Extremely long-term memory and familiarity after 12 years

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A R T I C L E   I N F O

Keywords:
Long-term memory
Familiarity
Explicit memory
Consciousness
Reactivation
Inactive memory

A B S T R A C T

In 2006 Mitchell demonstrated that implicit memory was robust to decay. He showed that the ability to identify fragments of pictures seen 17 years before was significantly higher than for new stimuli. Is this true only for implicit memory? In this study, we tested whether explicit memory was still possible for drawings (n = 144) that had been presented once or three times, two seconds each time on average, approximately 12 years earlier. Surprisingly, our data reveal that our participants were able to recognize pictures above chance level. Preserved memory was mainly observed in the youngest subjects, for stimuli seen three times. Despite the fact that confidence judgments were low, reports suggest that recognition could be based on a strong sense of familiarity. These data extend Mitchell’s findings and show that familiarity can also be robust to decay.

1. Introduction

Implicit memory does not involve explicit or conscious recollection and is inferred from behavioral performance (Graf & Schacter, 1985; Roediger, 2012; Schacter, 1987). Mitchell (2006) published a report demonstrating that implicit memory could be preserved on the very long-term and over a much longer time period than the several months that had been previously investigated (Kolers, 1976; Mitchell & Brown, 1988; Sloman, Hayman, Ohta, Law, & Tulving, 1988). In his experiment, participants were better at identifying fragments of black-and-white line drawings they had seen 17 years before than new drawings, even though some of them could not remember having participated in the original study. This study shows the longest duration of implicit memories to date.

In contrast to this, direct and intentional reference is made to prior learning events in explicit memory tests (Graf & Schacter, 1985; Schacter, 1987; Voss, Baym, & Paller, 2008). This holds true for recognition memory tasks where participants have to determine whether an item has already been experienced or not. It is generally assumed that recognition in such tasks relies on two processes: familiarity, which is the ability to identify that an item has previously been encountered, and recollection, which involves the retrieval of contextual details associated with the item (Mandler, 1980).

Numerous studies have shown that explicit memory can extend to a few decades if not for a lifetime. The first empirical evidence was provided in the late 19th century by Galton (1879) who could retrieve past events cued by a list of words, some of these events belonging to his childhood. This task was later developed (Crovitz & Scifflman, 1974) and used in several studies to measure participants’ autobiographical memory across the lifespan (e.g. Fitzgerald & Lawrence, 1984; Rubin & Schulkind, 1997) including early childhood (Crovitz & Quina-Holland, 1976). These studies confirmed the ability to maintain very long-term memories although the accuracy of such episodic memories is difficult to verify.

Other tasks were developed in which remote semantic information was assessed. For example, participants were tested on their memory of old classmates (Bahrick, Bahrick, & Wittlinger, 1975), knowledge learned in school (Conway, Cohen, & Stanhope, 1991) or old TV program titles (Squire, 1989). In all cases, participants were able to retrieve a significant amount of information.

These studies demonstrated that memories could survive for several decades despite performance decreasing over time. Indeed, performance quickly decreases after the acquisition phase before stabilizing several years later. This “forgetting curve” was first described by Ebbinghaus (1885) and seems to correspond to the power function of time according to recent models (Anderson & Schooler, 1991; Rubin & Wenzel, 1996; Wixted & Ebbesen, 1991). Interestingly, the manipulation of different experimental parameters can affect the shape of the forgetting curve and slow down decay over time. Spaced repetition of new information leads to longer lasting memory traces than
single exposure or massed repetition (Dempster, 1988; Ebbinghaus, 1885; Hintzman, 1976; Melton, 1970). Active reactivation of the stimuli through testing results in better performance than passive exposure (Carrier & Pashler, 1992; Roediger & Karpicke, 2006). Emotional content can also directly influence involuntary reactivations of an event and therefore its long-term maintenance (Berntsen & Rubin, 2002; Waters & Leeper, 1936).

Importantly, such reactivations slow down forgetting by directly influencing the neurobiological mechanisms involved in the consolidation of a new memory trace. Indeed, after the stabilization of its synaptic weights in localized networks, the memory trace requires consolidation at the system level (Frankland & Bontempi, 2005). During this phase, repeated reactivations of the memory trace allow the strengthening of the engram in the neocortical structures and its long-term maintenance (Girardeau, Benchenane, Wiener, Buzsáki, & Zugaro, 2009; Sutherland & McNaughton, 2000). Therefore, reactivation of the memory trace through direct re-exposure to the stimulus or when the stimulus is mentally evoked would help the completion of such a process.

From the literature reviewed above, it appears that information acquired from everyday experiences can last for a decade or even longer. In all these studies, the information was presented for at least several hours and repeated many times (TV programs, classmates’ names and faces, conceptual knowledge, etc.). In addition, it was probably reactivated either voluntarily (knowledge learned in school) or involuntarily, for example if associated with strong emotions. All these factors increase the probability of retrieving information and therefore increase long-term maintenance. Hence, these conditions are very different from Mitchell’s experiment where very long-term priming was found for simple drawings that had been presented for one to three seconds and at most three times. Therefore, we do not know how long explicit memory can be maintained if exposure to the material is brief and especially if no rehearsal has taken place in the meantime.

Recent neuronal models based on Spike Time Dependent Plasticity (Masquelier & Thorpe, 2007) show that a few exposures to simple stimuli can be enough to create hyper-selective neurons. Such neurons could potentially remain silent and their synaptic weights could be preserved until the same stimulus or a close representation is presented again (Barron et al., 2016). According to this view, implicit but also explicit memories might be maintained for a life-time (Thorpe, 2011). Although theoretical and based on modeling, this point of view provides plausible mechanisms suggesting that very long-term memory is possible in the absence of rehearsal. In this study we decided to test it experimentally.

In the present paper, we tested participants’ recognition memory for simple colored drawings that had been presented once or three times for two seconds each time on average, between 8 and 14 years earlier. Because the stimuli were simple and not particularly interesting (a third of them were abstract figures which were difficult to verbalize), we thought that it was unlikely that the participants ever thought about them in the meantime.

2. Materials and methods

2.1. Participants

Between 2002 and 2008 (mean year = 2004, SD = 2.2), 243 healthy control subjects participated in a neuropsychological protocol in the Timone University Hospital in Marseille (France) with the aim of building normative data. This protocol included four cognitive tasks among which there was a visual recognition memory test that we used as the basis of the current study.

In 2016 we were able to retrieve telephone numbers and/or postal addresses for 63 of the initial 243 participants. These 63 subjects were called back or written to and informed that we would like them to come back for a scientific experiment to test their memory of the pictures presented in the initial test. They were also informed that we thought their memory could be maintained for such a long time and that this was precisely why we wanted to do the test. Importantly, we were not able to obtain written consent for 38 of these 63 individuals: 31 participants could not be contacted either because the contact details taken at the time of the initial test had changed or because they simply did not respond to our messages; two participants passed away during the intervening period and their widows, who also participated in the initial study, did not want to do the test; one participant moved away and could not come back to do the experiment; two participants overtly declined the invitation to participate in our experiment because of a lack of interest. Overall, twenty-five subjects agreed to participate. One of them was not included because of macular degeneration. Thus 24 subjects were included in this study. None reported the presence of important neurological, psychological or psychiatric troubles since 2002 and they are referred to as test participants in this paper (14 females, mean age = 60.8 y, SD = 17.5, range: 34–84 y). All test subjects had normal or corrected-to-normal vision and audition. The overall cognitive abilities of the test participants beyond age 60 were assessed in 2002–2008 using the Mini-Mental State Examination (MMSE) (Folstein, Folstein, & McHugh, 1975) from the French GRECO sensuous version (mean MMSE score 29.5 out of 30, SD = 0.7, range: 28–30). All test participants were tested with the MMSE again in the context of the current study with no deficit found for any of them (mean score = 29.5 out of 30, SD = 0.9, range: 27–30).

A group of 24 naive control subjects, who had never seen any of the drawings from the first experiment and matched for gender and age, were also recruited (14 females, mean age = 62.5 y, SD = 20.7, range: 33–94 y).

The current study was approved by the INSERM Ethical Evaluation Committee (CEEI, N’15-263) and all participants gave informed written consent before experimentation.

2.2. Initial test: the DMS-48

The basis of the current study is a visual recognition memory test, the DMS-48, that is widely used in memory clinics in French-speaking countries (see for example Barbeau et al., 2004; Didic et al., 2013). The DMS-48 is freely available for research purposes (http://cerco.ups-tlse.fr/~barbeau/dms48.html).

During an incidental encoding phase (test participants were not told that it was a memory test), 48 pictures were presented one after the other. For each stimulus, test participants were simply instructed to say if the picture had more or less than three colors. Two forced-choice recognition memory phases took place after three and 60 min. Different neuropsychological tasks were presented during the interfering phases. Test participants were asked to identify which picture they had previously seen by choosing from two stimuli presented simultaneously (one old stimulus and one distractor each time). There were three categories (examples in Fig. 1). In the Unique category, the old and distractor pictures were real-world objects with names and shapes (e.g. a rooster and a digger). In the Paired category, the old and distractor items had the same name and similar shapes and colors (e.g. two different snowmen). The Abstract category involved abstract patterns that were difficult to verbalize. A separate set of 48 new distractors was used for each of the test phases. All stimuli were presented on A4 white sheets of papers.

Performance on the DMS-48 is expressed as a percentage (maximum performance 100%).

2.3. Initial number of presentations of the stimuli

Overall, the 48 old stimuli were seen three times (during the incidental encoding phase and the recognition phases at three and 60 min), whereas the other 96 stimuli that served as distractors during the recognition phases at three and 60 min were seen only once. This
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