Intact Semantic Priming of Critical Lures in Alzheimer's Disease: Implications for False Memory

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Objectives. The present study examines the question of the activation of the critical lure (CL) in Alzheimer's patients with a Deese–Roediger–McDermott (DRM)-like task. More precisely, older adults and Alzheimer's patients performed a lexical decision task in which they were asked to categorize strings of letters as words or nonwords. Contrary to the DRM paradigm in which the activation of the CL is inferred from its production at recall, such a lexical decision task does not require the joint use of intentional recovery strategies and source-monitoring processes that are known to be particularly impaired in Alzheimer's patients. The performance at the lexical decision therefore reflects the activation of the CL without contamination from such strategic processes.

Method. Twenty-nine older adults and 25 Alzheimer's patients performed a lexical decision task with DRM lists intermixed with neutral words and nonwords.

Results. Analysis indicated that older adults as well as Alzheimer's patients showed shorter lexical decision latencies for CLs than for other types of words.

Discussion. Contrary to the existing literature, our results suggest that the activation of the CL is preserved in Alzheimer's patients at mild to moderate stages of the disease.

Key Words: Activation—Alzheimer's disease—DRM paradigm—False memories—Lexical decision.

THE study of memory impairments in Alzheimer's disease extends beyond the study of simple forgetting of events and also investigates the production of mnemonic distortions that are frequently associated with the disease. These include memories of events that never occurred or that are distorted compared with what was actually experienced (Roediger & McDermott, 1995). Among the different experimental techniques developed to study these so-called "false memories," the Deese–Roediger–McDermott (DRM) paradigm (Deese, 1959; Roediger & McDermott, 1995) is one of the most used. Participants are presented with lists of words that are semantically related and strongly associated with another word, called critical lure (or CL) that is never presented. Participants perform an immediate free recall task as well as a recognition task. Studies indicate that healthy participants usually show a strong tendency to falsely recall and recognize the CL (Balota et al., 1999; Deese, 1959). According to the *activation-monitoring* theory (Roediger, Watson, McDermott, & Gallo, 2001), during the presentation of the semantically related words, the *activation* would automatically spread to other items in the network. Thus, this would make the intervention of the *monitoring* process very difficult. This process usually makes it possible to discriminate the source of information, that is, to distinguish words that were presented in the lists from those that were automatically activated in memory.

Several studies used the DRM paradigm with Alzheimer's patients and showed that patients produce less CLs than control participants (e.g., Balota et al., 1999; Budson et al., 2002; Gallo et al., 2006; Waldie & Kwong See, 2003), although the reverse is also observed (see Watson, Balota, & Sergent-Marshall, 2001) illustrating source memory impairments in Alzheimer's disease (Rosa, Deason, Budson, & Gutchess, 2014). Many hypotheses have been suggested in the literature to account for the lower production of CLs in Alzheimer's patients. It has been suggested that Alzheimer's patients fail to identify the associative links between items in the DRM paradigm either due to a disruption of semantic knowledge or to an attentional deficit. Therefore, they fail to extract the general theme of the list, that is, the CL, which would consequently neither be activated nor reminded (Budson, Daffner, Desikan, & Schacter, 2000; Gallo et al., 2006). Another hypothesis suggested that Alzheimer's patients would automatically activate the CL within the semantic network but that the mnemonic trace, like that of the other items, would fade abnormally fast—because of episodic memory issues (Ergis & Eusop-Roussel, 2008)—too fast to be recalled later.

In healthy young and older adults, different procedures have been used to study separately the automatic activation of the CL (e.g., Brédart, 2000; Dehon & Brédart, 2004; McDermott, 1997; Meade, Watson, Balota, & Roediger, 2007). For example, in a study conducted on young adults,

Sergi, Senese, Pisani, and Nigro (2014) showed that the incident encoding of DRM lists resulted in an activation of the CL and that its mnemonic trace and that of the target items followed the same pattern of decay. In a modified DRM procedure, Dehon and Brédart (2004) revealed that older adults showed as much activation of the CL as their younger counterparts. However, older adults, contrary to young adults, presented impaired monitoring processes that explain the greater production of false memories regularly reported in normal aging (Balota et al., 1999; Rosa & Gutchess, 2013). Using a lexical decision task, Tse and Neely (2005) conducted a series of experiments, in which young participants had to decide as quickly as possible whether strings of letters, including CLs, formed words or not. Lexical decision tasks were performed right after the presentation of a DRM list. The results indicated faster lexical decisions for CLs than for other words, which confirmed a semantic priming effect on CLs. However, to our knowledge, lexical decision tasks have never been used to examine the question of the activation of CL in a DRM paradigm with Alzheimer's patients.

Thus, the objective of the present study was to extend previous research to Alzheimer's patients and to investigate the activation process of the CLs in a lexical decision task in which participants have to decide whether strings of letters can be categorized as words or as nonwords. With regard to the study of false memories, this kind of task should allow us to obtain a relatively pure measure of the activation of the CLs (Tse & Neely, 2005). Unlike the DRM paradigm, the lexical decision task investigates the functioning of the semantic memory independently from the episodic memory that is severely impaired in Alzheimer's patients. Consequently, the lower production of CLs commonly observed in Alzheimer's disease in DRM experiments might be interpreted as the result of a degradation of the episodic trace of the CL or as a failure to activate the CL. In line with the episodic memory impairments usually associated with Alzheimer's disease (e.g., Ergis & Eusop-Roussel, 2008), we suggest that the activation of the CL is preserved in Alzheimer's patients. Consequently, we expected Alzheimer's patients as well as older adults to show faster lexical decisions for CLs than for neutral and target words.

METHOD

Participants

Twenty-five patients (70–95 years, M = 80.16, standard deviation [SD] = 5.78, 72% female) with a clinical diagnosis of probable Alzheimer's disease (McKhann et al., 2011) and 29 older adults (70–91 years, M = 79.65, SD = 6.32, 69% female) were recruited for the experiment. Patients with Alzheimer's disease were recruited partly from the clinical population at the Memory Center (Saint-Nazaire)

and with the help of the France Alzheimer Association (Nantes). Older adults were recruited in senior centers and homes in the area of Nantes. Participants were all native French speakers; they received no compensation for their participation.

Older adults were excluded if they scored lower than 26 (M = 28.38, SD = 1.01) on the French version of the Mini-Mental State Examination (MMSE; Derouesné et al., 1999). Patients showed mild to moderate impairment on the MMSE (17–28, M = 19.16, SD = 2.61). Patients and older adults were matched on mean age, $t(52)$ = 0.30, p = .76, Cohen's d = 0.08, and on education (M_{patients} = 11.40, SD_{patients} = 3.16; M_{older} = 10.21, SD_{older} = 1.76), $t(52)$ = 1.74, p = .09, d = 0.47).

Material

The experiment consisted of 144 (6 lists of 24 items including 1 practice list) lexical decision trials. Each list consisted of 5 target items, 1 related CL, 6 neutral items, and 12 pronounceable nonwords. The target items corresponding to the five first words of DRM lists (Corson & Verrier, 2007) were presented in block, always in the same order, and just before the CL. The nonwords followed spelling rules of French language but have no meaning. They were matched for length to the CL and neutral items of their list. Neutral words were French words semantically unrelated to both the target items and the CL of their lists. They were matched for length and word frequency (LEXIQUE; New, Pallier, Brysbaert, & Ferrand, 2004) with the CL of each list. List 1: M_{neutral} = 17,156, SD_{neutral} = 1,089, M_{CL} = 17,451; List 2: M_{neutral} = 43,381, SD_{neutral} = 1,249, M_{CL} = 45,802; List 3: M_{neutral} = 1,427, SD_{neutral} = 18, M_{CL} = 1,425; List 4: M_{neutral} = 2,460, SD_{neutral} = 33, M_{CL} = 2,480; List 5: M_{neutral} = 1,285, SD_{neutral} = 23, M_{CL} = 1,297. Words presentation order varies from one list to another to allow the CL to be presented at different positions of the list.

Procedure

Participants were tested individually in a single session that lasted approximately 30 min. After obtaining informed consent, participants performed the lexical decision task without any prior study phase. Stimuli were displayed on a Macbook computer with Psyscope software (Cohen, MacWhinney, Flatt, & Provost, 1993) used to control the presentation of the stimuli and the recording of response latencies. Five lists of 24 items (preceded by 1 practice list) were presented in the same fixed order for all the participants. Participants were asked to perform a lexical decision task on letter strings that appeared one at a time on the screen. Each letter string was preceded by a fixation cross for 500 ms and was displayed in the center of the screen until the participant made a response. The intertial interval was 500 ms. Participants were instructed to respond as quickly and as accurately as possible by pressing the green

key ("N") on the numerical panel if the stimulus was a word and the red key ("W") if it was a nonword. A short rest period (≈1 min) was provided between each list, if needed. At the end, participants were fully debriefed and thanked for their participation.

RESULTS

Data from trials with incorrect lexical decisions were removed. Reaction times (RTs) faster than 100 ms and slower than 10 s were also removed. Mean RTs for each participant across all types of words were calculated. Finally, mean RTs higher or lower than ±3 *SD* were excluded resulting in the loss of 2.45% of the whole data.

An analysis of variance with Group (patients, older adults) as between-subject factor and Word type (neutral, target, nonwords, CLs) as a repeated measure factor was conducted on RTs. The analysis yielded a marginally significant effect of Group, $F(1, 52) = 3.98$, $p = .051$, $\eta_p^2 = .07$ suggesting that Alzheimer's patients tend to be slower than older adults, and a significant main effect of Word type, $F(3, 156) = 26.62$, $p < .001$, $\eta_p^2 = .34$. The Group × Word type interaction was not significant, $F(3, 156) = 0.03$, $p = .99$, $\eta_p^2 = .0005$ (see Figure 1). Follow-up analyses indicated that participants showed shorter RTs for CLs than for target words, $F(1, 52) = 23.72$, $p < .001$, $d = 0.28$. In addition, participants performed faster lexical decisions for CLs than for neutral words, $F(1, 52) = 54.76$, $p < .001$, $d = 0.55$. Finally, according to Tukey's Honestly Significant Difference post hoc tests, RTs for nonwords were longer than those for neutral, CLs, and target words (all ps < .001), and RTs were longer for neutral words than for target words ($p < .001$).

DISCUSSION

The results obtained in this study showed that an activation of the CL, following the presentation of target items in a DRM-like paradigm, normally occurs in Alzheimer's patients as well as in older adults. This is consistent with the *activation-monitoring* theory (Roediger et al., 2001) that suggests that during the presentation of the semantically related words of a DRM list, activation automatically spreads from those words to the CL. Accordingly, in the present study, the successive presentation of five target words has repeatedly spread activation to the CL and thus reduced the associated decision latencies. Why do Alzheimer's patients produce few CLs in a DRM task? By providing a demonstration of an activation of the CL in Alzheimer's patients, our findings rather support the hypothesis of an activation followed by the disappearance of the episodic mnemonic trace (Ergis & Eusop-Roussel, 2008) than the hypothesis of difficulties in extracting the general theme of a list (e.g., Gallo et al., 2006). In addition, because lexical decision latencies were significantly shorter for CLs and target words than for neutral words, it is reasonable to argue against a semantic disturbance (e.g., Laisney et al., 2011) in the patients. At the very least, the organization of the semantic network requested by the lexical decision task seems preserved in our Alzheimer's patients.

However, several limitations to the present study are important to acknowledge. First, we used a task quite different from the original DRM paradigm in order to examine the possible activation of the CL. Consequently, it cannot be excluded that in a DRM task, attentional deficits or distraction in Alzheimer's patients (e.g., Perry, Watson, & Hodges, 2000) disrupt the activation process and thus prevent the production of the CL. Future research would benefit from investigating this issue more thoroughly. Second, to test the hypothesis of an abnormally rapid disappearance of the mnemonic trace of the preactivated CL, tasks would necessarily imply a comparison between the *activation* and the *production* of CLs. Nevertheless, the results of the present study provide evidence for a first step toward answering the question of why Alzheimer's patients sometimes produce fewer CLs than older adults in a DRM task.
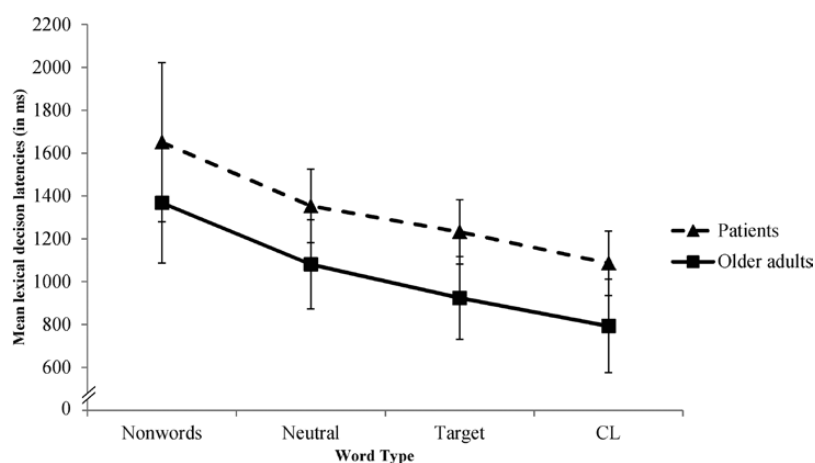

Figure 1. Mean lexical decision latencies for Alzheimer's patients and older adults as a function of Word type. Error bars represent 95% confidence intervals.

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