AMNESIA AND THE DRM PARADIGM: HOW ENCODING FACTORS (DO NOT) AFFECT LURE RECOGNITION

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In the DRM paradigm, participants are presented with, and their memory is tested for, lists of words that are associatively related to a non-presented lure word. Recent studies have revealed that amnesic patients show heightened immediate, but diminished delayed false recognition of such related lure words as compared to healthy controls. These findings may reflect deficient encoding, retrieval, or both. In two experiments, the importance of encoding factors was evaluated by investigating whether story contexts would increase delayed lure recognition, and whether personally-relevant content would decrease immediate lure recognition in Korsakoff patients. With delayed testing, patients’ lure recognition was consistently lower than controls’. With immediate testing, lure recognition was less frequent for personally-relevant than for neutral materials. However, as opposed to controls, Korsakoff patients did not show a difference in source memory, but merely a change in response bias. Results point to the conclusion that deficient explicit recollection is the main factor determining the difference in false recognition between amnesic patients and controls.

Introduction

In the Deese/Roediger-McDermott (DRM) paradigm, participants are presented with lists of words (e.g., bed, rest, awake, tired, …), which are associatively related to a critical, non-presented lure word (e.g., sleep; Deese, 1959; Roediger & McDermott, 1995). Immediately after each list, they are asked to recall as many words as possible. At the end of the experiment, an old/new recognition test is administered. In both types of test, people tend to erroneously identify the critical lure word as if it was presented. Both false recall
and false recognition have been shown to occur at remarkably high rates and to approximately the same extent as correct recall/recognition of studied list words (see Gallo, 2006, for a review).

When amnesic patients are tested with the DRM paradigm, they typically demonstrate reduced false recognition and different patterns of false recall as compared to memory-intact controls (Melo, Winocur, & Moscovitch, 1999; Schacter, Verfaellie, & Anes, 1997; Schacter, Verfaellie, Anes, & Racine, 1998; Schacter, Verfaellie, & Pradere, 1996; Verfaellie, Schacter, & Cook, 2002). The underlying factors of these differences are, however, not entirely clear yet. Several studies have tried to determine whether the patients’ low false recognition rates could be attributed to deficient relational encoding, or rather to deficient recollection of adequately encoded thematic information. Van Damme and d’Ydewalle (2009a; 2009b) obtained evidence in favour of the latter proposition by administering immediate and delayed recognition tests, as well as implicit stem completion tests, to Korsakoff patients and healthy controls. First, the patients’ false recognition rate was only significantly lower than controls’ when testing was postponed until the end of the experiment (as in the original paradigm), but not when testing occurred immediately after each study list. Second, priming of critical lures in an implicit memory test was similar for patients and controls. These findings are difficult to reconcile with an encoding deficit account. Rather, retrieval appears to be the critical factor determining DRM performance in amnesia: Korsakoff patients’ false memory level was only significantly lower than controls’ when intentional, strategic recollection was required to fulfil the memory task at hand.

When tested immediately after each list, patients in Van Damme and d’Ydewalle (2009b) even showed (numerically) more false recognition and significantly more ‘remember’ judgments of critical lures than control participants did (cf Tulving, 1985; Yonelinas, 2002). This is consistent with fluency-based retrieval: due to difficulties with strategic retrieval and source-monitoring (e.g., Cermak, Butters, & Gerrein, 1973; d’Ydewalle & Van Damme, 2007), amnesic patients cannot use item-specific recollection to counteract the false feeling of familiarity for critical lures. Accordingly, with immediate testing, deficient intentional retrieval will induce an increased level of false recognition. With delayed testing, on the other hand, one can no longer solely rely on familiarity; explicit recollection is required to remember both gist and item-specific information. Hence, in this condition, deficient

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1. Due to the use of simplified instructions, ‘remember’ and ‘know’ responses in this experiment reflected strong versus poor confidence in recognition memory, with familiarity as well as explicit recollection as possible bases of these confidence levels (cf Yonelinas, 2002; see also Van Damme & d’Ydewalle, 2009b, p. 360, for a more extensive discussion).
intentional retrieval will induce a decrease in both false and veridical recognition.

It should be noted, however, that Verfaellie, Page, Orlando, and Schacter (2005) did find evidence for an encoding deficit as a contributing factor to diminished false memory in a mixed group of amnesic patients. In addition, it has been shown that Korsakoff patients’ explicit retrieval of associative information can be improved by giving them additional time and support during the study phase (Van Damme & d’Ydewalle, 2008; Van Damme & d’Ydewalle, 2009a). This suggests that encoding factors do affect the patients’ explicit memory performance. It is in accordance with theories proposing that the formation of new associations, or even the processing of any contextual information, constitutes the basic deficit in amnesia (e.g., Cohen, Poldrack, & Eichenbaum, 1997; Johnson & Chalfonte, 1994; Mayes, Meudell, & Pickering, 1985). Therefore, the goal of the present study was to replicate the findings of Van Damme and d’Ydewalle (2009a; 2009b) and to investigate the effect of encoding factors on both immediate and delayed recognition of critical lures. This was done by manipulating encoding context and encoding content.

In Experiment 1, the effect of encoding context on delayed recognition was examined. It was investigated whether enhancing the saliency of the semantic relations between the study words would affect Korsakoff patients’ later explicit retrieval of the gist and thus increase delayed recognition of critical lures. DRM words were embedded in short stories, written as such that they emphasised the lists’ overall theme (cf. Dewhurst, Pursglove, & Lewis, 2007). The manipulation was based on presumed similarity between Korsakoff patients’ and children’s false memory performance. Despite their vulnerability to memory distortion and relatively poor source monitoring skills, young children exhibit low levels of DRM false memory (e.g., Brainerd, Reyna, & Forrest, 2002). Similarly, Korsakoff patients are known to confabulate and suffer from impaired source monitoring (e.g., Kessels, Kortrijk, Wester, & Nys, 2008), but consistently show lower (delayed) false recognition than controls (e.g., Schacter et al., 1996). Dewhurst et al. (2007) embedded DRM words in stories and found that, relative to 8- and 11-year-olds, 5-year-olds recognised fewer lures when the words were presented in list format, but more lures when the words were part of a story. The authors argued that the story context enhanced the children’s ability to make inferences based on the theme of the stimuli. Experiment 1 was designed to investigate whether studying stories instead of lists would increase Korsakoff patients’ explicit gist memory in a similar way as it did for 5-year-olds.

In Experiment 2, the effect of encoding content on immediate recognition was examined by including not only neutral, but also personally-relevant materials. Lists either consisted of typical DRM words or of words related to
alcohol. Four groups of participants were tested: amnesic patients with and without a history of chronic alcoholism (i.e., Korsakoff and non-Korsakoff), and memory-intact controls with and without a history of chronic alcoholism. It was predicted that alcohol-related words would be more distinctive to people with a history of alcoholism, and that this would heighten veridical memory and lower false memory. Indeed, research has demonstrated that relating information to oneself is a successful encoding strategy, which benefits memory (the ‘self-reference’ effect; e.g., Gutchess, Kensinger, Yoon, & Schacter, 2007; Hamami, Serbun, & Gutchess, 2011). Moreover, studying distinctive information in the DRM paradigm has been shown to inhibit false memories, both through increased item-specific encoding and through enhanced monitoring (e.g., Hanczakowski & Mazzoni, 2011). Hence, for alcoholic controls, immediate false recognition was expected to be lower for alcohol-related than for neutral lists. If deficient encoding underlies Korsakoff patients’ poor item-specific recollection and their overreliance on familiarity in an immediate recognition test, enhancing the distinctiveness of the list words should improve source memory and therefore also lower the likelihood of false recognition.

To summarise, the present study was designed to investigate the influence of encoding factors on lure recognition in amnesia. In Van Damme and d’Ydewalle (2009b), Korsakoff patients exhibited diminished delayed recognition, but increased ‘remembering’ of critical lures with immediate testing. The former can be attributed to deficient recollection of the gist; the latter can be explained by overreliance on familiarity unopposed by explicit recollection and/or source memory. In two experiments, we wanted to replicate these findings and to evaluate the possible effects of encoding factors. Experiment 1 was focused upon increasing delayed lure recognition by manipulating encoding context. Experiment 2 examined whether distinctive encoding content would improve source memory and therefore reduce immediate lure recognition.

**Experiment 1**

Following the procedure of Dewhurst et al. (2007), short stories were created on the basis of 18 Dutch DRM lists. Both lists and stories were presented auditorily, in order to be able to control the encoding duration of each study word (visual presentation of stories would complicate this). Implicit stem completion tests were administered immediately after each list/story, but were not the primary focus of the present study. A recognition test was provided after hearing six lists/stories. ‘Meaning retrieval’ instructions were used, in order to allow for a direct comparison of patients’ and controls’ explicit retrieval of the gist of the lists, without having to take into account
possible inhibition of false memory by controls (cf Verfaellie et al., 2002; see also Brainerd & Reyna, 1998). Participants were asked to respond ‘old’ to any item that shared the meaning of the studied lists, irrespective of whether or not they had actually heard it before.

Based on the importance of explicit recollection in a delayed recognition test, a group difference was expected in memory for both item-specific and gist information (cf earlier findings; e.g., Van Damme & d’Ydewalle, 2009b; Verfaellie et al., 2002). That is, Korsakoff patients were expected to endorse fewer studied words and fewer related lure words than controls. Importantly, if this typically obtained diminished level of gist recognition would be (partly) due to deficient relational encoding, the patients should show an effect of encoding context: The use of stories should heighten the probability of gist recognition by enhancing the saliency of the semantic theme. Control participants were not expected to show such an effect, as they were supposed to have normal encoding capacities and were therefore expected to connect the words spontaneously, even when presented within lists. To take into account Korsakoff patients’ history of chronic alcoholism, both alcoholic and healthy control participants were tested. No differences between these groups were to be expected, however (cf Van Damme & d’Ydewalle, 2009a; Verfaellie et al., 2005).

Method

Participants

Seventeen Korsakoff patients and 24 control participants took part in the experiment. Korsakoff patients (12 men, 5 women) were residents from two psychiatric institutions in Belgium. Their mean age was 52 years (range 42-66, \(SD = 7.1\)) and they had an average of 11.5 years of formal education (range 8-15, \(SD = 2.3\)). They all met the criteria for the DSM-IV Alcohol-Induced Persisting Amnestic Disorder (American Psychiatric Association, 1994) and the criteria for the Korsakoff syndrome as described by Kopelman (2002). More detailed information and clinical neuropsychological test scores are provided in the Appendix. All patients showed impaired memory performance on the Auditory Verbal Learning Test. In addition, they all produced an increased number of perseverative responses on the Wisconsin Card Sorting Test, and most patients exhibited impaired performance on the Trail Making Test and the Controlled Oral Word Association Test. Attention, as measured by the Bourdon-Wiersma Dot Cancellation Test, was disturbed in approximately half of the patients. For all of the tests, except for the WCST, Flemish normative data of Miatton, Wolters, Lannoo, and Vingerhoets (2004) were used.
The group of control participants consisted of 12 individuals with a history of alcoholism (9 men, 3 women) and 12 individuals with no known history of alcoholism (8 men, 4 women). The former were patients recruited from two psychiatric institutions in Belgium, and had abstained from alcohol for at least one month. Their mean age was 47 years (range 41-57, \(SD = 5.2\)) and they had an average of 11.5 years of formal education (range 8-15, \(SD = 2.2\)). Healthy controls had a mean age of 54 years (range 50-59, \(SD = 2.7\)) and also an average of 11.5 years of formal education (range 7-15, \(SD = 2.2\)). Both groups were matched as closely as possible to Korsakoff patients on the basis of age, gender, education, and (former) vocation.

Materials

 Lists and stories. The study materials consisted of 18 lists and 18 stories. Each list was composed of 15 strong associations to one critical word, which was not presented for study. Words within a list were ordered by association frequency, with the strongest associations occurring first. Based upon each list, a story was written: stories contained all of the list words and were meant to emphasise their overall theme.

 Stories ranged in length from 57 to 94 words, and included the DRM words preferably in the same order as they appeared in the original lists. If the latter was not possible, the word order in the list condition was altered to match the story condition (cf Dewhurst et al., 2007). Lists were taken from Van Damme and d’Ydewalle (2009a) and were constructed following the procedure of Roediger and McDermott (1995). Occasionally, a word was replaced or switched position, in order to enhance the story line. If changes were made, they were based on Dutch word association norms recently obtained by De Deyne and Storms (2008).

 One word from each list/story was selected to be the ‘list target’ for the implicit word stem completion task (cf McKone & Murphy, 2000). List targets were matched to critical lures on baseline completion (\(M = 16\%\) and 21\%) and word frequency (\(M = 115\) and 117 occurrences per million, based on the CELEX lexical database of Baayen, Piepenbrock, & Gulikers, 1995). List targets as well as critical lures were at least five letters long and had distinct three-letter stems, with at least eight possible completions.

 To allow for counterbalancing of studied and non-studied materials, the 18 lists/stories were divided into three sets of six, roughly equated on word frequency of the lures and the probability of false recall and false priming. One set was to be used for study in the List condition, one set was to be used for study in the Story condition, and one set was to remain unstudied and to serve as baseline. Assignment of the sets to the three positions was counterbalanced across participants, resulting in six different combinations.
Test construction. Six stem completion tests were constructed to be used in the list condition (i.e., one corresponding to each study list) and six to be used in the story condition. Each test consisted of 14 three-letter stems, of which 10 were filler items and 4 were considered crucial. These were the stems of the list target from the studied list/story, the critical lure corresponding to the studied list/story, a list target from one of the non-studied lists/stories, and the critical lure corresponding to the same non-studied list/story. The recognition test was modelled after Verfaellie et al. (2002), and consisted of 18 studied and 18 non-studied items in each condition. The studied items were obtained by selecting three words from each of the studied lists/stories (i.e., those in Positions 1, 8, 10). The non-studied items consisted of the six critical words corresponding to the studied lists/stories (i.e., critical lures), three critical words corresponding to non-studied lists/stories (i.e., critical distractors), and nine unrelated words originating from lists not used any further in the experiment (i.e., study distractors). Test items were visually presented, in a random order, using black uppercase letters in the centre of the screen. E-prime 1.1 (Psychology Software Tools, Pittsburgh, PA) was used for the presentation of all materials.

Design and procedure

Participants were tested individually, after providing informed consent. The study was approved by the local ethics committee. As encoding context was manipulated within-subjects, the experiment was administered twice to each participant; once using lists and once using stories, the two sessions being separated by at least four days. The order of the two sessions was counterbalanced.

In both sessions, six lists/stories were successively presented (alternated with stem completion tasks), after which a global recognition test was administered. Lists as well as stories were auditorily presented in a female voice, in a different random order for each participant. Intentional learning instructions were used. Instructions for the stem completion tasks simply asked participants to complete each stem with the first word that came to mind. Instructions for the recognition test informed participants that they would be presented with a series of words, of which some had been part of the studied materials and some had not. Retrieval instructions were modelled after Verfaellie et al. (2002), in order to reflect memory for the gist of the lists/stories. Participants were asked to respond ‘old’ if they recognised an item as being heard or if they believed it to be an example of any of the themes or concepts from the lists/stories. They were only to respond ‘new’ if the item did not fit any of the themes from the study phase. Hence, memory for critical lures was not considered to be ‘false’ in this experiment, as gist memory was actually the criterion for accepting an item as old.
Results

A 3 (Group: Korsakoff patients vs. Alcoholic controls vs. Healthy controls) × 2 (Encoding context: Lists vs. Stories) mixed design was used, with Group as a between-subjects variable, and Encoding context as a within-subjects variable. An alpha level of .05 was adopted for all statistical tests.

Implicit stem completion

As implicit memory was not the primary focus of the present article and results were in line with previous research, only the main findings will be presented.

A 3 (Group) × 2 (Encoding context) × 2 (Study status: Studied vs. Unstudied) analysis of variance on the stem completion rates to list targets revealed significant main effects of both Encoding context and Study status, which were qualified by a significant interaction, $F(1, 38) = 7.03$, $MSE = .02$, $p = .01$, $\eta_p^2 = .16$. Simple main effects revealed that veridical priming was significant in the list condition, $F(1, 71) = 24.27$, $p < .0001$, but did not reach significance in the story condition, $F(1, 71) = 2.92$, $p = .09$. This was due to the fact that correct completion of studied list targets was less frequent in the story condition than in the list condition ($M = .26$ vs. .39), $F(1, 76) = 12.65$, $p = .0007$.

The same analysis on the completion rates to critical lures revealed a significant main effect of Encoding context, $F(1, 38) = 16.95$, $MSE = .05$, $p = .0002$, $\eta_p^2 = .31$, and a marginally significant interaction between Encoding context, Group, and Study status, $F(2, 38) = 2.63$, $MSE = .02$, $p = .09$, $\eta_p^2 = .12$. The latter reflected a different result pattern for alcoholic controls than for the other participant groups. Nevertheless, pairwise comparisons (Tukey) on the priming scores revealed none of the differences between groups or conditions to be significant. Planned comparisons (Dunn) showed that, averaged over the two conditions, priming for critical lures was significant for both Korsakoff patients ($M = .17$), $t(38) = 3.23$, $p = .003$, and alcoholic controls ($M = .15$), $t(38) = 2.41$, $p = .02$, and approached significance for healthy controls ($M = .10$), $t(38) = 1.65$, $p = .10$.

Recognition memory

Recognition data for studied words and critical lures in each condition are shown in Table 1. Both absolute proportions of ‘old’ responses and corrected recognition scores are presented. The latter were calculated by subtracting the proportion of false alarms to study and critical distractors from the proportion of hits to the corresponding study words and critical lures (cf. Verfaellie et al., 2002). As analyses of absolute and corrected recognition scores produced
equivalent results, results reported in this section are based on corrected recognition scores.

A 3 (Group) × 2 (Encoding context) mixed-factors analysis of variance on recognition scores for list words revealed a significant main effect of Group, $F(2, 38) = 47.14, MSE = .05, p < .0001, \eta_p^2 = .71$. As expected, Korsakoff patients exhibited significantly lower veridical memory scores ($M = .27$) than both control groups did ($M = .77$; Tukey, both $p < .0001$). No significant main or interaction effects of Encoding context were obtained ($F$’s < 1).

The same analysis on recognition scores for critical lures revealed similar results. As expected, a significant main effect of Group, $F(2, 38) = 30.86, MSE = .11, p < .0001, \eta_p^2 = .62$, reflected the fact that Korsakoff patients showed a lower level of gist recognition than control participants did. The difference was significant when compared to both alcoholic and healthy controls ($M = .23$ vs. .75 and .85; Tukey, both $p < .0001$). No significant main or interaction effects of Encoding context were obtained ($F$’s < 1). A planned comparison of Korsakoff patients’ performance in the list versus story condition revealed no significant difference ($M = .03; t(38) = .32$).

**Discussion**

The present experiment was designed to replicate earlier findings of poor memory for both item-specific and gist information with delayed testing in Korsakoff patients (e.g., Van Damme & d’Ydewalle, 2009b; Verfaellie et al., 2002), as well as to test the hypothesis of deficient encoding underlying impaired recollection. In case of an encoding deficit, the use of stories should heighten the probability of gist recognition in Korsakoff patients by enhancing the saliency of the semantic theme.

**Table 1**

| Lists          | Studied | Distractor | Recognition |
|----------------|---------|------------|-------------|
| List words     |         |            |             |
| Korsakoff      | .42 (.06) | .15 (.04) | .27 (.06)   |
| Alcoholic      | .88 (.03) | .11 (.04) | .77 (.07)   |
| Healthy        | .86 (.04) | .13 (.04) | .73 (.04)   |
| Critical lures |         |            |             |
| Korsakoff      | .46 (.07) | .24 (.06) | .23 (.08)   |
| Alcoholic      | .96 (.02) | .17 (.06) | .79 (.07)   |
| Healthy        | .93 (.06) | .14 (.05) | .79 (.07)   |

| Stories        | Studied | Distractor | Recognition |
|----------------|---------|------------|-------------|
| List words     |         |            |             |
| Korsakoff      | .49 (.06) | .23 (.06) | .26 (.06)   |
| Alcoholic      | .83 (.05) | .06 (.03) | .76 (.05)   |
| Healthy        | .91 (.02) | .10 (.03) | .81 (.03)   |
| Critical lures |         |            |             |
| Korsakoff      | .55 (.06) | .35 (.08) | .20 (.11)   |
| Alcoholic      | .93 (.02) | .22 (.06) | .71 (.08)   |
| Healthy        | .99 (.01) | .88 (.04) | .90 (.04)   |

Note. Recognition scores were obtained by subtracting the proportion of false alarms to distractors from the proportion of hits to list words/lures from studied lists/stories. Standard errors of the mean are given in parentheses.
Results confirmed the expectation of diminished recognition of both studied words and critical lures in Korsakoff patients. Implicit memory for both types of items was normal as compared to controls (cf. Van Damme & d’Ydewalle, 2009a; Van Damme & d’Ydewalle, 2010). Delayed gist recognition did not show an influence of encoding context: Korsakoff patients’ performance was consistently lower than controls’, regardless of whether they had studied stories or lists. Together, these results argue against an explanation in terms of an encoding deficit, and point to deficient explicit retrieval as the main underlying factor of the difference between Korsakoff patients’ and controls’ DRM performance. Nevertheless, two alternative explanations for the lack of an effect of encoding context should be considered.

First, embedding words in a story might have failed to focus participants’ attention on the semantic theme. Such manipulation failure is unlikely, however, given the fact that encoding context did affect implicit memory. Priming for studied list words was lower when participants memorised stories than when they memorised lists. This suggests that attention was drawn to the whole of the story and thus to the semantic theme. Results are similar to the effect of ‘relational’ encoding instructions in Van Damme and d’Ydewalle (2009a), where focusing on relational information inhibited implicit memory for item-specific information (cf. Hunt & Einstein, 1981; Hunt & McDaniel, 1993). Second, embedding words in a story might not have sufficiently improved encoding efficiency to exert an influence on explicit retrieval. To further investigate this matter, the effect of encoding factors on explicit retrieval in the DRM paradigm was investigated in a different way in Experiment 2. As stated before, in an immediate recognition test, critical lures can be recognised on the basis of fluency (i.e., they seem familiar due to repeated semantic activation during study and the relatively short study-test delay), and explicit retrieval is evidenced by the inhibition of false recognition through the recollection of item-specific information.

Experiment 2

Experiment 2 investigated whether the content of the word lists used would influence Korsakoff patients’ level of false memory in an immediate recognition test. Both alcohol-related and neutral materials were used, and four groups of participants were tested: amnesic patients with and without a history of chronic alcoholism (i.e., Korsakoff and non-Korsakoff), and memory-intact controls with and without a history of chronic alcoholism (i.e., healthy controls and alcoholic controls). The starting hypothesis was that alcohol-related words would be more distinctive to Korsakoff patients and alcoholic controls (as compared to non-Korsakoff amnesics and healthy controls), and that this would enhance veridical memory and inhibit false memory.
Ten Dutch DRM lists were presented to participants. Half of the lists were related to alcohol, whereas the other half was neutral. Due to the typically obtained high levels of false recognition with immediate testing, study lists consisted of 9 (instead of 15) words, in order to avoid possible ceiling effects (cf. Robinson & Roediger, 1997; see also Clancy, Schacter, McNally, & Pitman, 2000). As the effect of distinctiveness on false recognition was expected to be mediated by differences in source memory, signal detection measures were calculated to estimate participants’ ability to discriminate between studied words and critical lures.

**Method**

**Participants**

Fourteen Korsakoff patients, 14 non-Korsakoff amnesic patients, 14 non-amnesic patients with a history of chronic alcoholism, and 14 healthy control participants took part in the experiment. The groups were matched as closely as possible in terms of age and formal educational level.

Korsakoff patients were residents from three psychiatric institutions in Belgium. Their average age was 55 years (range 46-67, \(SD = 5.3\)) and they had an average of 11 years of formal education (range 8-14, \(SD = 1.8\)). They all met the criteria for the DSM-IV Alcohol-Induced Persisting Amnesic Disorder (American Psychiatric Association, 1994) and the criteria for the Korsakoff syndrome as described by Kopelman (2002). More detailed information and clinical neuropsychological test scores are provided in the Appendix.

The other amnesic patients were recruited from two general hospitals and one rehabilitation centre in Belgium. Their average age was 61 years (range 35-77, \(SD = 11.0\)) and they had an average of 12 years of formal education (range 8-17, \(SD = 2.8\)). They had a variety of non-alcoholic aetiologies, including ischemic stroke (\(n = 7\)), haemorrhagic stroke (\(n = 2\)), traumatic brain injury (\(n = 1\)), and mild cognitive impairment (\(n = 4\)). More detailed information and neuropsychological test scores can be acquired from the first author upon request, but are not presented due to the large variability in tests used for specific patients.

Alcoholic patients were recruited from two psychiatric centres, and had abstained from alcohol for at least one month. Their average age was 54 years (range 42-66, \(SD = 6.6\)) and they had an average of 11 years of formal education (range 8-15, \(SD = 2.3\)). Healthy controls had an average age of 51 years (range 34-69, \(SD = 10.8\)) and an average of 12 years of formal education (range 8-15, \(SD = 2.3\)).
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Materials

A total of 10 word lists was used. Each list was composed of 9 strong associations to a critical word that was not presented for study (cf Roediger & McDermott, 1995). Words within a list were ordered by association frequency, with the strongest associations occurring first. Half of the lists were neutral; the other half consisted of alcohol-related words.

First, five alcohol-related lists were created on the basis of Dutch word association norms (De Deyne & Storms, 2008; de Groot, 1980; de Groot & de Bil, 1987). Next, five neutral lists were taken from the materials of Van Damme and d’Ydewalle (2009a). Only the first nine words of the lists were adopted. Selection of the lists was based on word frequency: Neutral lists of which the critical lure and the corresponding study words had frequencies similar to the frequencies of one of the alcohol-related lists were selected (cf CELEX lexical database, Baayen et al., 1995).

A separate recognition test was constructed for each study list. Tests consisted of three studied and five non-studied items. The studied items were obtained by selecting three words from the corresponding study list (i.e., those in Positions 1, 4, 7). The non-studied items comprised the critical word from the corresponding study list (i.e., critical lure), and a critical word and three unrelated words from lists not used any further in the experiment (i.e., one critical distractor; three study distractors). Distractors were matched as closely as possible to the studied words and critical lures in terms of word frequency. Test items were visually presented, in a random order, using black uppercase letters in the centre of the screen. E-prime 1.1 (Psychology Software Tools, Pittsburgh, PA) was used for the presentation of all materials.

Design and procedure

Participants were tested individually, after providing informed consent. The study was approved by the local ethics committee. The experiment consisted of 10 study-test trials. Trials were administered in a different random order to each participant. Study lists were presented auditorily, in a female voice, at a rate of approximately 1.5 s per word. Before presentation of each list, participants were told that they would hear a series of words which they should try to remember for a memory test that would follow. Instructions appeared on the computer screen and were read out loud by the experimenter. The test-part of each trial involved the administration of an old/new recognition test corresponding to the list that was just studied. Participants were asked to indicate for each item whether or not it was part of the immediately preceding list. Next, for items classified as ‘old’, they were instructed to indicate whether they could ‘remember’ its actual presentation or whether they simply ‘knew’ that it had occurred in the list (procedure following Melo et al., 1999;
Results

Proportions of ‘old’ responses and ‘remember’ judgments are presented in Tables 2 and 3. Proportions of ‘know’ judgments can be derived by subtracting the ‘remember’ proportions from the ‘old’ proportions. Both absolute and corrected recognition scores are provided. The latter were calculated by subtracting the proportion of false alarms to distractors from the proportion of hits to study words and critical lures (cf Verfaellie et al., 2002). As analyses of absolute and corrected scores produced equivalent results, all data reported in this section are based on corrected scores. Results from two participants (1 alcoholic control, 1 non-Korsakoff amnesic) were excluded from data analysis, due to severely outlying values (i.e., extremely poor performance).

Simplified Remember/Know instructions were used, in order for amnesic patients to understand them properly. As a consequence, ‘remembering’ did not really reflect the ability to mentally relive the study phase (cf Rajaram, 1993; Tulving, 1985), but merely indicated how certain participants were of having heard a word before (Yonelinas, 2002; see also Van Damme & d’Ydewalle, 2009b). Since analyses on ‘remember’ data revealed virtually identical results as analyses on recognition performance, only the latter will be discussed in full. Also, signal detection estimates will be presented, which were calculated to examine participants’ ability to distinguish between studied items and critical lures.

Table 2

Proportions of Items Judged as ‘Old’ by Patients and Controls in Experiment 2, as a Function of Encoding Content and Study Status

|                  | Neutral                  | Alcohol-related         |
|------------------|--------------------------|-------------------------|
|                  | Studied | Distractor | Recognition | Studied | Distractor | Recognition |
| List words       |         |            |             |         |            |             |
| Korsakoff        | .89 (.03) | .04 (.02) | .85 (.04) | .80 (.04) | .08 (.03) | .72 (.06) |
| Other amnesic    | .94 (.02) | .09 (.04) | .85 (.04) | .87 (.04) | .12 (.05) | .75 (.05) |
| Alcoholic        | .94 (.01) | .01 (.01) | .93 (.01) | .89 (.03) | .01 (.01) | .88 (.03) |
| Healthy          | .99 (.01) | .00 (.00) | .99 (.01) | .94 (.02) | .00 (.00) | .94 (.02) |
| Critical lures   |         |            |             |         |            |             |
| Korsakoff        | .70 (.06) | .03 (.02) | .67 (.06) | .51 (.09) | .06 (.04) | .46 (.08) |
| Other amnesic    | .72 (.07) | .11 (.05) | .62 (.06) | .68 (.05) | .06 (.04) | .62 (.05) |
| Alcoholic        | .91 (.04) | .00 (.00) | .91 (.04) | .54 (.06) | .00 (.00) | .54 (.06) |
| Healthy          | .56 (.07) | .00 (.00) | .56 (.07) | .40 (.04) | .00 (.00) | .40 (.04) |

Note. Recognition scores were obtained by subtracting the proportion of false alarms to distractors from the proportion of hits to list words/lures from studied lists. Standard errors of the mean are given in parentheses.
Recognition performance

A 4 (Group) × 2 (Encoding content) mixed-factors analysis of variance on veridical recognition scores revealed significant main effects of both Group, $F(3, 50) = 7.35$, $MSE = 0.027$, $p = .0004$, $\eta^2_p = .31$, and Encoding content, $F(1, 50) = 24.05$, $MSE = 0.008$, $p < .0001$, $\eta^2_p = .32$. A planned comparison (Dunn) revealed significantly poorer performance for amnesic patients than for non-amnesic controls, $t(50) = 4.45$, $p < .0001$, as was expected. Rather unexpectedly, the main effect of Encoding content reflected better performance with neutral than with alcohol-related lists (see Table 2).

A 4 × 2 analysis of variance on false recognition scores revealed significant main effects of Group ($F(3, 50) = 5.26$, $MSE = 0.053$, $p = .003$, $\eta^2_p = .24$), and Encoding content ($F(1, 50) = 19.42$, $MSE = 0.048$, $p < .0001$, $\eta^2_p = .28$), qualified by a significant interaction, $F(3, 50) = 3.18$, $MSE = 0.048$, $p = .03$, $\eta^2_p = .16$. In line with our expectations, planned comparisons (Dunn) revealed that the effect of Encoding content was significant only for Korsakoff patients ($M = .21$), $t(50) = 2.60$, $p = .01$, and alcoholic controls ($M = .37$), $t(50) = 4.32$, $p < .0001$. Both showed significantly less false recognition of alcohol-related lures than of neutral lures. Surprisingly, alcoholic controls differed significantly from healthy controls in their performance for neutral lures, $t(50) =$ 4.05, $p = .0002$, but not in their performance for alcohol-related lures. Korsakoff patients did differ from the other amnesics in the expected direction, though only marginally significantly so. False recognition of alcohol-related lures was diminished, $t(50) =$ 1.83, $p = .07$, whereas there was no group difference for neutral lures (see Table 2). In line with previous findings (Van Damme & d’Ydewalle, 2009b), immediate false recognition was on average higher for amnesic patients than for healthy controls, $t(50) = 2.07$, $p = .04$.
Signal detection measures

To investigate whether personally-relevant materials allowed for a better distinction between studied and related items or merely affected participants’ tendency to say ‘old’, signal detection analyses were carried out on the data. $A'$ was used as a measure of sensitivity, and $B_D$ was used as a measure of response bias. Both are non-parametric indexes (e.g., Donaldson, 1992; Grier, 1971; Snodgrass & Corwin, 1988) and have been successfully applied to DRM data before (e.g., Schacter, Verfaellie, Anes, & Racine, 1998).

$A'$ is defined as $0.5 + [(H - FA)(1 + H - FA)]/[4H(1 - FA)]$. Values can vary between 0.0 and 1.0, with higher estimates indicating greater sensitivity and 0.5 indicating chance performance. In cases where $FA > H$, the formula is adapted as follows: $0.5 - [(FA - H)(1 + FA - H)]/[4FA(1 - H)]$ (Snodgrass & Corwin, 1988).

$B_D$ is defined as $[(1 - H)(1 - FA) - HFA]/[(1 - H)(1 - FA) + HFA]$. Values vary between -1.0 (extremely liberal responding) and +1.0 (extremely conservative responding; Donaldson, 1992). As these measures are undefined with hit rates and/or false alarm rates of 0 or 1, data were first transformed by recalculating the proportions of ‘old’ responses by adding 0.5 to the frequencies and dividing by $(N + 1)$, as recommended by Snodgrass and Corwin (1988).

To investigate the distinction between studied and related items, estimates of $A'$ and $B_D$ were calculated treating ‘old’ responses to critical lures as false alarms, and ‘old’ responses to studied words as hits (cf Schacter et al., 1998). This way, information was provided about participants’ ability to distinguish between words that were part of the study list and words that were merely related to the list’s theme (critical lures), and hence, about their memory for the source of an item’s familiarity. Estimates are depicted in Table 4.

A $4 \times 2$ analysis of variance on the estimates of $A'$ revealed a significant main effect of Group, $F(3, 50) = 7.99$, $MSE = 0.017$, $p = .0002$, $\eta_p^2 = .32$, as well as a marginally significant interaction with Encoding content, $F(3, 50) = 2.35$, $MSE = 0.015$, $p = .08$, $\eta_p^2 = .12$. Planned comparisons (Dunn) showed the effect of Encoding content to be significant only for alcoholic controls, $t(50) = 2.69$, $p = .0098$. They were better able to distinguish between studied words and critical lures for alcohol-related than for neutral lists (see Table 4). However, when comparing alcoholic controls’ performance to healthy controls’, strong evidence was obtained for a difference in sensitivity for neutral materials, $t(50) = 4.30$, $p < .0001$, whereas there was only suggestive evidence for a difference in sensitivity for alcohol-related materials, $t(50) = 1.96$, $p = .056$. All groups in both conditions performed above chance ($A' > .50$), as could be expected in an immediate recognition test. There was no difference between Korsakoff and other amnesic patients in sensitivity for either neutral or alcohol-related materials (see Table 4). On average, both amnesic groups showed lower sensitivity than healthy controls, $t(50) = 2.12$, $p = .039$. 
Note. 'Old' responses to studied words were considered hits; 'old' responses to critical lures were considered false alarms. Standard errors of the mean are given in parentheses.

An analysis of variance on the estimates of $B_D''$ revealed significant main effects of both Group, $F(3, 50) = 4.51$, $MSE = 0.080$, $p = .007$, $\eta^2_p = .21$, and Encoding content, $F(1, 50) = 19.63$, $MSE = 0.061$, $p < .0001$, $\eta^2_p = .28$. On average, controls used more lenient response criteria than amnesic patients did, $t(50) = 2.58$, $p = .01$. As can be seen in Table 4, however, all four participant groups responded quite liberally. They did so in both conditions, but to a relatively greater extent with neutral than with alcohol-related materials. In other words, when confronted with alcohol-related words, all participants were less inclined to say 'old' to a test item than when confronted with neutral words. Numerically, differences were largest for Korsakoff patients and alcoholic controls (see Table 4). Planned comparisons (Dunn) revealed that these groups indeed used relatively more strict response criteria with alcohol-related than with neutral lists (Korsakoff patients: $t(50) = 4.03$, $p = .0002$; alcoholic controls: $t(50) = 2.24$, $p = .029$), whereas the difference for the participant groups without a history of alcoholism was not significant.

### Discussion

The goal of the experiment was to investigate whether personally-relevant stimulus content would improve source monitoring and reduce immediate recognition of critical lures. In an immediate recognition test, critical lures can be recognised on the basis of fluency (i.e., familiarity due to repeated semantic activation during study and the relatively short study-test delay), and explicit retrieval is evidenced by the inhibition of false recognition through the recollection of item-specific information.

First of all, veridical recognition and signal detection data showed that both Korsakoff and non-Korsakoff amnesics performed worse than controls, but still well above chance. This is in agreement with the argument that familiarity-based retrieval can suffice to obtain good performance in an immediate recognition test, and is consistent with Van Damme and d’Ydewalle (2009b). The effect of encoding content on veridical memory reflected higher recogni-
tion scores for neutral than for alcohol-related lists. This can be attributed to differences in response criteria: participants responded more liberally (and hence were more inclined to say ‘old’) to neutral than to alcohol-related test items.

As expected, alcoholic controls and Korsakoff patients showed significantly less false recognition of alcohol-related than of neutral critical lures. Numerically, the effect was present in all four participant groups, but it was significant only for those groups with a history of chronic alcoholism. When comparing studied items to critical lures, alcoholic controls demonstrated both increased sensitivity and more strict response criteria for alcohol-related than for neutral lists. Korsakoff patients, on the other hand, only showed a significant difference in response bias between the two types of lists. The latter finding indicates that stimulus content did not improve the patients’ explicit source memory, but merely changed their tendency to accept an item as ‘old’.

Surprisingly, alcoholic controls differed significantly from healthy controls in false recognition of, and sensitivity for, neutral information, whereas the difference for alcohol-related information was not significant. The former aspect is contrary to the typical finding of similar levels of DRM false memory in memory-intact controls with and without a history of chronic alcoholism (e.g., Schacter et al., 1998; Van Damme & d’Ydewalle, 2009a; Verfaellie et al., 2002). However, evidence also exists that chronic alcoholics suffer from executive function deficits and impaired source monitoring, which may lead to difficulties distinguishing between studied and related items in the DRM paradigm (Harbluk & Weingartner, 1997; Weingartner, Andreason, Hommer, Sirocco, Rio, Ruttimann et al., 1996; see also Pitel, Beaunieux, Witkowski, Vabret, de la Sayette, Viader et al., 2008). Therefore, the most likely conclusion is that alcoholic controls in the present study showed generally impaired source memory (i.e., for neutral materials), which was significantly improved when using personally-relevant, distinctive materials.

**General discussion**

Aim of this study was to replicate Van Damme and d’Ydewalle (2009b) and to investigate the influence of encoding factors on Korsakoff patients’ explicit retrieval abilities in the DRM paradigm. Experiment 1 was focused upon increasing delayed lure recognition by manipulating encoding context; Experiment 2 examined whether distinctive encoding content would improve source memory and therefore reduce immediate lure recognition.

In Experiment 1, DRM words were embedded in stories, written as such that they emphasised the lists’ overall theme (cf. Dewhurst et al., 2007). Korsakoff patients were expected to recognise fewer lures than controls after studying lists (cf. Van Damme & d’Ydewalle, 2009b). In case of deficient
encoding, the story context should heighten the patients’ delayed gist recognition by enhancing the saliency of the semantic theme. By using ‘meaning retrieval’ instructions, inhibition of false memory by control participants was avoided. As a result, recognition of critical lures purely reflected explicit memory for the gist of the lists/stories (see Verfaellie et al., 2002). Results replicated earlier findings of diminished lure recognition in Korsakoff patients, but did not show an effect of encoding context. The patients’ explicit gist memory was consistently poorer than controls’, regardless of whether they had studied lists or stories. Their implicit memory for critical lures was comparable to controls’, which also replicates previous findings (Van Damme & d’Ydewalle, 2009a).

In Experiment 2, encoding content was manipulated, by using both alcohol-related and neutral lists. Based on their personal relevance, it was expected that alcohol-related words would be more distinctive to participants with a history of chronic alcoholism than for non-alcoholic participants. As a consequence, it was predicted that the former participants would show better source memory, and therefore diminished false memory, for alcohol-related lists in an immediate recognition task. Results replicated Van Damme and d’Ydewalle (2009b) by showing that immediate false recognition was on average higher for amnesics patients than for healthy controls. As expected, both Korsakoff patients and alcoholic controls falsely recognised significantly less alcohol-related than neutral critical lures. Importantly, however, the underlying processes turned out to be different in the two groups. Whereas alcoholic controls demonstrated both increased sensitivity and more strict response criteria for alcohol-related lists, Korsakoff patients only showed a change in response bias. This suggests that distinctive stimulus content did not improve the patients’ explicit source memory, but merely changed their tendency to accept an item as ‘old’ (see also Dougal & Rotello, 2007; Starns, Cook, Hicks, & Marsh, 2006).

To sum up, in both of the present experiments, no evidence was obtained that encoding factors affect Korsakoff patients’ explicit retrieval of thematic and/or source information. Personally-relevant content did decrease the patients’ susceptibility to immediate false recognition, but merely through a change in response bias. Hence, results point to the conclusion that, at least with intentional learning, deficient explicit retrieval is the sole factor determining the difference in DRM performance between Korsakoff patients and memory-intact controls. One could argue that the lack of an effect of encoding factors on Korsakoff patients’ explicit memory performance might imply that these patients suffer from an encoding deficit so severe that it prevents them from benefiting from any support during the study phase. The assumption of such a severe impairment stands however in sharp contrast to the (repeated) finding of increased immediate false recognition as well as normal
priming, and is therefore unlikely. Thus, whereas Korsakoff patients’ false memory pattern does resemble young children’s, the underlying processes appear to be different. While recent studies (e.g., Dewhurst et al., 2007) have attributed children’s low false memory rates to deficient processing of semantic relationships, the current findings point to deficient recollection following adequate encoding in Korsakoff patients. This conclusion is in line with the fact that amnesic patients typically show diminished explicit false memory for both phonological and semantic DRM lists (Schacter et al., 1997), whereas children demonstrate high levels of false memory for phonological lists (e.g., Dewhurst & Robinson, 2004; Holliday & Weekes, 2006).

Important to mention is that the absence of an effect of encoding factors on Korsakoff patients’ explicit recollection cannot be attributed to the unimportance of encoding factors for memory in general. In Experiment 2, increased sensitivity for the difference between alcohol-related studied and lure words (as compared to neutral studied and lure words) was obtained for alcoholic controls. They were better able to monitor the source of the test items and to recollect which words were part of the study list when personally-relevant information was used. This is in accordance with literature about the effect of distinctiveness on false memory (e.g., Hanczakowski & Mazzoni, 2011). Surprisingly, however, they differed significantly from healthy controls only in false recognition of, and sensitivity for, neutral information. The most likely explanation is that alcoholic patients in the present study were characterised by impaired source memory under regular circumstances (e.g., Harbluk & Weingartner, 1997; Weingartner et al., 1996), which was significantly improved when using personally-relevant, distinctive materials².

In conclusion, the present study replicated Van Damme and d’Ydewalle’s (2009b) finding of diminished delayed and increased immediate lure recognition in Korsakoff patients. No evidence for an effect of encoding context on delayed recognition was obtained. Encoding content was shown to affect immediate false recognition, but a difference in sensitivity between neutral and alcohol-related lists was found only for alcoholic controls. The personally-relevant content did not improve Korsakoff patients’ recollection of source information, but merely elicited a change in response bias. Together, results suggest that deficient recollection (rather than deficient encoding) is the main underlying factor determining the difference in DRM performance between amnesic patients and memory-intact controls.

² Whether or not alcoholic controls in Experiment 1 also suffered from impaired source monitoring was unimportant for the results. Both in an implicit stem completion task and in a recognition task with ‘meaning retrieval’ instructions, memory for the source of the items is irrelevant.
The present findings also point to some more general conclusions regarding DRM false memories. First, the absence of an effect of encoding context on delayed gist recognition (for both patients and controls) is in line with the claim that relational encoding is the default strategy when participants are intentionally trying to remember word lists (e.g., Lampinen, Leding, Reed, & Odegard, 2006; Van Damme & d’Ydewalle, 2009a; see also Hunt & McDaniel, 1993; McCabe, Presmanes, Robertson, & Smith, 2004). Second, the effect of personally-relevant content on alcoholic controls’ source memory and on the ability to suppress false recognition has possible practical implications. Following Gallo’s (2006) statement that measuring false memory for words that are related to certain concepts (e.g., food, alcohol) can yield an indirect measure of the activation of these concepts in specific populations (e.g., people with eating disorders, alcoholics), the present findings suggest that it might be worthwhile to investigate the possibility of adopting the DRM paradigm as an individual difference measure. Not in a forensic, but in a clinical context. In daily life, there is a large variability in the degree of personal relevance of the information people are confronted with. It seems that false memories based on associative inferences are less likely for topics that are personally relevant. Nonetheless, in the present study, susceptibility to false memories under such circumstances was inhibited, not eliminated. This is in line with the argument that it is difficult to place the DRM illusion under conscious control (e.g., McDermott & Roediger, 1998). The fact that all participants exhibited a somewhat more conservative response bias for alcohol-related words than for neutral words additionally suggests that false memories are less likely for information that has multiple connections to other information in the environment: as opposed to neutral words, the alcohol-related words were not only semantically related within lists, but also – to a certain degree – between lists. Further studies will need to examine whether or not the same result pattern is obtained when comparing alcohol-related lists to lists sharing another common theme.

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### Appendix:
Demographic and neuropsychological characteristics of Korsakoff patients in Experiments 1 and 2

#### Vocabulary, attention, and memory

| Pt. | Experiment | Sex | Age | Educ. | WBQ | ART | AD | Omiss. | Err. | A1 | A2 | A3 | A4 | A5 | Sum | B | A6 | A7 | A8+ | A%- |
|-----|------------|-----|-----|-------|-----|-----|----|-------|-----|----|----|----|----|----|-----|---|-----|----|-----|-----|
| 01  | 1          | F   | 52  | 14    | 87  | 27.40| 5.21| 10    | 3   | 3  | 3  | 5  | 5  | 5  | 21  | 3 | 0   | 2  | 5   | 5  |
| 02  | 1          | F   | 59  | 15    | 84  | 11.32| 1.55| 8     | 0   | 4  | 4  | 5  | 3  | 5  | 21  | 3 | 0   | 1  | 15  | 12 |
| 03  | 1          | F   | 49  | 12    | 68  | 11.44| 1.23| 25    | 0   | 2  | 7  | 7  | 8  | 7  | 31  | 4 | 0   | 4  | 13  | 5  |
| 04  | 1          | M   | 42  | 12    | 72  | 13.76| 1.67| 4     | 0   | 5  | 7  | 6  | 6  | 4  | 28  | 4 | 1   | 0  | 12  | 15 |
| 05  | 1          | M   | 43  | 8     | 78  | 10.16| 1.25| 7     | 0   | 3  | 5  | 5  | 6  | 6  | 25  | 2 | 4   | 3  | 12  | 3  |
| 06  | 2          | M   | 49  | 12    | 57  | 20.88| 1.74| 4     | 0   | 5  | 5  | 4  | 6  | 6  | 26  | 3 | 0   | 0  | 7   | 6  |
| 07  | 2          | M   | 56  | 12    | 78  | 14.12| 1.74| 13    | 0   | 4  | 3  | 4  | 4  | 5  | 20  | 1 | 2   | 0  | 11  | 14 |
| 08  | 2          | M   | 53  | 12    | 55  | 12.80| 1.94| 19    | 1   | 2  | 4  | 4  | 3  | 2  | 15  | 1 | 1   | 0  | 9   | 2  |
| 09  | 1          | M   | 48  | 12    | 98  | 16.56| 0.92| 6     | 0   | 5  | 6  | 8  | 6  | 6  | 31  | 4 | 4   | 1  | 10  | 12 |
| 10  | 2          | M   | 50  | 12    | 92  | 24.48| 2.20| 1     | 0   | 4  | 5  | 5  | 5  | 6  | 25  | 0 | 3   | 1  | 14  | 7  |
| 11  | 2          | M   | 58  | 12    | 106 | 13.00| 0.96| 5     | 0   | 3  | 3  | 5  | 5  | 6  | 22  | 2 | 1   | 0  | 3   | 2  |
| 12  | 1          | M   | 44  | 10    | 72  | 13.16| 1.28| 6     | 1   | 5  | 6  | 4  | 4  | 4  | 23  | 1 | 3   | 0  | 14  | 18 |
| 13  | 2          | M   | 58  | 8     | 60  | 15.80| 4.07| 98    | 4   | 2  | 5  | 4  | 4  | 4  | 19  | 2 | 0   | 0  | 13  | 10 |
| 14  | 1-2        | M   | 52  | 14    | 91  | 14.24| 1.33| 8     | 0   | 3  | 5  | 7  | 7  | 7  | 29  | 6 | 0   | 4  | 15  | 8  |
| 15  | 1          | F   | 52  | 12    | 105 | 8.84 | 0.85| 13    | 0   | 5  | 5  | 3  | 6  | 6  | 27  | 4 | 0   | 0  | 4   | 0  |
| 16  | 1          | M   | 49  | 8     | 55  | 11.68| 0.95| 2     | 0   | 2  | 3  | 3  | 2  | 5  | 15  | 2 | 1   | 0  | 2   | 2  |
| 17  | 1          | M   | 61  | 12    | 55  | 15.28| 2.13| 9     | 2   | 3  | 3  | 5  | 5  | 4  | 20  | 2 | 2   | 1  | 13  | 17 |
| 18  | 1-2        | M   | 66  | 12    | 97  | 21.12| 2.77| 13    | 0   | 2  | 4  | 5  | 5  | 4  | 20  | 2 | 0   | 0  | 7   | 8  |
| 19  | 1          | M   | 61  | 8     | 55  | 16.08| 2.10| 2     | 0   | 4  | 4  | 5  | 4  | 7  | 24  | 3 | 1   | 1  | 12  | 12 |
| 20  | 1          | M   | 59  | 12    | 91  | 15.68| 3.92| 4     | 0   | 2  | 3  | 4  | 4  | 4  | 17  | 4 | 0   | 0  | 12  | 7  |
| 21  | 1          | M   | 46  | 14    | 86  | 11.00| 0.91| 4     | 0   | 6  | 6  | 8  | 8  | 7  | 35  | 6 | 2   | 0  | 2   | 0  |
| 22  | 2          | M   | 50  | 12    | 76  | 24.44| 2.69| 31    | 8   | 4  | 5  | 3  | 5  | 5  | 22  | 3 | 0   | 0  | 12  | 10 |
| 23  | 1          | F   | 47  | 12    | 78  | 26.36| 4.01| 9     | 0   | 3  | 3  | 3  | 5  | 6  | 20  | 1 | 0   | 0  | 9   | 11 |
| 24  | 2          | M   | 58  | 12    | 56  | 12.48| 1.61| 6     | 0   | 3  | 4  | 4  | 4  | 5  | 20  | 1 | 0   | 0  | 15  | 14 |
**Vocabulary, attention, and memory**

| Pt. | Experiment | Sex | Age | Educ. | WBQ | ART | AD | Omiss. | Err. | A1 | A2 | A3 | A4 | A5 | Sum | B | A6 | A7 | A8+ | A8- |
|-----|------------|-----|-----|-------|-----|-----|----|--------|-----|----|----|----|----|----|-----|---|----|----|-----|-----|
| 1   | F          | 52  | 14  | 72”   | 138”| 12  | 8  | 10     | 11  | 2  | 19 | 60 | 71 | 55 | 5   | 0 | 1  | 1 | 0   | 0   |
| 2   | F          | 59  | 15  | 24”   | 94” | 15  | 5  | 8      | 11  | 2  | 14 | 57 | 44 | 37 | 20  | 2 |
| 3   | F          | 49  | 12  | 40”   | 77” | 16  | 7  | 10     | 16  | 6  | 11 | 27 | 19 | 13 | 13  | 1 |
| 4   | M          | 42  | 12  | 52”   | 85” | 14  | 9  | 8      | 11  | 6  | 11 | 13 | 16 | 9  | 4   | 0 |
| 5   | M          | 43  | 8   | 32”   | 85” | 18  | 6  | 7      | 14  | 5  | 17 | 44 | 34 | 28 | 16  | 2 |
| 6   | M          | 49  | 12  | 35”   | 84” | 9   | 6  | 11     | 12  | 0  | / | 72  | 50 | 42 | 30  | 0 |
| 7   | M          | 56  | 12  | 50”   | 102”| 13  | 7  | 8      | 10  | 0  | / | 53  | 20 | 20 | 33  | 0 |
| 8   | M          | 53  | 12  | 43”   | 146”| 20  | 8  | 12     | 12  | 4  | 21 | 31 | 20 | 17 | 14  | 2 |
| 9   | M          | 48  | 12  | 46”   | 76” | 24  | 13 | 16     | 17  | 0  | / | 58  | 52 | 38 | 20  | 1 |
| 10  | M          | 50  | 12  | 46”   | 233”| 18  | 10 | 12     | 10  | 3  | 10 | 48 | 53 | 42 | 6   | 1 |
| 11  | M          | 58  | 12  | 39”   | 79” | 19  | 17 | 17     | 12  | 6  | 15 | 32 | 29 | 26 | 6   | 1 |
| 12  | M          | 44  | 10  | 57”   | 80” | 16  | 9  | 9      | 15  | 4  | 10 | 34 | 19 | 19 | 15  | 2 |
| 13  | M          | 58  | 8   | 39”   | 132”| 17  | 8  | 12     | 14  | 0  | / | 72  | 50 | 41 | 31  | 0 |
| 14  | M          | 52  | 14  | 55”   | 129”| 20  | 9  | 8      | 12  | 3  | 11 | 45 | 34 | 28 | 17  | 1 |
| 15  | F          | 52  | 12  | 27”   | 85” | 23  | 18 | 22     | 34  | 6  | 11 | 31 | 15 | 14 | 17  | 1 |
| 16  | M          | 49  | 8   | 38”   | 129”| 15  | 6  | 8      | 7   | 6  | 12 | 29 | 18 | 16 | 13  | 2 |
| 17  | M          | 61  | 21  | 38”   | 80” | 13  | 8  | 7      | 9   | 6  | 11 | 31 | 18 | 17 | 14  | 0 |
| 18  | M          | 66  | 12  | 69”   | 200”| 13  | 12 | 7      | 14  | 2  | 39 | 63 | 62 | 50 | 13  | 1 |
AMNESIA AND THE DRM PARADIGM

Note: Educ. = Years of formal education; TMT = Trail Making Test; COWAT = Controlled Oral Word Association Test; WCST = Wisconsin Card Sorting Test; Anim. = Animals; # Categ. = Number of categories completed; # Trials = Number of trials needed to complete the first category; Perc.Err. = Percentage of Errors; Perc.P.Res. = Percentage of Perseverative Responses; Perc.P.Err. = Percentage of Perseverative errors; Perc.NP.Err. = Percentage of Non-Perseverative Errors; FMS = Failure to maintain set; M = Male / F = Female.

| Pt | Sex | Age | Educ. | A   | B   | Anim. | 'N' | 'K' | 'A' | 'K' | # Categ. | # Trials | Perc.Err. | Perc.P.Res. | Perc.P.Err. | Perc.NP.Err. | FMS |
|----|-----|-----|-------|-----|-----|-------|-----|-----|-----|-----|---------|----------|-----------|-------------|--------------|---------------|-----|
| 19 | M   | 61  | 8     | 58''| 20''| 13    | 8   | 12  | 12  | 12  | 0       | 1        | 30        | 66          | 53           | 17            | 0   |
| 20 | M   | 59  | 12    | 39''| 294''| 13    | 6   | 3   | 7   | 15  | 6       | 18       | 25        | 18          | 16           | 9             | 0   |
| 21 | M   | 46  | 14    | 24''| 58''| 15    | 12  | 11  | 10  | 10  | 6       | 13       | 23        | 14          | 13           | 10            | 0   |
| 22 | M   | 50  | 12    | 45''| 124''| 19    | 13  | 15  | 15  | 15  | 2       | 32       | 59        | 50          | 42           | 17            | 1   |
| 23 | F   | 47  | 12    | 61''| 192''| 15    | 9   | 7   | 8   | 15  | 1       | 50       | 49        | 29          | 29           | 29            | 2   |
| 24 | M   | 58  | 12    | 31''| 98''| 7     | 4   | 2   | 6   | 7   | 6       | 20       | 33        | 26          | 24           | 9             | 0   |
| 25 | M   | 56  | 8     | 52''| 234''| 11    | 1   | 2   | 4   | 11  | 3       | 61       | 38        | 20          | 20           | 19            | 4   |
| 26 | M   | 56  | 8     | 24''| 108''| 17    | 10  | 10  | 10  | 17  | 4       | 15       | 47        | 35          | 28           | 19            | 0   |
| 27 | M   | 51  | 9     | 41''| 137''| 15    | 13  | 10  | 15  | 15  | 6       | 12       | 25        | 15          | 11           | 14            | 2   |

Executive functions