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RESEARCH REPORT

Comparison of activation level between true and false items in the DRM paradigm

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Abstract The aim of the present study was to compare the activation levels of true and false memories in the Deese–Roediger–McDermott (DRM) paradigm. For this purpose, we used a lexical decision task (LDT) that can be considered a relative pure measure of activation. Participants had to study a list of words that were semantically associated to a critical non-presented word (CI), and afterwards had to classify the actually studied words, the CI and new words in the LDT. Results indicated that the classification latency of the CI was the same as actually studied words and shorter than new words. The results might be interpreted as evidence that the false and true memory items have the same activation level and that the false memory effect can be based on the indirect activation of the CI at the encoding.

Keywords False memory · Activation level · Lexical decision task · DRM

Introduction

False recognition and false recall of words can be easily induced in people using variants of Deese–Roediger–McDermott (DRM) paradigm (Roediger and McDermott 1995). In the DRM paradigm, subjects study lists of words (e.g., sugar, candy, bitter, good) that are semantically associated to a critical non-presented word (e.g., sweet). On subsequent tests, subjects are more likely to falsely recall and/or recognize the non-studied critical item (CI) than unrelated control items (Gallo 2006).

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Roediger and his colleagues have proposed a dual process model called the activation/monitoring theory to explain the DRM illusion (McDermott and Watson 2001; Roediger and McDermott 2000). During encoding, the presentation of associated words indirectly activates the representation of the CI via a spread of activation. This indirect activation of the CI accumulates as each of its associates is studied. Indeed, the research has shown that levels of false memories are a function of the number of associates that were studied (Robinson and Roediger 1997). During testing, the participants come to believe that the CI was studied because of a source-monitoring failure (Johnson et al. 1993) that was induced by previous activation. They fail to distinguish between items generated internally and those presented to them externally. Following the activation/monitoring theory, the false memories are produced by the conjunction of heightened indirect activation of non-studied CIs and source-monitoring failure. This model has been supported by much experimental evidence (e.g., Roediger et al. 2001a, b; Roediger and Gallo 2004). Interestingly, a meta-analysis has shown that the backward associative strength index of the list (BAS; Deese 1959) is the most important predictor of false recall (Roediger et al. 2001b). This index measures the degree to which the list items evoke the association to the CI. Therefore, the higher the BAS the more likely is the false memory production. As Hancock et al. (2003, p. 10) put it: "the degree to which a list activates its critical lure's representation determines its availability, which in turn may be the first stage in making the lure a candidate for becoming a false memory later".

This perspective gives a primary relevance to the activation of the false memory trace during encoding. The aim

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of the present study was to test this idea by comparing the activation levels of false and true memory traces in the DRM paradigm.

The dual process model has encouraged researchers to investigate false memory by paradigms useful to disentangle the specific role of each process, and to define the factors that moderate their effects (Dewhurst et al. 2008; Gallo et al. 2001; Gallo and Roediger 2002; McDermott and Watson 2001). Researchers that have compared the activation of true and false memories used mainly implicit memory paradigms (e.g., word fragment completion, lexical decision task). In this research, we used the lexical decision task (LDT) paradigm because "it seems to be a good candidate for providing a relatively *pure* measure of how much activation the study of a DRM list produces for studied associates and non-studied CIs" (Tse and Neely 2005, p. 534). In the LDT, participants are presented with strings of letters and are asked to classify them by pressing one of the two keys indicating a word or a non-word. The underlying logic is that there is an inverse relationship between lexical decision latency and activation. In other words, more highly activated items are responded more quickly than the less activated items (Anderson 1983).

So far, only few studies have used the LDT to measure activation from intentionally studied DRM lists, and have produced controversial results (see Tse and Neely 2005 for a review). Some authors did not obtain a facilitation of the CI if the source-monitoring process was inhibited (McKone 2004; Zeelenberg and Pecher 2002), whereas others found a facilitation of the CI when a test item occurred immediately after the activation phase (Meade et al. 2007). Finally, Tse and Neely (2005) and Hancock et al. (2003) provided a demonstration of a genuine CI semantic priming effect in a delayed indirect memory test that should be free of intentional retrieval strategies.

In order to clarify the status of the activation level of actually studied items and CI, we selected the DRM list "sweet" (see Appendix). This was a 15-item list developed according to the DRM paradigm in the Italian population. It was chosen because a previous study indicated that it had a high BAS index and therefore a high probability of inducing false memories (Nigro and Brandimonte 2005). The LDT was administered between study phase and test phase (recognition task). Besides, to avoid a possible semantic additive effect due to the re-presentation of the list items in the LDT, the CI was presented before each studied item.

In the encoding phase, the participants had to read the 15-item list. After reading the list, they had to perform a LDT and a recognition task. The latter task was used as a control task aimed at evaluating the explicit false remembering and the general memory accuracy. In the LDT, the participants were asked to classify words as Italian or non Italian. In this task, among new Italian words (that were not semantically related to the studied items) and non-words, they were presented with the CI and actually studied items. We assumed that the time necessary to classify words in the LDT was an inverse function of the level of activation of the underlying representation (Anderson 1983). In this sense, the activation of an actually studied item should be reflected in shorter classification latencies as compared with matched new words (Hancock et al. 2003). Besides, according to the activation process and given the strength of the DRM list, we expected that the CI should have shorter classification latencies as compared with matched new words and similar latencies to the studied items. These predictions should be verified by a main effect of the item type.

Method

Participants

Forty undergraduate university students (24 females and 16 males) participated in the experiment. Their ages ranged from 18 to 30 years ($M = 24.4$ years, SD = 3.2). Each participant was tested individually in sessions that lasted approximately 15 min.

Design

The experiment consisted of a single factor design where the type of item (studied words, CI, new words, and non-words) was manipulated within subjects. The dependent variable was the reaction time of subjects' responses on the LDT.

Materials and procedure

The experiment consisted of three phases. In the first phase (study phase), participants were asked to read the 15 words of the list "*sweet*" (see Appendix). The items of the list were presented at the center of the computer screen for 2 s each. The list was adjusted according to the DRM paradigm (Stadler et al. 1999). In the instructions, the LDT task and the recognition task were presented as two classification tasks, and no mention was made about memory or the final recognition test. According to the implicit memory literature, this should minimize participant's motivation to use the intentional retrieval strategy, thereby ensuring a pure measure of activation. In the LDT, participants were presented with letter strings and were asked to classify them as correctly spelled Italian words or non-words. The letter strings to be classified were 46: 2 filler words (punto and norto); 3 items of the list sweet (I, VIII, and XI); the

CI; 18 new words (e.g., birra [beer], marmo [marble]); 22 non-words (e.g., logna, furma). The new words were selected according to the following criteria: (a) they were Italian words semantically unrelated to the items of the studied list and to the CI and (b) on the basis of normative data for words in Italian (CoLFIS; http://www.ge.ilc.cnr.it/strumenti.php), they were matched for length, syllable number, and word frequency to the list items and to the CI. The last variables are known to affect latency independently of the activation status and therefore particular care was given to the matching procedure (Hancock et al. 2003). The non-words were all Italian orthographically regular and pronounceable letter strings. In each trial, a fixation "+" was first presented for 250 ms. After a 750-ms ISI, the letter string was shown and remained on the screen until participants pressed the response key. They were told to respond as quickly and accurately as possible. In the case of misclassification, a red "X" was presented just below the letter string of the screen until participants made the correction. The presentation of items during the LDT was random under some constraints. The first two items were filler words. The subsequent items were divided into four blocks with 11 words in each block. The critical lure was presented in the first block and before the list items. In the recognition task, participants were presented with a series of words and were asked to classify them as items presented ("old item") or not presented ("new item") during the studying phase. In this task, participants were presented 21 words: 6 words from the list (I, II, VII, VIII, XII, XIII), the CI, 7 new words selected among the new Italian words presented during the LDT, and 7 completely new words. Items appeared in random order.

Data analyses

Preliminarily, the univariate distributions of the observed RT for mean scores of each type of item were examined for normality (Shapiro and Wilk 1965). Results indicated that the univariate normality did not hold. RTs faster than 200 ms and slower than 2,000 ms were excluded from the analyses of the LDT. This resulted in removal of 1.7% of the RTs for correct responses. Besides, an inverse logarithmic transformation was used for all variables to normalize the distributions (Tabanick and Fidell 1996). The analysis was performed on the transformed variables, but for descriptive purposes, untransformed data are used to report means (in milliseconds) and standard deviations.

Mean RTs (for correct responses) were analyzed in a one-way ANOVA that treated type of item (studied words, CI, matched new words, and non-words) as within-participant fixed-effect variable. The Bonferroni correction was used to analyse post hoc effects.

Results

The one-way ANOVA showed that the latency of the LDT was influenced by the type of item, $F(3,117) = 56.99$; $p < 0.001$; $\eta^2 = 0.59$. The post hoc analyses for the type of item effect revealed that the mean latency for classifying both actually studied items and the CI was shorter than the matched new words ($p < 0.002$ and $p < 0.02$, respectively) and non-words ($ps < 0.001$). The difference between new words and non-words was also significant ($p < 0.001$). The respective mean latencies were: studied items $M = 626.3$ (SD = 24.9); CI $M = 621.5$ (SD = 22.3); matched new words $M = 685.9$ (SD = 22.5); non-words $M = 858.3$ (SD = 36.9).

Finally, we also examined the accuracy of the recognition task of the DRM paradigm. The results showed that in the 97.5% of the cases ($n = 39$), participants indicated as an "old item" the non-presented CI, and the actually studied items were correctly recognized as old in the 92.5% of the cases (SD = 0.1), and the matched new items were correctly classified as new in the 93.6% of the cases (SD = 0.1).

Conclusions

The aim of the present study was to compare the activation levels of false and true memory traces in the DRM paradigm by means of the LDT. In line with our hypotheses, the CI was characterized by shorter latencies than new words, and similar latencies as compared with actually studied words. Since classification latencies in the LDT should be an inverse function of the level of activation of the underlying representation (Anderson 1983), then we can infer that the false memory trace has the same level of activation as the true memory traces.

Our results are in line with Hancock et al. (2003), Meade et al. (2007), and Tse and Neely (2005) who also used a full DRM 15-word list and found a clear facilitation of the CI. Interestingly, Meade et al. (2007) claimed that the duration of the false memory trace was about 1 s, presumably, because they introduced non-words in the lists, thereby reducing the BAS index. Since in our procedure, the CI was always presented after the filler words, we might argue that the false memory trace is longer than 1 s, and this could be a further proof of the strength of the BAS index. However, our results contrast with McKone (2004) and Zeelenberg and Pecher (2002) who found no facilitation for the non-presented CI. This discrepancy might be due to a procedural factor. Indeed, in these studies, the lists were simply taken from Roediger and McDermott (1995) and were not adapted for the sample population as the DRM paradigm prescribes.

Regarding the recognition task, our results confirm that the list "sweet" had a high power to induce false memories (see Nigro and Brandimonte 2005). Taken together, the results suggest that after the encoding of the DRM list, the CI trace has the same status as the memory contents that refer to really experienced items. Studies using different neuroimaging paradigms have given further support to behavioural data by showing that the true and false memories share largely overlapping neural areas, although true memories were associated with a greater activation of early visual regions than false memories (Cabeza et al. 2001; Schacter et al. 2007; Slotnick and Schacter 2004). According to Slotnick and Schacter (2004), we can hypothesize that the false memories are observed when "the sensory signature that distinguishes true from false recognition may not be accessible to conscious awareness" (p. 664), so that real events and mental representations are confounded. In line with this idea, some studies have shown that when list items are made distinctive, for example by enriching the encoding trace (Gallo et al. 2004), the probability of false recall and/or recognition decreases.

In conclusion, our results seem to confirm that the false memory effect can be based on the indirect activation of the CI at the encoding and that the activation level of the critical lure's representation makes the lure a good candidate for becoming a false memory (Hancock et al. 2003; Roediger and McDermott 2000). Further research should investigate how long the increasing activation of CI lasts and whether it is due to automatic activation (Cotel et al. 2008; Dewhurst et al. 2008) or to the selective use of voluntary memory strategies during encoding.

Appendix

Item	List sweet	
	Italian	English
I	Miele	Honey
II	Caramella	Candy
III	Zucchero	Shugar
IV	Pasticcino	Pastry
V	Aspro	Sour
VI	Soave	Suave
VII	Tenero	Tender
VIII	Torta	Cake
IX	Amaro	Bitter
X	Cioccolata	Chocolate
XI	Crostata	Pie
XII	Gusto	Taste
XIII	Frappè	Milkshake
XIV	Buono	Good
XV	Piacevole	Pleasant
Critical item	Dolce	Sweet

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