PSY789
RECONSOLIDATION

Nivedita- 160462

October 2018

Abstract

Memory as an ever-evolving organization of the record of experience. Memories from the long term become labile and susceptible to modifications on retrieval. This process is called reconsolidation. Here, we go through the its initial evidence, the wide range of conditions in which it can occur and recent results further revealing its fascinating nature. Conceptual issues of when and why reconsolidation happen is addressed. The potential clinical and therapeutic implications of memory modifications by reconsolidation is discussed.

Contents

1 The Dynamic nature of Memory

Memory does not consist of a single process. Instead it is a organization of distinct phases, each one relying on distinct mechanisms supporting different cognitive demands. [2]The first phase is the encoding (or learning phase) that takes place during a new experience. It allows for the acquisition of information that is being processed by the brain predicting an event.
As Hebb (1949) stated, "neurons that fire together, wire together." That is,

given that, in the brain information flows through specific synaptic connections, in order for it to persist as a long-lasting representation (i.e., a memory trace) the efficiency of such connections must be strengthened and stabilized, otherwise the experience will be forgotten (Ebbinghaus 1885). This happens during the consolidation phase that is triggered after initial acquisition (also referred to as synaptic consolidation) and culminates in memory storage. Consolidated memories allow for the retrieval phase that is the recall of the stored information in order to better guide behavior—the main physiological function of memory. Hence, a whole set of different but interconnected processes (acquisition, consolidation, and retrieval) allows animals to adapt their behavior according to their experiences and their environments.

All consolidation theories state that once consolidation is complete, a memory will remain in the consolidated stated that is, fixed and stable. As opposed to this expectation, a lot of empirical evidence suggests that consolidated memories can be transferred again into a labile state, from which they are restabilized by a reconsolidation process. Retrieval appears to be the key process that transfers memory from the stable to the unstable state which is dynamic and susceptible to modifications.

2 A Brief History

The consolidation theory does not answer a number of behavioural observations. One of them arose from initial studies demonstrating that performance can be impaired if amnestic treatments (electroconvulsive shock) or new competing are presented after a reactivation/ retrieval sessions, (cue-dependent amnesia). It suggested that following reactivation, memory returned to an unstable state, after which a restabilization process must takes place. This was contrary to the mainstream view that, following consolidation, memory is permanently stored as a fixed, non-labile trace, and all the subsequent processes would be simple passive readouts of the Long Term Memory. It led to disagreement with the notion that plasticity was confined only to the birth of a new memory and new theories of memory were proposed. After the reports of cue-dependent amnesia, it appeared that plasticity is momentarily on hold when memory was not being used, but returns when it was reactivated.

Manipulations to memories only effective if done temporally proximal to retrieval. These findings implied that after retrieval, memory can return to an unstable, vulnerable state that needs to be restabilized in order to persist. It was proposed that reconsolidation as a necessary restabilization step proceeding a retrieval-induced destabilization.

But why would a process which subverts memory stability be so prominent? Also, is our brain constantly destabilizing and restabilizing memory or does it happen only in specific circumstances? Interestingly, these questions, the 'when'

and the 'why' appear to be directly related. We will further study how.

3 Boundary Conditions - "When"

Unlike consolidation, reconsolidation is not ubiquitous. It has been reported across several levels of analysis, but not always does a retrieved memory undergo this process. [3] There are important parameters that determine whether reconsolidation will take place. These parameters, also called 'the boundary conditions' are related to characteristics of the consolidated memory that is being retrieved and the way memory is reactivated.

There are two main properties of a consolidated memory directly that determine its probability of being destabilized following retrieval; One is memory strength, the other is age. It has been reported that very strong training protocols or protocols that induce asymptotic levels of learning result in a memory that is unlikely to be affected by amnestic agents following a reactivation session. In other words, more the strength of the memory, lesser is the chance of it getting labile. Secondly, age, given that longer delays between training and reactivation sessions have been shown to create a protective effect against post-reactivation interference, that is older memories are less vulnerable to alteration.

The characteristics of the retrieval are also play a crucial role for determining if reconsolidation will occur. Too short reactivation sessions fail to induce reconsolidation. Also, it has been reported that reconsolidation is constrained when reactivation occurs in a distinct context, when it is predictable, when the stimulus is not directly linked to the memory being assessed.

It is proposed that with sufficient newness, a familiar experience can be encoded as a new, dissociable trace embedded in the old one.This phenomenon referred to as "consolidation-update," competes with reconsolidation. This differs from reconsolidation in that it does not imply a complete recapitulation of the consolidation process but, rather, the encoding and integration of new information with existing knowledge via destabilization of only relevant parts of the neural ensemble that encodes a memory.
This implies there is a gradient of destabilization during memory reactivation rather than an all-or-none phenomenon.

To conclude, the conditions that constrain the probability of reconsolidation taking place, or the boundary conditions on reconsolidation that have been most consistently reported are the memory's old age, memory strength, weak reactivation sessions, new learning, and the absence of a prediction error.

In opposition to the boundary conditions, new information, increased intensity of reactivation session, and pharmacological agents that boost plasticity can promote reconsolidation in conditions where it does not usually happen.

4 Psychological Role - "Why"

Studies understanding the boundary conditions of reconsolidation provide important insights on its psychological role. There are two leading theories that although distinct, are not mutually exclusive. [1]
1. Reconsolidation reflects "lingering consolidation"
2. It is a mechanism for memory updation

In common, these two theories suggest that a malleable phase following retrieval allows memory to adapt in order to keep its relevance in an environment that is in constant change.

The memory strength boundary condition (the absence of reconsolidation for strong memories) led to the view that reconsolidation takes place in order to enhance weak memories. Accordingly, each time a weak memory is reactivated and reconsolidated, it is strengthened. If learning is already asymptotical, there is no need for reconsolidation to occur. A second theory emphasises on the functional role stating that it enables the updating of memory with new information.

5 Therapeutic tool

Our brain is able to update memories/ representations in content, strength, and/or expectations; by the memory reconsolidation process. [3] Thus, a retrieved memory enters in a transient labile state followed by a re-stabilization phase in order to persist (destabilization followed by memory reconsolidation). Cognitive neuroscience and its insight into psychiatric problems attributes a close relationship between memory (formation, maintenance, and utilization) and several mental disorders. In this framework, the reconsolidation process could open a novel therapeutic window. Researchers are searching for effective reactivation reconsolidation protocols and amnestic agents capable of disrupting maladaptive memories in humans to cure mental disorders like PTSD, anxiety disorder, fears and phobias.

The beta-blocker propranolol is shown to selectively and robustly disrupt the emotional component of spider phobia when administrated after a reactivation [4]. This effect was long-lasting and did not affect the declarative component of the spider memory, only the anxiety and fear responses elicited by phobia-related cues. In drug abuse related cases, addicts on withdrawal were exposed to a reactivation-exposure procedure. Memory reactivation was initiated by using a video containing drug-related cues. Then, the extinction session consisted of a 60-min exposure to no drug cues. It was found that the group that had watched the video with drug-related images (reactivation session) and had received the extinction session, had lower craving scores. The effect remained after 30 and 180 days. Based on these promising results, the authors concluded that it seems feasible to design new therapies to disrupt drug-abuse memories.

It has also been shown that if an extinction session is conducted during the reconsolidation window, a fear response is attenuated permanently.

The conclusion is that when preceded by a reactivation, the safe information provided by an extinction session is incorporated into the labile memory,thus changing its content.

6 Conclusion

Reconsolidation is evident at multiple levels of analysis, from molecular in nuero biology and physiological to behavioral in psychology, thereby indicating that it is a fundamental property of memory. [2] Memory is associated with dynamicity instead of being fixed. Reconsolidation has become a topic of intensive research and there is growing application of reconsolidation and its updating properties as a therapeutic tool in several clinical conditions, such as PTSD, fears, drug addiction. We are just beginning to understand how the brain is capable of maintaining memory stability over time and how this stability can be transiently lifted given appropriate learning situations. We have just touched the surface as far as the intricacies of processes involved in memory organization are concerned and there is a long way to go.

References

[1] Rodrigo S. Fernández, María E. Pedreira, and Mariano M. Boccia. Does reconsolidation occur in natural settings? memory reconsolidation and anxiety disorders. *Clinical Psychology Review*, 57:45 – 58, 2017.

[2] Josue Haubrich and Karim Nader. *Memory Reconsolidation*, pages 151–176. Springer International Publishing, Cham, 2018.

[3] Karim Nader. Chapter 1 - the discovery of memory reconsolidation. In Cristina M. Alberini, editor, *Memory Reconsolidation*, pages 1 – 13. Academic Press, San Diego, 2013.

[4] Marieke Soeter and Merel Kindt. An abrupt transformation of phobic behavior after a post-retrieval amnesic agent. *Biological Psychiatry*, 78(12):880 – 886, 2015. Mechanisms of Stress, Memory, and Posttraumatic Stress Disorder.