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Mechanisms underlying the production of false memories for famous people's names in aging and Alzheimer's disease

Gaën Plancher[a,1], Anne Guyard[a,b,1], Serge Nicolas[a], Pascale Piolino[a,*]

[a] CNRS UMR 8189, Laboratoire Psychologie et Neurosciences Cognitives, Université Paris Descartes, France
[b] Centre Hospitalier de Cholet, Service de neurologie-rhumatologie, France

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ABSTRACT

It is well known that the occurrence of false memories increases with aging, but the results remain inconsistent concerning Alzheimer's disease (AD). Moreover, the mechanisms underlying the production of false memories are still unclear. Using an experimental episodic memory test with material based on the names of famous people in a procedure derived from the DRM paradigm [Roediger, H. L., III, & McDermott, K. B. (1995). Creating false memories: Remembering words not presented in lists. *Journal of Experimental Psychology: Learning, Memory & Cognition*, *21*, 803–814], we examined correct and false recall and recognition in 30 young adults, 40 healthy older adults, and 30 patients with AD. Moreover, we evaluated the relationships between false memory performance, correct episodic memory performance, and a set of neuropsychological assessments evaluating the semantic memory and executive functions. The results clearly indicated that correct recall and recognition performance decreased with the subjects' age, but it decreased even more with AD. In addition, semantically related false recalls and false recognitions increased with age but not with dementia. On the contrary, non-semantically related false recalls and false recognitions increased with AD. Finally, the regression analyses showed that executive functions mediated related false memories and episodic memory mediated related and unrelated false memories in aging. Moreover, executive functions predicted related and unrelated false memories in AD, and episodic and semantic memory predicted semantically related and unrelated false memories in AD. In conclusion, the results obtained are consistent with the current constructive models of memory suggesting that false memory creation depends on different cognitive functions and, consequently, that the impairments of these functions influence the production of false memories.

1. Introduction

According to Tulving (2002), episodic memory is defined as the memory for personal events located in their spatiotemporal encoding context. In contrast with other long-term memory systems (semantic memory or procedural memory), which remain focused on the present, episodic memory allows the mind to travel in time and thus to relive past personal experiences. One of the most unexpected aspects of this form of memory is the creation of false memories, that is to say, the recall or the recognition of events that never took place (Balota et al., 1999; Guyard & Piolino, 2006; Henkel, Johnson, & De Leonardis, 1998; Koutstaal & Schacter, 1997; Norman & Schacter, 1997; Schacter, Koutstaal, & Norman, 1997). Memory necessarily undergoes a certain amount of deformation because it corresponds to an approximate rebuilding of reality, bounded by our own knowledge and our memories (Conway & Pleydell-Pearce, 2000). This phenomenon raises the question of the interface between normal memory and pathology when it comes to errors or distortions (Guyard & Piolino, 2006; Henkel et al., 1998; Koriat & Goldsmith, 1996; Schacter, 1996, 1999; Schacter, Verfaellie, & Anes, 1997).

Studying these phenomena therefore makes it possible to provide information about the normal operation of memory and its fragility in both healthy younger and older subjects (Schacter, Koutstaal, et al., 1997; Schacter, Verfaellie, et al., 1997) and to better understand the memory disorders related to cerebral pathologies. The first neuropsychological studies were focused on the investigation of the negative symptoms observed in memory disorders after cerebral lesions (deficits affecting the recall or recognition of a learned item of information). Recent studies have shown a growing interest in the comprehension of the positive symptoms (a false recall or a false recognition) that can appear in case of confabulations (Dalla Barba, 1993, 1995, 1997, 2000), intrusions, or

* Corresponding author at: Laboratoire Psychologie et Neurosciences Cognitives, Groupe Mémoire et Apprentissage, CNRS UMR 8189, Université Paris Descartes, 71 avenue E. Vaillant, Boulogne Billancourt 92774 Cedex, France.
Tel.: +33 1 55 20 59 22; fax: +33 1 55 20 54 24.
E-mail address: pascale.piolino@parisdescartes.fr (P. Piolino).
[1] The authors have contributed equally to this article.

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mistaken recognitions in the traditional neuropsychological tests of episodic memory (e.g., Dalla Barba, Parlato, Lavarone, & Boller, 1995; Desgranges et al., 2002; Gallo, Chen, Wiseman, Schacter, & Budson, 2007).

Interestingly, with the development of experimental episodic memory tests, false memories have been created in healthy subjects and patients with cerebral diseases using the same paradigms. The original Deese–Roediger–McDermott (DRM) paradigm developed by Roediger and McDermott (1995) is widely used. On the basis of earlier work by Deese (1959), their method has demonstrated exceptionally high levels of false recognition with non-pathological subjects. The participants saw lists of 15 words that were most strongly associated with a missing word or *critical item* in word association norms (Russell & Jenkins, 1954). For example, participants might be presented with a list of words: *bed*, *rest*, *awake*, *tired*, *dream*, *wake*, *snooze*, *blanket*, *doze*, *slumber*, *snore*, *nap*, *peace*, *yawn*, *drowsy*, all related to the non-presented critical word *sleep*. Directly after the presentation of a study list, the participants recalled as many words from the list as possible, in any order. Roediger and McDermott (1995) discovered that the lists of words tended to lead subjects to recall or recognize the critical items. In order to understand the subject's phenomenal experience of remembering at the time of false recognition, the authors asked them to state the nature of their recollection in the recognition task using the "Remember"/"Know" (R/K) paradigm (Gardiner, 1988; Gardiner & Java, 1993; Tulving, 1985). The participants had to classify each recognized item into one of two categories: a "Remember" response when the recognition was accompanied by the conscious memory of elaborated representation during the encoding (e.g., a mental image or an association of ideas) and a "Know" response when the recognition was carried out on the basis of a feeling of familiarity, without any conscious access to information relating to the context of the learning. Roediger and McDermott found that the false recognitions were often associated with a "Remember" response and thus were based on an erroneous feeling of reliving the learning context.

Two main explanations have been proposed to account for false memory effects within the DRM paradigm. According to the *implicit associative response* hypothesis (Underwood, 1965), the presentation of lists of words automatically activates other non-presented words, such as the critical lures. These words emerge through the spreading of activation in a pre-existing associated semantic network. Thus, false memories result from the confusion of learning sources between the information that the subject personally generated internally and the real external information; this constitutes an error in reality monitoring (Johnson, Hashtroudi, & Lindsay, 1993). Another explanation, based on *fuzzy-trace theory* (Reyna & Brainerd, 1995), maintains that true or false recognitions depend on verbatim (a memory of specific details) or gist traces (a memory for general meaning) that are stored separately in memory during the encoding phase. Consequently, an accurate recognition of previously studied items, as in the DRM paradigm, probably depends on both item-specific and gist information, whereas a false recognition of related lure words follows from remembering gist but not item-specific information.

Many studies have used the DRM paradigm to explore factors influencing the nature and prevalence of false memories in normal and pathological aging. It has been shown that healthy older adults are more likely to produce intrusions or false recognitions of critical lures than younger adults, while they produce fewer true recalls and recognitions (Dennis, Kim, & Cabeza, 2007; Koutstaal & Schacter, 1997; Norman & Schacter, 1997; Tun, Wingfield, Rosen, & Blanchard, 1998). Balota et al. (1999) compared the memory performance of young adults and healthy older adults with the performance of patients with mild Alzheimer's disease (AD). Their results demonstrated that the proportion of true recall and recognition decreased significantly with age and even more with dementia. Intrusions and false recognitions of critical lures increased concurrently with age, but a different pattern was found in patients with AD. In that group, the intrusions of critical lures did not seem to be influenced by the dementia, and the false recognitions of critical lures were diminished compared to normal aging. Although unexpected, the diminution of false memories in AD was confirmed by further work (Budson, Daffner, Desikan, & Schacter, 2000; Gallo et al., 2007; Hudon et al., 2006; Watson, Balota, & Sergent-Marshall, 2001).

The mechanisms of false memories in normal and pathological aging are still misunderstood. In general, authors have suggested that the number of false memories in the DRM paradigm can be understood in terms of the changes in memory and executive functions (Balota et al., 1999; Budson et al., 2000; Budson, Desikan, & Schacter, 2001; Koutstaal, Schacter, Verfaellie, Brenner, & Jackson, 1999). Indeed, the source memory requires controlled cue specification and monitoring processes, which may depend on the left prefrontal cortex (Dobbins, Foley, Schacter, & Wagner, 2002). More specifically, Balota et al. (1999) were the first to claim that the production of false memories might depend on both the executive function and semantic memory capacity. On one hand, the increase in the false recognition of critical lures in healthy older adults might depend on age-related deficits of executive functions (Butler, McDaniel, Dornburg, Price, & Roediger, 2004). On the other hand, their reduction often observed in patients with AD might depend on additional deficits of semantic memory. Accordingly, the growth of false memories in normal aging might result from an accentuation of source dismantling problems. Hence, it is difficult to distinguish between information that is personally generated by the subject, who makes an association with the critical lure, and the external information that is really encoded. In contrast, the reduction of false memories in patients with AD might result from their problems with identifying the semantic topic of the list. Indeed, patients do not produce a memory representation of the critical lures during the encoding phase; thus, they are less susceptible to a false memory creation than younger adults, and even less than healthy older adults (Budson et al., 2000; Gallo et al., 2007; Garrard, Lambon Ralph, Hodges, & Patterson, 2001; Peraita, Díaz, & Anllo-Vento, 2008). According to this hypothesis, some studies have shown that patients with AD produced more false recognitions of critical lures when the procedure (e.g., repeated trials of the learning list) gave them the possibility to create a stronger representation of the main topic of the list (Budson et al., 2000; Budson, Sullivan, Daffner, & Schacter, 2003; Gallo, Sullivan, Daffner, Schacter, & Budson, 2004), whereas the healthy subjects decreased their false memory production in that case. Although some studies suggested that executive and semantic abilities could explain the creation of false memories, other studies observed that the quality of the episodic memory might modulate the false memory creation (Lövden, 2003). Indeed, a decrement in verbatim memory might produce a greater reliance on gist; consequently, a decrease of the correct memories should modulate false memory production. The mechanisms of false memories therefore might depend on changes in executive functions and both semantic and episodic memory. However, to date, this hypothesis has never been thoroughly tested in normal aging and AD, and the exact nature of the mechanisms behind the phenomenon of false memories in normal and pathological aging remains unclear.

The first aim of the present study was to confirm the earlier results regarding normal and pathological aging effects with new material based on famous people's names, which are more relevant to daily life than lists of words and that are also more attractive to patients. The second aim was to identify the mechanisms underlying the false memory by comparing the rate of false memories and performance on neuropsychological tests assessing the semantic