives all the time, and false memory is not a mistake in the aspect of memory. But instead, the presence of underlying cues, emotional influences, and activation-related information effectively affects the memory's validity. The study of several pieces of literature found that memory is unreliable under certain conditions. There are also false memories caused by associative activation factors, which are imperfect reconstructions of reality between perception and memory. This article is divided into three main parts to introduce these formation mechanisms of false memory and what factors lead to the formation of false memory. These three parts are the principle of creating false memory in the hippocampus, the effects of associative activation on memory and causal enhancement and attenuation of associative activation, and the transmission of misinformation and the effect of retrieval cues on memory during the retrieval phase.

Keywords: false memory, cognitive science, memory paradigm

1. Introduction

This paper principally discussed the mechanism of false memory formation and the factors that would cause it. Two essential points about this theme are briefly introducing what false memory is and what impact on lives. False memory could be a fabricated or distorted way of collecting about events, including entirely false and imaginary memories. Another way of explaining false memory could be containing elements of fact distorted and interfering with related information about remembered things. False memory could happen in lives anywhere and anytime, but it is not just a simple mistake and also involves the level of certainty about the validity of the memory. While experiencing memory impairment, the uniqueness of false memories can represent vivid recollections about things which did not happen; that is not about forgetting or confusing details which people experienced before, but remembering things which they have not experienced in the first place. Suggestions, emotional influence, activation-related information, and the attribution of sources of misinformation all should be considered as mechanisms for false memory.

Ramirez et al. elucidated that memory can be said to be unreliable, as dentate gyrus (DG) neurons of memory engram-bearing cells in the hippocampus were activated by optogenetic manipulation of mice, which later occurred under fear conditions; optically reactivated activation occurred in a variety of contexts may lead to context-specific false memories in mice [1]. Otgaar et al. believed that activating association is a mechanism of memory that can trigger the potential impact on the

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formation of false memory. It may be explained why people who have certain forms of psychosis can develop false memory [2]. Moreover, in part on associative activation, it will be described in more detail that associative activation has a special relationship with the causal relationship between false memory, and it has explanatory value for false memory. Straube clarified that perceptive memory would be imperfect reconstructions of things of reality, and memory is susceptible to various factors during the reconstruction process and also leads to false memories [3]. False memories would appear in ways of recollecting things or details of events that did not actually happen. During the encoding, merging, and retrieval stages, these sub-processes are all affected, leading to false memories. Especially in the retrieval phase, the distortion of information by the misinformation effect strengthens the generation of false memories. The monitoring process is an essential condition for rejecting false memories, which will be explained in detail in the retrieval stage of false memories.

2. Literature Review

2.1. Creating a False Memory in the Hippocampus

2.1.1. Engram Cells in the Hippocampus

Neuroscience could explain how the human brain drives our cognition and how our perceptions affect our inner mental expression and, thus behavioral activities. Humans generate rich mental representations in their brains, such as recalling consciousness or unconsciousness, having dreams and related imagination [4]. However, how intertwined with the inner human expression has not been discovered. According to Ramirez et al., this paper demonstrated that providing an opportunity to explore how an internal expression with specific content is elicited by external stimuli of high valence [1]. Firstly, it was shown from this experiment that was inspired by damage to the hippocampus affects episodic memory. Then, this experiment employed fear conditioning as a model of episodic memory in mice and found out that the “Dentate Gyrus” of the hippocampus acts such an engram cell for contextual memory [5]. Moreover, in terms of activating context-dependent fear memories, optogenetics could be used to stimulate cells that create shocks to the foot. Here a hypothesis was put forward by activating recently formed memory traces while conveying a false fear memory to the foot where no foot impact occurred. To testify to this hypothesis, the experiment was attached to test whether light activation in the DG cells can affect contextual memory. The light activation here can be referred to as the conditioned stimulus as fear conditioning [1].

2.1.2. Effects of Light-activated Expression

Through the theory that the hippocampus processes mnemonic information, this experiment investigated that both groups primarily operated on DG cells to form false memories. Then, overlapping activity significantly reduced contextual memory in this group after light-activated expression compared to the other group without light-activated conditioned stimuli [6]. Based on the theory of false and genuine memories caused by the hippocampus activity, the experiment just mentioned provided an animal model that can distinguish between real and unreal to explore the level of memory engram [7]. And in the case of optically activating episodic memory, it induced its retrieval memory and associated this memory with high-valence events such as foot shocks, thus forming a new but false memory.

2.1.3. Contextual Memory

Although this experiment took place in a laboratory environment to retrieve contextual memory by artificially adjusting the light as a conditioned stimulus, it can be speculated that some false memories

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also formed in the human stage, which is associated with external high-valence stimuli by retrieving internally driven previously formed memories. Lastly, in practice, this experiment found that activating neurons in a more comprehensive spatial and time-limited manner, such as only a few minutes of light stimulation, is beneficial to observe the formation of true and false memories [1].

2.2. Associative Activation on the Composition of False Memories

2.2.1. Impact on Associative Activation

A matter of concern about false memory is what kinds of mechanisms would generate false memories. It is significant to explore this question in theory-building, and it is also essentially used in legal cases or therapeutic situations. This practical momentum can be interpreted as false memories will manifest in these situations. Some studies demonstrate that the causality of "associative activation" is strongly linked to the generation of false memories. The definition of "associative activation" originated from the communication activation model, which means simultaneously processing a concept and stimulating related concepts in the knowledge bases [2]. For example, "bed" can make people think of night, moon and blanket. Specifically, "false" activation of concepts begins when related concepts are related, such as the word "sleep", which is not presented here but is incorrectly remembered as information seen or heard. This example can illustrate that associative activation can be incorrectly activated about specific details, thus resulting in a false memory.

2.2.2. Causality to the Increase in Associative Activation

In exploring the correlation between the causal role in association activation and the relation about false memory in general, the "DRM paradigm" is called from "Deese/Roediger-McDermott paradigm", which can be used to explain the way of correlation [8, 9]. The "DRM paradigm" can be interpreted as presenting participants with related words containing associations. Adding "critical lure" words that never appeared before will also be associated with previously presented words. According to Otgaar et al., recall and recognition tests showed that 70 percent of the participants incorrectly recalled that "critical lure" words had appeared in the previous words lists [2]. Another emphasis of the "DRM paradigm" is about the tightness of association around listing things and "key lure" known as "backwards association strength" and "forward association strength", which both BAS and FAS can contribute significantly to false memory generation [10]. Arndt also found that BAS can account for large numbers of variables during the generation of false memory and other factors such as word length [11]. These elements are significantly expressed in the process of forming false memories.

2.2.3. Causality to the Reduction in Associative Activation

Suppose the study wants to verify further the casual relationship between associative activation and false memory generation. In that case, there is another way to confirm it: to create opportunities to reduce the incorrect relations in the participants' knowledge bases to see whether false memory will reduce generation in some stages. Otgaar et al. demonstrated that children showed lower rates of false memory than adults under distracting conditions; adults did not experience a decrease in false memory rates when distracted. Instead, their false memory rates would increase in divided attention [12]. Pérez-Mata et al. explained the above experiment results that distraction may make associations inclined to spread to potential theme nodes, leading to more errors in memory formation [13]. In the process of children's memory, distraction could make associative activation blocked in some ways during the encoding process, resulting in less associative activation or spreading of the list presented by related words, which would reduce the formation of false memories.

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2.3. Retrieval Processes on False Memory

2.3.1. Misinformation Paradigm

In the retrieval stage of false memory formation, they are generally initially related to the retrieval cues or some tasks linked to the perceptual process, recalling the information from memory and related executive function processes [3]. During these retrieval stages, some crucial processes were that the participants provided false information related to retrieval cues, as stated in the misinformation paradigm. Here is the explanation of the misinformation paradigm. Okado and Stark illustrated that the misinformation effect is under the procedure of replacing or transforming the memory that has been formed after receiving some suggestive or more detailed information [14].

2.3.2. Retrieval Cues

However, during constructive or adaptive memory updating, precious memories may have been altered by suggestive retrieval cues to be retrieved, so it can be supposed that the post-event information could result from memories related to recall cues being processed together with new information. Some parts are also involved in the creation of these memories, such as the perceptual range of regions in brains, the area of “medial temporal lobes”, and the “prefrontal cortex” [15]. And also, research on the retrieval process of false recognition could be involved with this DRM paradigm. Gallo clarified that false identifications could be detected through the DRM paradigm. This is often used for the false memory phase retrieval stage because participants showed a high rate of mistakes when presented with critical items assigned to some experimental situations [16].

2.3.3. Activation Monitoring Theory

Regarding retrieval mechanisms, it would be influenced by the spreading out of activation while crossing a mass of cognitive tasks. There is a hypothesis that other related concepts and memories are linked when things or concepts are activated in memory through encoding or retrieval. This activation could extend to those concepts [17]. The “activation monitoring theory” refers to the combination of a more controlled and monitored process of disseminated activation and retrieval. This fundamental theory made participants would be affected by their associations. Therefore, participants can combine information not only by activating concepts during the retrieval phase but also relying more on monitoring processes to separate those activated things not studied from the learned ones before. So, with that being said, during this execution, monitored retrieval may have an essential effect in verifying the accuracy of the memory [3].

2.3.4. The Influence of the Cerebral Cortex

False memory occurs during the retrieval phase, an aspect extensively studied between neuropsychology and neuroimaging. After comparing the true and false recognitions responses of these neural activities in multiple studies, neuroimaging studies have shown that the occurrence of false recognition would raise the level of neural activity in “medial areas” and “lateral frontal cortex”. Thus, it can be said that “the frontal cortex” could be essential in detecting relevant false recognition [18]. Some findings proposed that the involvement of the PFC during memory recognition could cause genuine memories to contain more information in ranges of perception and feeling. Still, false memories contain more information about processing cognition [19].

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2.3.5. Reconstructive Process

So, in other words, perceptually successful retrieval of memory events and combining different sources of information during reconstruction are indispensable for specific conditions. The reconstruction process of failure can majorly contribute to confusion and associated false memories. In this circumstance, the hippocampus could be essential during the reconstructive procedure. And also, it is thought to be involved in associative processing, which means integrating information from various sources and reorganizing them together [20]. Hence, the contribution of the hippocampus to constructive memory is to bind memories together flexibly; however, sometimes, erroneous reorganizations could lead to false memory recognition [21].

3. Implication

Robert Jacobs is a cognitive scientist, and he with his colleagues have been developing new theoretical and experimental methods to explore the formation of false memories. They tend to think, counterintuitively, that memory errors can be a good thing. False memories are a desirable side effect of efficient work in cognitive systems with limited capacity. And also, some memory errors may indicate that cognitive systems are generally optimal or rational. During the formation of false memories, especially when information is ambiguous or uncertain, or even after emotional fluctuations, people will make mistakes in memory, reasoning, decision-making and action. When the brain performs cognitive tasks, the optimal strategy is to combine data information from things seen or experienced with common sense known to humans. Forming false memories is unavoidable when perceiving and reasoning with ambiguous inputs and uncertain information. In other words, the brain already completes cognitive tasks as much as possible. Whether it is a genuine or false memory, they are both mechanisms of memory. Moreover, cognitive behaviour is subject to certain limitations in all links of living beings. Due to these limitations, whether it is attention limitations, memory limitations and the inability to remember all details. That brought about an optimal perceptual or cognitive state that may not always be achieved. But in these constraints, people still remember the main body of things. The lack of details is due to constraints; however, these also prove that the memory is operating as much as possible under these constraints, which is a good thing.

4. Conclusion

While having memories of experiences and incidents that have never happened can be emphasized as the existence of false memory. Or in other words, during peoples' recollection of events, how the event occurred is different from how people perceive the event. Through the study of the former papers, it was founded that memory can be produced by potential influencing factors or unexpected associations with other events. From the perspective of brain science, the stimulation of light in the hippocampus of mice produced frightening emotions to trigger false memories. The critical factor for this result was that the dentate gyrus (DG) in the hippocampus acted as an engram cell for contextual memory and provided the conditions for false memory creation. Then, using the DRM memory paradigm, it was known that the "critical lure" would trigger the memory association and cause false memory. However, when compared between children and adults, providing children with distractions could reduce memory associations, leading to fewer false memories. And it is also to be found that distraction makes adults more prone to creating false memories. It can be seen that the influence of potentiality is essential to the generation of memory. Referencing the retrieval phase of false memories, misinformation paradigms can be seen as alterations or mis-transmissions of information. Moreover, combining new information and previous information by retrieval cues would also cause people to misunderstand information and create false memories. It would follow that failures in the reconstruction process could be a central element for forming false memories during these

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reconstructions in brains. And also, the hippocampus could be significant in integrating information. The weakness in the flexible reorganization of memory in the hippocampus is the false memory recognition caused by erroneous reorganizations. This review article described the formation mechanism of false memory and the factors that cause false memory. And also, this study proposed that false memory is an ideal side effect in a cognitive system with limited capacity.

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