Psicológica (2013), 34, 285-298.

Effect of divided attention on the production of false memories in the DRM paradigm: A study of dichotic listening and shadowing

Eduarda Pimentel[1] and Pedro B. Albuquerque[2]

[1]*Portuguese Catholic University (Portugal)*

[2]*University of Minho (Portugal)*

The Deese/Roediger-McDermott (DRM) paradigm comprises the study of lists in which words (e.g., bed, pillow, etc.) are all associates of a single nonstudied critical item (e.g., sleep). The probability of falsely recalling or recognising nonstudied critical items is often similar to (or sometimes higher than) the probability of correctly recalling or recognising studied associates. False memories produced throughout this paradigm are usually seen as vivid, long lasting, and difficult to consciously avoid. Our experiment aimed to analyse the effect of dichotic listening and shadowing procedures on the production of false memories in the DRM paradigm. The results showed that the production of false memories under a divided attention condition during processing was not eliminated, independently of the type of memory task – recall or recognition. Moreover, the proportion of false memories produced in our study was similar to the amounts of correct recall and recognition in both encoding conditions. Therefore, our study confirms the robustness of this type of memory distortion (e.g., Gallo, Roediger, & McDermott, 2001), because even when the encoding conditions are impoverished, participants are prone to falsely remember the critical words, reinforcing the theoretical assumption of the automatic activation of critical lures.

---

[1] EP was sponsored by national funding through the Foundation for Science and Technology: PhD scholarship SFRH/BD/22832/2005 and Research Program PEst-OE/FIL/UI0683/2011. Correspondence should be addressed to Eduarda Pimentel, Faculdade de Filosofia (Centro Regional de Braga da Universidade Católica Portuguesa), Praça da Faculdade, 1, CP 4710 - 297 Braga, Portugal. E-mai: epimentel@braga.ucp.pt

[2] PBA was supported by the Portuguese Foundation for Science and Technology through the Research Program PEst-C/PSI/UI1662/2011.

False memory production has been mostly studied with the DRM paradigm (Roediger & McDermott, 1995), a procedure that involves the presentation of lists of words (e.g., *cake*, *sugar*, *chocolate*, *candy*, *pleasant*, etc.) associated with a non-presented word or critical item (e.g., *sweet*). This presentation is usually followed by explicit memory tests - recall or recognition. Even when participants are warned to avoid guessing during retrieval, participants robustly create false memories (i.e., the retrieval of critical items) during recall, recognition, and even implicit memory tasks (e.g., Cadavid, Beato, & Fernandez, 2012; Hicks & Starns, 2005; McKone & Murphy, 2000; Pimentel & Albuquerque, 2011; Smith, Gerkens, Pierce, & Choi, 2002; Tajika, Neumann, Hamajima, & Iwahara, 2005).

One explanation for the emergence of false memories in the DRM paradigm is that recall is due to both the processing of the surface features (*verbatim* traces) and the semantic content of the associates (*gist* traces). Given this parallel processing, the recall of presented words becomes an important memory cue to yield the theme (or *gist*) of the words, resulting in false recall of the critical item (Brainerd & Reyna, 1996, 1998, 2002).

Unlike fuzzy trace theory, the activation-monitoring framework was developed to specifically explain how false memories are produced in the DRM paradigm (McDermott & Watson, 2001; Roediger, Watson, McDermott, & Gallo, 2001). According to this approach, false remembering is a consequence of two independent and opposing processes: activation and monitoring. The first process is an outcome of the association between concepts in our semantic network. When a concept (studied word) is processed, the resulting activation is spread among related concepts, including the critical item, which become highly activated. This spreading of activation is an extremely fast and automatic process and, thus, cannot be consciously controlled. Evidence for the activation mechanism has been widely shown (e.g., Robinson & Roediger, 1997; Roediger et al., 2001; Roediger, Balota, & Robinson, 2000 in Roediger, Balota, & Watson, 2001; Seamon, Luo, & Gallo, 1998). On the other hand, source monitoring is a control mechanism that prevents false memory production. According to Gallo (2006), source monitoring allows the participant to decide that a word (i.e., a critical lure) retrieved in the recall procedure was not presented using one of two judgement paradigms: (1) *diagnostic monitoring*, when the failure to recollect the self-generated word lead participant to conclude that it was not presented (e.g., “If the word *mother* was presented, I would remember it”), or (2) *disqualifying monitoring*, when the recall of presented items allows participant to reject an invalid self-generated word (e.g., “I remember all the words of that list, so this word could not be presented”). In fact, several studies support the role of monitoring processes in reducing false memories (e.g., Gallo, 2006; Gallo et al., 2001; Gallo, Roberts, & Seamon, 1997; Israel & Schacter, 1997; McDermott & Roediger, 1998; McDermott & Watson, 2001; Roediger et al., 2001; Smith & Hunt, 1998).

Monitoring processes can be disrupted when participants have insufficient information to distinguish the associates from the critical items. Similarly, failure in monitoring processes may occur when the processing conditions force an individual to divide attention between several stimuli or perform a concurrent task. When a monitoring process is disrupted, an activation mechanism is thought to cause participants to make incorrect attributions about the source of their memories. Dividing attention can reduce an individual's memory for what happened during the process of encoding a list (e.g., perceptual details, emotional reactions, cognitive operations involved at encoding). Consequently, this impairs the recollection-based monitoring processes, which are thought to support accurate memory (Gallo, 2006). According to Perez-Mata, Read and Diges (2002), the monitoring processes of *detection* and *marking* of the self-generated (critical) items should demand attention. Thus, the impoverished encoding conditions that are due to divided attention can result in an increase in false memories, despite a reduction in correct recall or recognition.

Studies that enhance the distinctiveness of items in the list (e.g., repeating list words, listening and writing the presented words or their second letter - Benjamin, 2001, Experiment 2; Seamon et al., 2003, Experiment 1) show a reduction in DRM false memory production, supporting the role of *verbatim* traces in promoting effective recollection-based monitoring processes.

We could also hypothesise that a reduction of false memories, not an enhancement, would occur due to the disruption of the activation of the semantic network caused by division of attention during encoding. The majority of studies that analysed the impact of the processing level during the DRM standard procedure (full attention) reinforce this hypothesis, confirming that shallow processing of associates decreases the occurrence of false memories in recall and recognition task (e.g., Rhodes & Anastasi, 2000, Experiments 1 and 2; Thapar & McDermott, 2001, Experiments 1 and 2; Toglia, Neuschatz, & Goodwin, 1999, Experiment 1). In fact, the tasks that emphasise processing semantic features of words (e.g., assessment of the level of pleasantness of words, completion of sentences) increase the probability of falsely retrieving the critical lure because the words share a common meaning (associates and critical lures). This induces participants to misattribute the source of their memories for critical words.

Research investigating the effects of divided attention has produced conflicting results. Overall, studies have found that dividing attention reduces correct recall and increases false recall (e.g., Dewhurst, Barry, & Holmes, 2005, Experiment 1; Dewhurst, Barry, Swannell, Holmes, & Bathurst, 2007, Experiment 3; Pérez-Mata et al., 2002, Experiments 1 and 2). Some authors suggest that this pattern is determined by the participants' adoption of a response criterion shift that compensates for their poor performance. When participants realise that performance under a divided attention condition is impaired, they try to compensate for their poor performance by recalling related intrusions. Some of the related intrusions are critical items (Dewhurst et al., 2005, 2007). In fact, the increase in falsely recalling unrelated items is consistent with this explanation (Dewhurst et al., 2007, Experiments 1 and 3). Concerning the recognition task, the results are also conflicting. While some studies showed lower levels of false alarm for critical lures when attention was divided during the encoding phase (e.g., Dewhurst et al., 2005; Dewhurst et al., 2007), others report an increase in false alarm for the critical item or did not find any difference relative to the full attention condition (e.g., Dodd & MacLeod, 2004; Peters et. al, 2008; Wimmer & Howe, 2010).

These conflicting results may be accounted for by differences in the dividing attention procedures employed across the studies. In studies aiming to analyse the impact of the level of attention at encoding, participants are instructed to perform a secondary task while they study the DRM lists. Different tasks have been used, such as articulatory suppression (Dewhurst et al. 2005), random number generation (Dewhurst et al., 2005; Dewhurst et al., 2007), digit monitoring (Dewhurst et al., 2007), Stroop modified task (Dodd & MacLeod, 2004), video clip perspective changes monitoring task (Pérez-Mata et al., 2002), digit/letter monitoring (Pérez-Mata et al., 2002), auditory oddball task (Peters et al., 2008), writing words (Seamon et al., 2003), writing the second letter of words (Seamon et al., 2003), counting backward (Seamon et al., 2003) and the day/night Stroop task (Wimmer & Howe, 2010).

Several authors claim that the production of false memories depends on the extent to which the secondary task is cognitively demanding and, thus, interferes with the monitoring processes, (externally presented or internally generated). In addition, false memory production depends on the level at which the secondary tasks disrupt the activation of the semantic network, preventing the generation of semantic associates. Because research concerning the effect of dividing attention on DRM false memory production has reported incongruent results and because of the multiple hypotheses that can be generated based on theories explaining false memories, more studies are necessary to understand the role of attention in the DRM paradigm. Our study aimed to contribute to this debate by comparing the effect of divided attention on false memory for critical items produced in free recall and recognition tests using the same concurrent task. Within participants, we manipulated attention using dichotic listening (Broadbent, 1958) and shadowing (Cherry, 1953). Contrary to the reported studies, participants did not perform a concurrent task that was totally unrelated to the target task. Instead, we simultaneously presented two DRM lists, and asked the participants to either pay attention to both - a dichotic listening procedure which forced participants to their divide attention between both lists presented - or to rehearse aloud the words of one of the lists - a shadowing procedure that induced full attention on the rehearsed list and reduced the attention paid toward the unshadowed list. By doing this, we sought to increase memory load through the simultaneous presentation of two lists of words and to interfere with the activation of associates during the dichotic and shadowing procedures.

According to the activation-monitoring framework, because semantic activation plays an important role in explaining the DRM effect, we expect a decrease in false memories in the divided attention condition (dichotic listening) comparing to the shadowing condition. Despite participants being unable to successfully monitor their memory for the presented items – given the encoding of two concurrent lists – which results in an increase in false memories, we expect a reduction in false memories due to decreased activation of the semantic network. In fact, the presentation of lists associated with different critical items should induce a lower activation of each critical item, and thus reduce the thematic extraction.

METHOD

Participants. A total of 76 college students (69 females, 7 males, mean age = 20.6, SD = 3.89, age range from 18 to 40 years-old) from the University of Minho participated in this study for course credits.

Materials and stimuli. Participants were given six Portuguese lists of 15 associates developed by Albuquerque (2005, see Appendix A). In addition, there were two practice lists drawn from the same Portuguese free association norms.

All the lists were recorded by the same female voice, and each word pair was presented simultaneously, at a rate of 1.5 seconds. To record and control presentation times and align the beginning of each pair of words, "Avid Media Composer 9000" software was used. The lists were presented on independent channels using headphones.

The words selected for the recognition task included the following: six critical lures of the studied lists, 12 studied words (1st and 5th presented word of each list), 12 non-studied associated words (two from each list), and 12 non-studied unrelated words (see Appendix B).

Design and procedure. A 2 (encoding condition: dichotic listening versus shadowing) x 2 (type of item: studied words versus critical items) within-participants factorial design was used. Thus, similar to other studies, the attention (full versus divided) was manipulated within-participants (e.g., Dewhurst et al., 2005, Experiment 1; Dewhurst et al., 2007).

We conducted separate ANOVAs to analyse the recall and recognition results. The order of list presentation, encoding condition and auditory channel shadowed (right or left) were counterbalanced.

Participants were tested individually, and they were informed that they would simultaneously hear two different lists in each auditory channel using headphones. In one trial, participants were told to pay (divide) attention to words heard in both channels, and in the remaining two trials, they were instructed to focus attention on the words heard in one channel (right or left) and repeat those words. To encourage participants to follow these instructions, they were informed that the experimenter would check the accuracy of word repetition or shadowing. Participants were also informed that they would be presented with three different pairs of lists in the three trials: one with the dichotic listening presentation, one with the left ear presentation of the shadowed list, and one with the right ear presentation of the shadowed list.

Because the memory task was manipulated between-subjects, the participants were assigned to each condition in an arrival basis. Despite the encoding condition, the participants knew that they should remember both lists for a subsequent memory task (recall or recognition). Regardless of the encoding task, participants of the recall condition were instructed to write all the words they remember without guessing after listening to each pair of lists. Each recall task lasted 60 seconds. The remaining participants were told that after the presentation of all pairs of lists, they would be presented with several words. They had to identify the words they remembered hearing (regardless the encoding task). To respond, participants had to press two distinct keyboard keys ("Y" or "N", yes or no response, respectively) to identify their answers.

The total procedure lasted an average of 20 minutes.

RESULTS

Recall task

Two participants were excluded because they did not follow the instructions.

Table 1 shows the mean percentage for recall and recognition of the presented words and critical items for the shadowed lists (SL) and dichotic listening lists (DL).

Table 1. Mean proportions and standard deviations (in parentheses) for studied words and critical lures in recall and recognition tasks as a function of encoding condition (SL – shadowed lists; DL – dichotic lists)

	Recall		*Recognition*	
Item Type	SL	DL	SL	DL
Studied Words	.40 (.10)	.30 (.08)	.80 (.22)	.72 (.25)
Critical Items	.38 (.35)	.26 (.08)	.87 (.22)	.75 (.30)

A 2 (type of item: studied words versus critical items) x 2 (encoding condition: shadowing versus dichotic listening) ANOVA for repeated measures yielded a significant main effect of encoding condition [$F(1, 35) = 6.123$, $p = .018$, $\eta^2 = .149$]. Neither the main effect of type of item [$F(1, 35) = .628$, $p = .433$] nor the interaction between encoding condition and type of items [$F(1, 35) = .003$, $p = .957$] were significant.

In the shadowing condition (as in the dichotic listening) participants must recall all presented words in each trial, which includes the items in the shadowed list and the unshadowed list (associates: $M_{uSLists} = .11$, $DP_{uSLists} = .09$; critical items: $M_{uSLists} = .14$, $DP_{uSLists} = .23$). Thus, we also conducted a 2 (type of item: studied words versus critical items) x 2 (type of list: shadowed lists versus unshadowed lists) ANOVA for repeated measures. Both main effects of type of item [$F(1, 35) = .0002$, $p = .988$] and the interaction of type of item and list [$F(1, 35) = 1.071$, $p = .308$] were not significant. Only list encoding reached significance [$F(1, 35) = 49.364$, $p < .001$, $\eta^2 = .585$].

Recognition task

Concerning recognition task, we conducted a 2 (type of item: studied words versus critical items) x 2 (encoding condition: shadowing versus dichotic listening) ANOVA for repeated measures. This analysis showed that the main effect of type of item [$F(1, 37) = 2.511$, $p = .122$] and interaction between type of item and encoding condition [$F(1, 37) = .455$, $p = .50$] were not significant. The main effect of encoding condition was marginally significant [$F(1, 37) = 3.942$, $p = .05$, $\eta^2 = .096$].

Concerning the shadowed condition, and similar to recall task, we performed a 2 (type of item: studied words versus critical items) x 2 (type of list: shadowed lists versus unshadowed lists) ANOVA for repeated measures (associates: $M_{uSLists} = .26$, $DP_{uSLists} = .24$; critical items: $M_{uSLists} = .22$, $DP_{uSLists} = .34$). The main effect of type of item [$F(1, 37) = .233$, $p = .632$] and the interaction between variables [$F(1, 37) = 3.295$, $p = .078$] were not significant, contrary to the main effect of list type [$F(1, 37) = 138.156$, $p < .001$, $\eta^2 = .789$]

DISCUSSION

Our experiment aimed to analyse the effect of dichotic listening and shadowing procedures on the production of false memories in the DRM paradigm. Based on the amount of false recall and false alarms for the critical items, we can confirm the robustness of this memory distortion (e.g., Gallo et al., 2001; McDermott & Roediger, 1998, Experiments 2 and 3). In fact, even when the encoding conditions are impoverished, participants are prone to falsely remember the critical words.

In both memory tasks, participants' performance in the SL condition differ from the DL condition, suggesting that, when compared with dichotic listening, shadowing produces higher levels of retrieval of presented words and critical lures. These results are in line with those of other research showing that involvement in a secondary task is an important factor to explain performance in divided attention conditions (Dewhurst et al., 2005). In fact, our results for the recall task showed that in both encoding conditions (DL and SL) false recall was similar to the recall of studied items. This effect can be explained by the strength of semantic activation. It is important to consider that beyond dividing attention at encoding, we also increased the memory load (instead of one list, participants heard two lists simultaneously and were instructed to retrieved them later). Dividing attention between lists and increasing memory load impaired word processing, and thus, the likelihood of activating the semantic associates. Participants were unable to deeply encode the meaning of each word, and consequently, to identify the semantic relation among presented and nonpresented items, thus, reducing correct and false recall. A parallel effect was found in studies aiming to analyse the impact of level-of-processing of associates in DRM, which show a decrease of correct and false recall and false recognition when associated lists are shallowly encoded (e.g., Rhodes & Anastasi, 2000, Experiments 1 and 2; Thapar & McDermott, 2001, Experiments 1 and 2; Toglia et al., 1999, Experiment 1).

We also stress that, compared to previous studies that manipulated attention during the DRM paradigm, we notice an opposite result concerning false recall of critical words. In fact, the majority of studies have found that dividing attention reduces correct recall and increases false recall (Dewhurst et al., 2005; Dewhurst et al., 2007; Pérez-Mata et al., 2002). To understand these distinct results, it is important to take into account (besides the lower activation of critical lures) that during each trial condition in our study, participants heard two word lists simultaneously. Moreover, independent of having to shadow one list, participants knew that later they would have to recall the words heard in both channels (a major procedural difference between our and other studies). Thus, contrary to the mentioned studies, overall correct recall was similar across the three trials ($M_{SLits\ and\ uSLists}$ = .27; M_{DLists} = .30). We stress that the data pertaining to the shadowed and unshadowed lists were derived from the same recall task (trials with shadowing task where participants can recall the shadowed and the unshadowed words). Moreover, because participants heard two lists of 15 items (instead of one list), .27 and .30 represents a mean of 8 and 8.9 words, respectively. Unlike the reported studies, the recall of studied items was not impoverished. Consequently, participants were not encouraged to enhance their performance by trying to guess lists words, which explains the absence of an increase in false recall in the DL condition relative to the SL condition.

The same pattern of results, concerning studied and critical words, was obtained when participants performed the recognition task, which reinforces the assumption that the occurrence of an increase in false recall in dividing attention conditions may be due the adoption of a lower response criterion by participants. In fact, some authors stress this factor as explaining the false recall results (e.g., Dewhurst et al., 2005, 2007). Our findings suggest that the effect of divided attention on false memory does not depend on how memory is tested, at least with explicit measures. Participants do not have the possibility of boosting their performance trying to guess the presented words.

Concerning the recall task, an interesting finding was obtained for the unshadowed lists. Despite the fact that participants were unable to recall the large amount of words presented on that ear channel (.11), the proportion of false recall was higher (.14). This result seems to suggest that the activation of the critical word is automatic and, thus, not dependent on the amount of attentional focus given to the unshadowed lists. Evidence that the DRM effect does not require the conscious generation of critical words at the study phase comes from several studies, using different methodologies. Namely, these studies present words extremely rapidly (e.g., Gallo & Seamon, 2004; Seamon et al., 1998) or ask participants to rehearse the words aloud during the encoding of lists (e.g., Seamon et al., 2002).

It is possible that the false alarm for critical lures could be significantly reduced, relative to correct recognition, if the modality of the encoding and tests were the same. In fact, in the present experiment, participants could not use clues concerning perceptive characteristics of the word lists to reject the critical items, via diagnostic monitoring. This occurs when the subject fails to recollect expected information (Gallo, 2006) (e.g., "I didn't hear this word because I don't remember this voice saying it"). In effect, compared to recall tasks that use auditory presentation, (in standard DRM procedure) research shows that visual study reduces the production of critical items. According to Smith and Hunt (1998), visual presentation contributes to a better distinction between items internally generated and externally presented (critical items versus words lists). This effect is so robust during recognition tasks that it is even observed in cross-experiment comparisons (see Gallo, 2006). Lacking the distinctive visual features of words, participants' memory for words may have relied mainly on their gist trace, which is enduring. However, further studies are needed to clarify the role played by modality in the DRM effect when attentional focus is disturbed.

To our knowledge, the present experiment is the first using shadowing and dichotic listening tasks to analyse the effect of divided attention during encoding on DRM false memory production. Future research, employing the same methodology, should use more lists per encoding condition. It could also be enlightening to adapt the method to a visual presentation in order to specifically examine the impact of modality and divided attention encoding on the DRM effect.

RESUMEN

Efectos de la atención dividida en la producción de falsos recuerdos en el paradigma DRM: Un estudio con escucha dicótica y ensombrecimiento. En el procedimiento Deese/Roediger-McDermott (DRM) se presenta a los participantes listas de palabras asociadas (e.g., cama, noche, pesadilla, etc.) a una palabra crítica no presentada (e.g., sueño). La probabilidad de producir un falso recuerdo de la palabra crítica no presentada es muchas veces similar (o un poco superior) a la probabilidad de recordar correctamente una palabra presentada en mitad de la lista. Los falsos recuerdos producidos mediante este procedimiento son, en general, muy vívidos, de larga duración y muy difíciles de evitar. Nuestro experimento intentó analizar el efecto de la escucha dicótica y del ensombrecimiento - dos procedimientos clásicos de manipulación de la atención - en la producción de falsos recuerdos con el paradigma DRM. Los resultados muestran que no se elimina la producción de falsos recuerdos cuando las listas se presentan por el canal no atendido, independientemente de la prueba de memoria – recuerdo libre o reconocimiento –. De hecho, la proporción de falsas memorias es similar a la proporción de recuerdo y reconocimiento correctos. Este estudio confirma la robustez de este error de la memoria (e.g., Gallo, Roediger, & McDermott, 2001), verificándose que incluso cuando las condiciones de procesamiento son difíciles (debido a la división de la atención entre dos listas y el ensombrecimiento de una de ellas) los participantes tienden a producir falsas memorias, lo que refuerza la hipótesis de la activación automática de los ítems críticos.

REFERENCES

Albuquerque, P. B. (2005). Produção de evocações e reconhecimentos falsos em 100 listas de palavras associadas portuguesas. *Laboratório de Psicologia, 3,* 3-12.

Benjamin, A. S. (2001). On the dual effects of repetition on false recognition. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 27*, 941-947.

Brainerd, C. J., & Reyna, V. F. (1996). Mere memory testing creates false memories in children. *Developmental Psychology*, *32*, 467-476.

Brainerd, C. J., & Reyna, V. F. (1998). Fuzzy-trace theory and children's false memories. *Journal of Experimental Child Psychology, 71*, 81-129.

Brainerd, C. J., & Reyna, V. F. (2002). Fuzzy-trace theory and false memory. *Current Directions in Psychological Science, 11,* 164–169.

Broadbent, D. E. (1958). *Perception and communication*. London: Pergamon Press.

Cadavid, S., Beato, M. S., & Fernandez, A. (2012). Falso reconocimiento en listas DRM con tres palabras críticas: Asociación directa vs. inversa. *Psicológica*, *33*, 39-58.

Cherry, E. C. (1953). Some experiments on the recognition of speech, with one and with two ears. *Journal of the Acoustical Society of America, 25,* 975-979.

Dewhurst, S. A., Barry, C., & Holmes, S. J. (2005). Exploring the false recognition of category exemplars: Effects of divided attention and explicit generation. *European Journal of Cognitive Psychology, 17*, 803-819.

Dewhurst, S. A., Barry, C., Swannell, E. R., Holmes, S. J., & Bathurst, G. L. (2007). The effects of divided attention on false memory depend on how memory is tested. *Memory & Cognition, 35,* 660-667.

Dodd, M. D., & MacLeod, C. M. (2004). False recognition without intentional learning. *Psychonomic Bulletin & Review, 11,* 137-142.

Gallo, D. A. (2006). *Associative illusions of memory: false memory research in DRM and related tasks*. New York: Psychology Press.

Gallo, D. A., Roberts, M. J., & Seamon, J. G. (1997). Remembering words not presented in lists: Can we avoid creating false memories? *Psychonomic Bulletin & Review, 4,* 271-276.

Gallo, D. A., Roediger, H. L., & McDermott, K. B. (2001). Associative false recognition occurs without strategic criterion shifts. *Psychonomic Bulletin & Review, 8,* 579-586.

Gallo, D. A., & Seamon, J. G. (2004). Are nonconscious processes sufficient to produce false memories? *Consciousness & Cognition*, *13,* 158-168.

Hicks, J. L., & Starns, J. J. (2005). False memories lack perceptual detail: Evidence from implicit word-stem completion and perceptual identification tests. *Journal of Memory and Language, 52,* 309-321.

Israel, L., & Schacter, D. L. (1997). Pictorial encoding reduces false recognition of semantic associates. *Psychonomic Bulletin & Review, 4,* 577-581.

McDermott, K. B., & Roediger, H. L. (1998). Attempting to avoid illusory memories: Robust false recognition of associates persists under conditions of explicit warnings and immediate testing. *Journal of Memory and Language, 39,* 508-520.

McDermott, K. B., & Watson, J. M. (2001). The rise and fall of false recall: The impact of presentation duration. *Journal of Memory and Language, 45,* 160-176.

McKone, E., & Murphy, B. (2000). Implicit false memory: Effects of modality and multiple study presentations on long-lived semantic priming. *Journal of Memory and Language, 43,* 89-109.

Pérez-Mata, M. N., Read, J. D., & Diges, M. (2002). Effect of divided attention and word concreteness on correct and false memory reports. *Memory, 10,* 161-177.

Peters, M. J. V., Jelilic, M., Gorski, B., Sijstermans, K., Giesbrecht, T. & Merckelbach, H. (2008). The corrective effects of warning on false memories in the DRM paradigm are limited to full attention conditions. *Acta Psychologica, 129*, 308-314.

Pimentel, E. & Albuquerque, P. B. (2011). Paradigma Deese-Roediger-McDermott: Efeito da evocação prévia e tipo de tarefa de memória. *Psicologia: Teoria e Pesquisa, 27,* 315-325.

Robinson, K. J., & Roediger, H. L. (1997). Associative processes in false recall and false recognition. *Psychological Science, 8,* 231-237.

Roediger, H. L., Balota, D. A., & Watson, J. M. (2001). Spreading activation and the arousal of false memories. In H. L. Roediger, J. S. Nairne, I. Neath, & A. M. Surprenant (Eds.), *The nature of remembering: Essays in honor of Robert G. Crowder* (pp. 95-115). Washington, DC: American Psychological Association Press.

Roediger, H. L., III, & McDermott, K. B. (1995). Creating false memories: Remembering words not presented in lists. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 21,* 803-814.

Roediger, H. L., III, Watson, J. M., McDermott, K. B., & Gallo, D. A. (2001). Factors that determine false recall: A multiple regression analysis. *Psychonomic Bulletin & Review, 8,* 385-407.

Rhodes, M. G., & Anastasi, J. S. (2000). The effects of a levels-of-processing manipulation on false recall. *Psychonomic Bulletin & Review, 7,* 158-162.

Seamon, J. G., Goodkind, M. S., Dumey, A. D., Dick, E., Aufseeser, M. A., Strickland, S. E., et al. (2003). "If I didn't write it, why would I remember it?" Effects of encoding, attention, and practice on accurate and false memory. *Memory & Cognition, 31,* 445-457.

Seamon, J.G., Lee, I.A., Toner, S.K., Wheeler, R.H., Goodkind, M.S., & Birch, A.D. (2002). Thinking of critical words during study is unnecessary for false memory in the DRM procedure. *Psychological Science, 13*, 526-531.

Seamon, J. G., Luo, C. R., & Gallo, D. A. (1998). Creating false memories of words with or without recognition of list items: Evidence for nonconscious processes. *Psychological Science, 9,* 20-26.

Smith, S. M., Gerkens, D. R., Pierce, B. H., & Choi, H. (2002). The roles of associative responses at study and semantically guided recollection at test in false memory: the Kirkpatrick and Deese hypotheses. *Journal of Memory and Language, 47,* 436-447.

Smith, R. E., & Hunt, R. R. (1998). Presentation modality affects false memory. *Psychonomic Bulletin & Review, 5,* 710-715.

Tajika, H., Neumann, E., Hamajima, H., & Iwahara, A. (2005). Eliciting false memories on implicit and explicit memory tests after incidental learning. *Japanese Psychological Research, 47,* 31–39.

Thapar, A., & McDermott, K. B. (2001) False recall and false recognition induced by presentation of associated words: Effects of retention interval and level of processing. *Memory & Cognition, 29,* 424-432.

Toglia, M. P., Neuschatz, J. S., & Goodwin, K. A. (1999). Recall accuracy and illusory memories: When more is less. *Memory, 7,* 233-256.

Wimmer, M. C., & Howe, M. L. (2010). Are children's memory illusions created differently from those of adults? Evidence from levels-of-processing and divided attention paradigms. *Journal of Experimental Child Psychology, 107*, 31-49.

APPENDIX

Appendix A. Mean scores by list of associates (english translation in parenthesis): mean backward association (MBAS), word frequency, word concreteness, word imagery, probability of false recall, probability of false alarm, and theme identifiability)

List	MBAS	Frequency	Concreteness	Imagery	False Recall	False Recognition	Theme identifiability
Slow	.274	73,359	4.54	4.01	.69	.83	.11
Sweet	.334	75,968	4.85	4.27	.68	.92	.30
Needle	.145	28,715	4.87	5.16	.67	.93	.32
Wine	.189	58,036	5.18	5.68	.61	.89	.17
Door	.262	116,664	4.57	5.08	.60	.87	.54
Sun	.156	177,291	5.34	5.87	.58	.69	.25

Lento (Slow)*:* rápido (quick), caracol (snail), devagar (slowly), tartaruga (turtle), calmo (calm), vagaroso (tardy), preguiçoso (idle), demorado (lasting), comboio (train), molengão (lazy), tempo (time), lesma (slug), inactivo (inative), irritante (irritating), alentejo (*without translation*)
Doce (Sweet)*:* bolo (cake), bom (good), amargo (bitter), açúcar (sugar), chocolate (chocolate), mel (honey), algodão (cotton), salgado (salty), gelado (ice-cream), agradável (nice), saboroso (delicious), rebuçado (lollipop), guloso (glutton), sobremesa (dessert), gostoso (tasty)
Agulha (Needle)*:* picada (prick), linha (string), coser (to sew), dor (pain), palheiro (straw loft), costura (needlework), dedal (thimble), alfinete (pin), fina (thin), fio (thread), seringa (syringe), bordar (to embroider), injecção (injection), roupa (clothes), sangue (blood)
Vinho (Wine)*:* tinto (tinged), uvas (grapes), álcool (alcohol), bebida (drink), copo (glass), água (water), garrafa (bottle), verde (green), porto (oporto), jantar (dinner), branco (white), bebedeira (drunkenness), beber (to drink), vermelho (red), adega (wine cellar)
Porta (Door)*:* entrada (entrance), casa (house), janela (window), aberta (open), saída (exit), abrir (to open), chave (key), madeira (wood), fechada (closed), fechadura (lock), passagem (passage), obstáculo (obstacle), maçaneta (knob), segurança (security), campainha (bell)
Sol (Sun)*:* praia (beach), calor (heat), luz (light), verão (summer), amarelo (yellow), alegria (joy), quente (warm), brilho (brightness), lua (moon), vida (life), dia (day), chuva (rain), céu (sky), brilhante (brilliant), férias (holiday)

Appendix B. Words presented at the recognition task: critical lures, studied words, nonstudied associated words, and nonstudied unrelated words (English translation in parenthesis)

List	Critical lure	Studied words	Nonstudied associated words	Nonstudied unrelated words
1	lento (slow)	rápido (quick) calmo (calm)	chato (annoying) lentidão(slowness)	amor (love) áfrica (africa)
2	doce(sweet)	bolo (cake) chocolate (chocolate)	morango (strawberry) azedo (sour)	presos (prisoners) cão (dog)
3	agulha (needle)	picada (prick) palheiro (straw loft)	costureira (dressmaker) espetar (to spit)	azul (blue) sujidade (dirt)
4	vinho (wine)	tinto (red wine) copo (glass)	festa (party) bêbado (drunk)	peixes (fishes) cultura (culture)
5	porta (door)	entrada (entrance) saída (exit)	rua (street) barreira (barrier)	baixo (low) carne (meat)
6	sol (sun)	praia (beach) amarelo (yellow)	claridade (brightness) energia (energy)	puro (pure) círculo (circle)

(Manuscript received: 21 June 2012; accepted: 23 January 2013)