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Remember/Know and Modality Effects in a Forced-Choice Test of False Memory

Sahte Hatıralarda Zorunlu Seçim Yöntemi ile Hatırlıyorum/ Biliyorum ve Modalite Etkileri

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ABSTRACT

The main aim of this study was to observe the sensitivity for discriminating old and new words for three word types (critical, related, unrelated) in Deese-Roediger-McDermott (DRM) lists. With this aim, for all three kinds of DRM paradigm word types we paired one presented word on study phase against one word that was not presented in each trial in a two-alternative forced choice test. We tried to answer three questions related to false positive responses in the DRM paradigm: First, do false positives stem from a response bias or do the participants have lower sensitivity to distinguish nonstudied from studied words? We used a forced-choice recognition task in order to isolate the effect of sensitivity. Second, is a potential reduction in sensitivity related to recollection or familiarity? We asked participants to classify their responses as "remember", "know", or "guess" in order to explore this issue. Third, is there a difference in sensitivity for prior study in auditory and visual list learning tasks and their distribution into the three kinds of recognition responses? For the first question of the study as a result of the research we observed lower sensitivity for the critical words of the DRM lists than words in unrelated lists. When the findings they classified in terms of recognition memory were examined, it was observed that remember responses clearly differentiated for the three types of words. It was an answer for the second question of the study that sensitivity reduction was related with recollection more than familiarity. Modality did not make a difference in any measure.

Keywords: False memory, DRM paradigm, signal detection theory, remember/know

ÖZ

Araştırmanın temel amacı Deese-Roediger-McDermott (DRM) yöntemiyle ortaya çıkan sahte hatıralarda eski ve yeni kelimeler üzerindeki duyarlılığın etkisinin gözlemlenmesi ve yanıt yanlılığı dışarıda bırakılarak DRM listelerindeki kelime türleri üzerinden duyarlılık etkilerinin daha iyi anlaşılabilmesidir. Bu amaçla DRM paradigmasında iki alternatifli zorunlu seçim yöntemi yardımı ile üç kelime türünün (kritik, ilişkili, ilişkisiz) gerçekten çalışılmış ve gerçekte çalışılmamış çiftleri eşleştirilmiştir. Bu sayede DRM görevlerinde gözlenen yanlış pozitif cevaplarla ilgili üç soruya cevap vermeye çalışılmıştır: Birinci soru, yanlış pozitif yanıtlar bir yanıt yanlılığından mı kaynaklanıyor yoksa katılımcılar çalıştıkları sözcükleri ayırt etmekte daha az bir duyarlılığa sahip olduklarından, yani kelimelerin kendilerine gerçekten sunulup sunulmadığını ayırt edemediklerinden dolayı mı hata yapmaktadır? Yanıtlardaki yanlılık etkileri dışarıda bırakılarak, duyarlılığın etkisini izole etmek için test aşamasında evet-hayır testi yerine iki alternatifli zorunlu seçim tanıma görevi kullanılmıştır. İkinci soru, duyarlılıktaki potansiyel bir azalma, tanıma belleğinin anımsama mı yoksa aşinalık bileşeni ile mi ilişkilidir? Bu konuyu araştırmak için katılımcılardan yanıtlarını "hatırlıyorum", "biliyorum" veya "tahmin ediyorum" şeklinde sınıflandırmaları istenmiştir. Üçüncü ve son soru ise, listeleri işitsel veya görsel modalitede öğrenme görevlerinde, çalışılan kelimelere karşı duyarlılıklarında ve bunların üç tür tanıma yanıtına dağılımı arasında bir fark var mıdır? Çalışmanın birinci sorusuna yanıt olarak araştırma sonucunda katılımcıların, DRM listelerinin kelime türlerinden kritik kelimeler için ilişkisiz listelerdeki kelimelerden daha düşük duyarlılıkları olduğu gözlemlenmiştir. Çalışmanın ikinci sorusuyla ilgili olarak verdikleri yanıtlarını tanıma belleği açısından sınıfladıkları bulgular incelendiğinde hatırlıyorum yanıtlarının üç kelime türü için açık şekilde farklılık gösterdiği gözlenmiştir. Duyarlılıktaki azalmanın aşinalıktansa anımsama ile ilgili olduğu görülmüştür. Görsel ve işitsel modalite arasında herhangi bir ölçümde anlamlı bir fark olmadığı görülmüştür.

Anahtar Kelimeler: Sahte hatıralar, DRM listeleri, sinyal denetleme teorisi, hatırlıyorum/biliyorum

In the 1990s Roediger and McDermott (1995) popularized an experimental method of inducing false memories in remembering word lists. This method, which came to be known as the Deese-Roediger-McDermott (DRM) paradigm involves presenting lists of words that are created by eliciting semantic associates of a single word. The seed word, which is called the *critical word*, is not presented among the words to be remembered but it is frequently recalled and recognized as having been presented. Such instances of false memory occur at rates similar to the correct recall and recognition rates of words that are presented in the middle portion of the list, that is, outside of the primacy and recency regions (Gallo, 2006; Roediger & McDermott, 1995; Schacter, Norman, & Koutstaal, 1998). In addition to their frequency, these memory errors are striking on account of being mostly "remember" rather than "know" type of recognition responses (Roediger & McDermott, 1995).

Although findings of Roediger and McDermott (1995) precipitated a very active line of research since, the certain aspects of the memory error have not been studied extensively. A non-studied word may be reported as having been studied because participants are unable to distinguish them from studied items or they may be biased to respond to the critical words as having been studied. Miller and Wolford (1999) were the first to object to the authenticity of the observed phenomenon as false memory. They pointed out that because the critical words were never presented in the DRM paradigm, it was not possible to compare responses to non-studied critical words with responses to studied critical words.

Miller and Wolford (1999) did present some of the critical words to their participants in their experiments and observed that not only false alarm (FA) rates but also hit rates were exceptionally high for the critical words. A Signal Detection Theory (SDT; Green & Swets, 1966) analysis of the responses indicated that response biases were different for critical, related (list items that were associates of the critical words) and unrelated (items that were unrelated to other items within and across lists) words. Sensitivity (that is, the measure of the ability to distinguish "old" from "new" items at test) on the other hand, did not differ among the three kinds of words. However, Westerberg and Marsolek (2003) showed that sensitivity for critical words was lower than sensitivity for related and unrelated words following DRM list learning in three experiments using SDT procedures. Calvillo and Parong (2016) and Ost and others (2013) also observed reductions in discriminating critical words from actually presented words com-

pared to discriminating unrelated new words from presented words in yes/no (or old/new) recognition tests.

An alternative way of concentrating on sensitivity and leaving out response bias as an explanation of memory errors with DRM lists is to use a forced-choice response procedure rather than a yes/no procedure in the recognition test (Green & Swets, 1966). In forced-choice recognition participants are asked to select which one of the response alternatives represents a studied word. In a two-alternative forced choice recognition test each studied word would be presented together with a non-studied word in each trial of the test. Westerberg and Marsolek (2003, experiments 2 and 3) and Weinstein, McDermott and Chan (2010) used forced-choice recognition tests in the context of DRM list learning. Whereas Westerberg and Marsolek presented two words of the same type (e. g., two critical words) such that one would be studied and one would be non-studied, Weinstein and others pitted non-studied critical words against studied related words. Both studies demonstrated reductions in sensitivity for critical words when response bias was eliminated as an explanation in this manner.

Another important property of false recognition responses in the DRM paradigm is the phenomenology of the responses. Unlike FAs in most memory tasks, false memories in the DRM paradigm are accompanied by a false recollection experience. Recognizing an item as having been studied earlier may be based on two factors: On the one hand the item may be processed fluently and perceived as being familiar. On the other hand, the respondent may be able to mentally recreate the original encounter with the test word in order to decide that it was studied (Gardiner & Parkin, 1990; Rajaram, 1993; Yonelinas, 2002). One way of distinguishing these two types of recognition is to ask the participants to indicate whether they "know" (K response) or "remember" (R response) having studied the test word. Falsely recognized critical words in the DRM paradigm receive very high rates of R responses (Miller & Wolford, 1999; Roediger & McDermott, 1995).

Considering the reduction in sensitivity in recognition and the high rates of R responses brings up an important question: Do the high rates of reporting recollection experiences for the episode of study for the critical words reflect a bias to respond in that manner or are the participants in such experiments unable to distinguish recollection of an actually studied target word from the false recollection of a critical word that has not been studied? Brainerd, Reyna, and Mojardin (1999) introduced the concept of phantom

recollection for such false recollective experiences. DRM lists can cause phantom recollection because strong gist memory for the meanings of the related items converging on the meaning of the critical word can create a falsely vivid memory (Reyna & Lloyd, 1997). Examining the rates of "remember" and "know" responses in response to studied and non-studied words of different kinds (critical, related, unrelated) was another aim of this research.

EXPERIMENT 1

In the first experiment reported in this paper we had two goals. First, we wanted to replicate the reduction in sensitivity for critical words in the DRM paradigm that was reported by Westerberg and Marsolek (2003) and Weinstein and others (2010). We used the forced-choice recognition test in order to investigate this question. Second, we wanted to investigate the phenomenology of the sensitivity reduction in terms of "Remember" and "Know" responses in the DRM paradigm. For this purpose, after each recognition response we asked our participants to make a "remember", "know" or "guess" classification.

METHOD

Participants

Forty undergraduate students of Uludag University (26 female, 14 male) with a mean age of 19.23 (*SD* = 1.45) participated in the experiment. Participants were recruited by placing posters announcing the experiment in the Psychology Department of Uludag University and making announcements at class meetings of introductory courses at the same department. Participation was completely voluntary.

Materials

Tekcan and Göz's (2005) category norms in Turkish were used to create 32 DRM lists of 17 words each. Each list consisted of one critical word and 16 related words. The related words were the 16 words that were reported as the most frequent association of the critical word. These lists were used in the experiment in two different versions. In one version 16 related words were present but the critical word was not included. In the alternative version the critical word replaced one of the related words in the list. For this purpose, the word closest to the critical word in terms of imagery and concreteness values (Tekcan & Göz, 2005) was chosen. Mean associative strength of replaced related words were 7.31 (*Min*. = 1, *Max*. = 49).

In addition to the critical and the related words, the experiment included unrelated words. Four lists of unrelated words were created such that each word in these lists was semantically unrelated to the other words in the list and also to words in all other lists. Each unrelated list contained 16 words. The unrelated words were matched to the critical words as closely as possible in terms of average imagery and concreteness values. They were also matched to the related words that the critical words replaced when the critical words were presented in a list. The average imagery and concreteness values of the three types of words are given in Table 1.

Table 1. Average imagery and concreteness ratings and standard deviations of the words used in the experiments (*SD*s in parentheses)

	Imagery	Concreteness
Critical	5.23 (1.36)	5.41 (1.68)
Related	5.46 (1.29)	5.66 (1.48)
Unrelated	5.13 (1.11)	5.79 (1.33)

There were two more lists of unrelated words that were presented to all participants, one at the beginning and one at the end of the study phase of the experiment. These lists were used so that there would be no primacy and recency effects on the lists from which the data were obtained. No words were used multiple times in all lists. The lists were also used in the master's thesis of the first researcher (Şahin, 2011) and the observed findings were consistent with the other studies using the DRM lists.

Procedure

The experiment consisted of a study phase and a test phase. Participants sat in front of a computer that controlled stimulus presentation and recorded the responses of the participants. At the beginning of the study phase participants were instructed that they would listen to a list of words and they would have to remember them later. The method of the memory test was not specified at this point. Each participant listened to 16 lists that included the critical words but did not include one of the related words and 16 lists that included all the related words but not the critical word. The two versions of the lists were counterbalanced across participants so that the critical word and the related word for any given list was presented to equal numbers of participants. In addition, each participant listened to two of the four lists of unrelated words. The unrelated lists were also counterbalanced across participants. The order of the lists was randomized for each participant. The onsets of consecutive words were separated by 1500 milliseconds. Participants listened to the words through headphones.

In the test phase, all critical words, all related words that were omitted from the lists in which the critical word replaced a related word, and all members of the unrelated word lists were presented to all participants. Presentation was in pairs. In each trial of the test, participants saw two words of the same type (critical, related, or unrelated) such that one was studied and the other was not. The correct word was equally likely to be presented on the left or on the right of the screen. They were instructed to indicate which one of the pair had been presented to them during the study phase of the experiment. They indicated their choices by pressing one of two specified keys on the keyboard. After they indicated which one of the pair they thought was presented, they were asked to indicate whether they remembered, knew or guessed that they had studied that word in the pair. They gave their responses to this question by pressing one of three specified keys on the keyboard.

RESULTS

The proportion of correct responses (hits) was calculated for the three types of words separately for each participant. The proportions were compared across the three types of words by a one-way repeated-measures analysis of variance (ANOVA). Average proportions of hits are presented in Table 2. The ANOVA revealed that there was a significant effect of word type ($F(2, 78) = 11.477$, $p < .01$, $\eta^2 = .28$). Comparisons of pairs of means with Sidak corrections for multiple comparisons indicated that the proportion of hits was higher for the unrelated words compared to the related and the critical words.

After having determined that the participants had greater difficulty distinguishing whether the critical and the related words had been actually presented we went on to analyze the proportions of the R and K responses. Each kind of response was analyzed in a separate ANOVA in which word type and response accuracy (responses following a correct identification of which word in the test pair had been studied [hits], and those following an incorrect choice of the non-studied word as studied [FAs]) were two repeated-measures independent variables.

The average proportions of R responses following hits and false alarms for the three types of words are given in Table 2. The ANOVA showed that R responses were given more frequently following hits than following FAs ($F(1, 39) = 34.24$, $p < .001$, $\eta^2 = .47$) and there was also a significant main effect of word type ($F(2, 78) = 18.74$, $p < .001$, $\eta^2 = .32$). However, these effects were qualified by a significant two-way inte-

raction ($F(2, 78) = 4.10$, $p < .001$, $\eta^2 = .10$). R responses following hits and FAs were analyzed separately in one-way ANOVAs with word type as a repeated-measures variable for this reason. These analyses showed that the effect of word type was significant for the FAs only ($F(1.63, 63.72) = 21.48$, $p < .001$, $\eta^2 = .36$; degrees of freedom were adjusted in this and following analyses if the data significantly departed from the sphericity assumption). Comparisons of means with Sidak corrections showed that average proportions of R responses following FAs for all three kinds of words differed significantly from the other two.

Table 2. Proportions of total, remember, and know hits and false alarms for the three types of words in Experiment 1 (*SD*s in parentheses)

	Hit	Remember (hit)	Know (hit)	False Alarm	Remember (fa)	Know (fa)
Critical	.57 (.16)	.34 (.19)	.14 (.10)	.43 (.16)	.23 (.18)	.11 (.10)
Related	.61 (.13)	.30 (.18)	.14 (.11)	.39 (.13)	.14 (.12)	.11 (.11)
Unrelated	.69 (.13)	.29 (.20)	.15 (.10)	.31 (.13)	.06 (.05)	.07 (.07)

The average proportions of K responses following hits and FAs for the three types of words are given in Table 2. A parallel ANOVA on these responses revealed a significant effect of word type only ($F(2, 78) = 4.53$, $p < .05$, $\eta^2 = .10$). Sidak comparisons showed that there was a smaller proportion of K responses (both correct and incorrect) for critical than for unrelated words. The interaction of word type and accuracy did not reach significance ($p = .06$).

DISCUSSION

Proportion of hits for the three types of words in Experiment 1 differed significantly. This supported the conclusion that false recognition with DRM lists involved a reduction in sensitivity: Participants were less able to distinguish critical words that had been presented from those that had not been presented compared to unrelated words. However, opposite to what Westerberg and Marsolek (2003) found, there was a similar reduction in sensitivity for related words as well. The data also replicated the finding that the false recognition responses to critical words with DRM lists were mostly "remember" responses. In this case, the proportions of false R responses increased stepwise from unrelated to related and critical words. This differentiation did not happen for correct R responses. Thus, it appeared that although word type did not determine proportions of R responses for hits, that is responses to words that had been presented, it significantly influenced the probability of having a false sense of recollection. Such experiences were most common for the critical words.

In order to replicate and generalize these findings to the visual presentation of the study lists we did a second experiment. A further goal of the experiment was to examine whether a possible modality difference between the auditory and sensory modalities in false memory was due to "remember" or "know" type of differences. One of the findings that the DRM paradigm produced was that false memories for critical words were more frequent following auditory presentation of lists compared to visual presentation during the study phase (Gallo, McDermott, Percer, & Roediger, 2001; Hunt, Smith, & Dunlap, 2011; Kellogg, 2001; Smith & Hunt, 1998; Smith, Hunt, & Gallagher, 2008). The distinctive-feature and internal voice explanations have been proposed to explain this difference (Cleary & Greene, 2002). A comparison of the R and K responses after auditory and visual presentation of the to-be-remembered lists could help distinguishing between of the modality effect in false memory.

EXPERIMENT 2

In Experiment 2, we used a forced-choice recognition task in order to isolate the effect of sensitivity in the same way as in Experiment 1. We also asked participants to classify their responses as "remember", "know", or "guess" to investigate sensitivity relation with recollection and familiarity. Different from Experiment 1, we used auditory and visual modality in the list learning phase to examine whether there was a difference in sensitivity for false memories between two modality.

METHOD

Participants

Forty undergraduate student of Uludag University (28 female and 12 male) with a mean age of 19.94 (SD = 1.85) who had not participated in Experiment 1 participated in the experiment. Participants were recruited in the same manner as in Experiment 1.

Materials

Materials were the same as the materials in Experiment 1.

Procedure

The procedure was the same as in Experiment 1 for 20 of the 40 participants. For the remaining 20 participants the only difference was that the words were presented visually rather than auditorily. Each word appeared for 1500 ms at the center of the computer screen.

RESULTS

The proportion of hits was calculated for the three types of words separately for each participant. The average proportions of correct responses can be found in Figure 1. The proportions were compared across the three types of words and two study modalities by a two-way mixed ANOVA. Average proportions of hits are presented in Table 3. Only the main effect of word type was found significant in this analysis ($F(1.83, 69.67) = 4.27$, $p < .05$, $\eta^2 = .10$). Sidak comparisons showed that, as in Experiment 1, there were lower proportions of hits for critical and related compared to unrelated words.

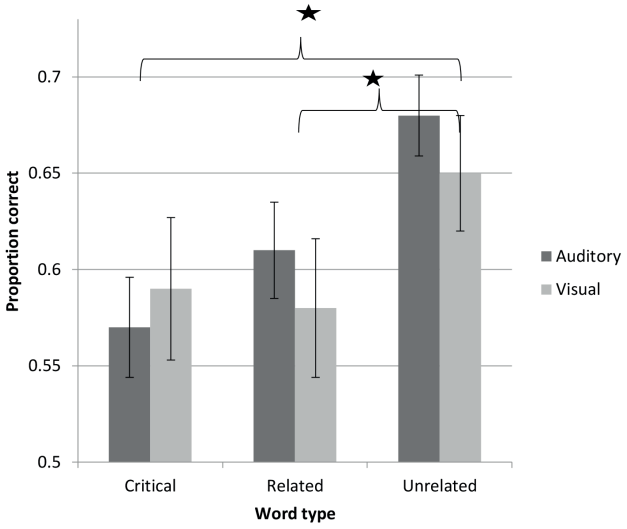

Figure 1. Average proportions of correct responses in the recognition test

Table 3. Proportions of total, remember, and know hits and false alarms for the three types of words studied visually and auditorily in Experiment 2 (*SD*s in parentheses)

		Hit			False Alarm		
		Total Hit	**Remember**	**Know**	**Total FA**	**Remember**	**Know**
Critical	Visual	.59 (.17)	.39(.21)	.10 (.08)	.41(.17)	.26 (.17)	.08 (.06)
	Auditory	.55 (.19)	.34(.23)	.15 (.13)	.45(.19)	.20 (.17)	.16 (.11)
	Total	.57 (.18)	.37(.22)	.12 (.11)	.43(.18)	.23 (.17)	.12 (.10)
Related	Visual	.58 (.21)	.32 (.21)	.11 (.09)	.42(.21)	.20 (.17)	.12 (.12)
	Auditory	.58 (.17)	.27 (.19)	.17 (.15)	.42(.17)	.17 (.13)	.14 (.11)
	Total	.58 (.19)	.29 (.20)	.14 (.12)	.42(.19)	.18 (.15)	.13 (.11)
Unrelated	Visual	.65 (.15)	.30 (.22)	.13 (.09)	.35(.15)	.11 (.11)	.08 (.07)
	Auditory	.64 (.18)	.20 (.12)	.20 (.14)	.36(.18)	.07 (.09)	.08 (.04)
	Total	.64 (.16)	.25 (.18)	.17 (.12)	.36(.16)	.09 (.10)	.08 (.06)

The proportions of R and K responses were analyzed in the same manner as Experiment 1. Only, presentation modality at study was added as a between-groups variable to word type and response accuracy. Average proportions of correct "remember" responses are presented in Figure 2. A significant difference was observed between hits and FAs for the R responses ($F(1, 38) = 20.31$, $p < .001$, $\eta^2 = .35$). As in Experiment 1, participants were more likely to give "remember" responses for words that had been actually studied. There was also a significant main effect of word type ($F(2, 76) = 33.57$, $p < .001$, $\eta^2 = .47$). Proportions of R responses for each kind of word were significantly different from the other two according to Sidak comparisons. There was not a significant main effect of modality or any significant interactions.

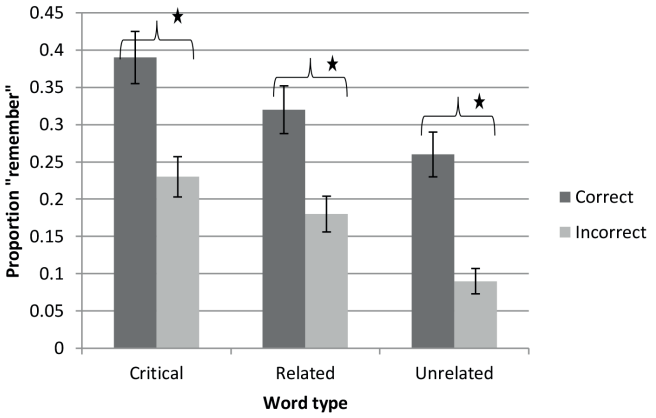

Figure 2. Average proportions of correct and incorrect "remember" responses

In the parallel ANOVA for the K responses there was a significant effect of accuracy ($F(1, 38) = 4.59$, $p < .05$, $\eta^2 = .11$) and a significant interaction of word type and accuracy ($F(2, 76) = 5.43$, $p < .01$, $\eta^2 = .12$). There was also a significant main effect of modality ($F(1, 38) = 6.10$, $p < .05$, $\eta^2 = .14$), which showed that participants who studied the lists auditorily gave more K responses than those who studied visually. Additionally, separate one-way ANOVA comparing proportions of hits and FAs for the three kinds of words showed that the proportions of K responses distinguished studied and non-studied words for the unrelated words only ($F(1, 38) = 19.14$, $p < .001$, $\eta^2 = .34$)

DISCUSSION

One striking result of Experiment 2 was the failure to find any differences between the auditory and visual presentation of the study lists except for fewer "know" responses

for the visual modality. Although it is common to observe more false memories following auditory than visual presentation, there have been studies that failed to obtain such a result (Boldini, Beato, & Cadavid, 2013; Israel & Schacter, 1997). Typically free recall and recognition following free recall are test conditions that are more sensitive to such modality effects (Smith et al, 2008). However, Smith and others (2008) observed a modality effect in a recognition test that required remember/know/guess distinction.

Proportion of hits for the three types of words in Experiment 2 differed significantly (parallel to the results of Experiment 1). Participants reliably had lesser ability to distinguish studied and non-studied critical and related words compared to studied and non-studied unrelated words as same as the results of Experiment 1. False memory in the DRM paradigm was found to involve a sensitivity effect as in the experiments of Westerberg and Marsolek (2003) and Weinstein and others (2010).

The classification of the phenomenology of the recognition responses were not totally consistent with Experiment 1, however. On the one hand, proportions of R responses increased for related compared to unrelated and for critical compared to related words as in Experiment 1. On the other hand, this increase was observed at similar rates for both hits and FAs, and was not specific to non-studied words. Furthermore, for the K responses, hits and FAs for unrelated words were differentiated significantly better than those for related and unrelated words in Experiment 2. This was also different from the results of Experiment 1.

GENERAL DISCUSSION

If we consider the findings of these two experiments together we find clear answers to some of the three issues that they addressed. First, statistically significant differences among proportions of correct responses to different types of words indicated that there was a contribution of reduced sensitivity to false recognition in the DRM paradigm: Participants were poorer at distinguishing studied and non-studied critical words compared to studied and non-studied unrelated words. However, a similar reduction in sensitivity for related words was the opposite of what Westerberg and Marsolek (2003) observed. Possibly the common theme of the list encouraged the Westerberg and Marsolek's participants to engage in verbatim retrieval rather than gist retrieval as described in the fuzzy-trace theory of Brainerd and Reyna (2002). However, our participants may have engaged in more gist retrieval for related words, which would have made

distinguishing presented and non-presented items more difficult. Replicability of both results and possible conditions for adopting either one of the two retrieval strategies require further investigation.

Second, our results provided a rather clear answer to the question of the role of remembering and knowing in false memories: Only the proportions of "remember" responses produced any statistically significant differences among the word types. Critical and related words, which yielded similar results in terms of overall sensitivity, were differentiated in this respect. Although both of these types of words resulted in similarly low levels of sensitivity R responses were significantly more frequent to critical than to related words.

Two experiments produced an inconsistency with regard to the R responses. In only one of the two experiments the differentiation of the three word types was specific to the proportions of FAs of the "remember" type. Thus, although we observed reliably that critical words elicited larger proportions of R responses than related words and related words elicited larger proportions of R responses than unrelated words we did not reliably observe larger proportions of false recollections for critical words. Considering Singer and Remillard (2008) observed phantom recollection in memory for text and Marche and Brainerd (2012) observed phantom recollection in false recall this is an issue that should be investigated further. Our first experiment supports phantom recollection as a possibility in false recognition. Again, further research should be done to investigate the replicability and boundary conditions of this finding.

Third, we did not observe any statistically significant effects of the modality of presentation on the overall rate of false recognitions. Such an effect had been observed in yes/no recognition tests that required remember/know/guess classifications (Smith et al, 2008) although it was not observed with simple old/new responses (Boldini et al, 2013; Smith et al, 2008). It appears that the modality effect depends on encoding perceptual characteristics of the to-be-remembered stimuli, which is more likely with visual compared to auditory words. This is supported by findings showing that factors such as dividing attention (Smith & Engle, 2011; Smith, Reed Hunt, & Dunlap, 2015), lower working-memory capacity (Smith & Engle, 2011), and age (Smith et al, 2015) eliminate the modality effect. It is possible that the absence of such an effect in our experiment may be due to limited attention assigned to the experimental task by our participants. Howe-

ver, two-alternative forced-choice recognition may be another limiting condition for the modality effect. If future research finds this to be a replicable effect, this is a finding that requires further investigation.

To sum up, the results of these experiments strengthen the conclusion that false recognition in the DRM paradigm is associated with an inability to distinguish presented critical words from their non-presented counterparts. This seems to be the case for both auditory and visual study of the lists. Although related words share the same reduction in sensitivity in comparison to unrelated words, they are distinguished from unrelated words in terms of their higher rates of "remember" type of recognition judgments. The rate of "remember" responses is highest for the critical words. The results are inconclusive on the question of whether true and false "remember" responses vary differently for different types of words.

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