Not lost in translation: Writing auditorily presented words at study increases correct recognition 'at no cost'

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Abstract

Previous studies have reported a translation effect in memory, whereby encoding tasks that involve translating between processing domains produce a memory advantage relative to tasks that involve a single domain. We investigated the effects of translation on true and false memories using the Deese/Roediger-McDermott (DRM) procedure [Deese, J. (1959). On the prediction of occurrence of particular verbal intrusions in immediate recall. *Journal of Experimental Psychology, 58,* 17–22; Roediger, H. L., III, & McDermott, K. B. (1995). Creating false memories: Remembering words not presented in lists. *Journal of Experimental Psychology: Learning, Memory, & Cognition*, *21*, 803–814]. Translation between modalities enhanced correct recognition but had no effect on false recognition. Results are consistent with previous research showing that correct memory can be enhanced "at no cost" in terms of accuracy. Findings are discussed in terms of understanding the relationship between true and false memories produced by the DRM procedure.

Keywords: Translation effect; modality effects, recognition memory; false memory

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According to the *translation hypothesis* proposed by Conway and Gathercole (1990), encoding activities that involve translating information from one processing domain to another produce a memory enhancement, relative to activities that involve only a single processing domain. This hypothesis was based on their finding that writing words that were presented auditorily enhanced subsequent recognition of those words, whereas writing words that were presented visually did not enhance their recognition. According to Conway and Gathercole, the former activity involved a translation between phonology and orthography but the latter did not. Although some subsequent studies have cast doubt on the generality of the translation hypothesis (e.g., De Haan, Appels, Aleman, & Postma, 2000), a recent study by Rackie, Brandt, and Eysenck (2015) confirmed the initial findings of Conway and Gathercole by showing translation effects in both recall and recognition memory.

The notion of translation between processing domains also explains previous findings by Gathercole and Conway (1988) that reading aloud visually presented words led to higher recognition scores than a range of conditions that did not involve translation between modalities, such as writing visually presented words. The mnemonic effect of vocalising visually presented words was also demonstrated by Rackie et al. (2015). Moreover, Rackie et al. found that the translation effects produced by vocalisation enhanced the conscious recollection of the studied words, as measured by *remember* responses (Tulving, 1985). Translation between processing domains thus appears to exert a robust effect on memory. The aim of the current study was to investigate the effects of translation between processing domains on false memories.

We investigated false memories using the Deese/Roediger-McDermott (DRM) paradigm. This paradigm, based on a study by Deese (1959) and extended by Roediger and

McDermott (1995), has been widely used to investigate the creation of spontaneous false memories in the laboratory. Briefly, participants study lists of words (e.g., *bed*, *wake*, *rest*, etc.) that are associates of a nonpresented critical lure (in this case, *sleep*). When subsequently asked to remember the words, participants frequently claim that the critical lures were presented at study. This illusory memory effect is observed in tests of both recall and recognition memory (Roediger & McDermott).

A number of theories have been proposed to account for the false memories produced by the DRM paradigm. According to activation-monitoring theory (Roediger, Watson, McDermott, & Gallo, 2001), critical lures are spontaneously activated in response to the DRM lists. At test, participants make errors of source monitoring (Johnson, Hashtroudi, & Lindsay, 1993) and falsely assert that the critical lures were externally presented rather than internally generated. According to fuzzy-trace theory (see Brainerd, Reyna, & Ceci, 2008), participants create both verbatim and gist traces of studied items. Critical lures are falsely remembered because they match the thematic gist of the studied items. The DRM effect has also been explained in terms of the relationship between relational and item-specific encoding (Hunt & Einstein, 1981). Specifically, false memories are increased when encoding activities encourage relational processing and reduced when encoding activities encourage item-specific processing. For example, McCabe, Presmanes, Robertson, and Smith (2004) found that false recognition rates were higher when participants related study items to one another than when they focused on the unique characteristics of each word.

An important issue that has to be accounted for by any theory of memory is the relationship between the true and false memories produced by the DRM procedure. Some studies have shown that false memories behave like true memories, in that they are affected in the same way by experimental manipulations. For example, Toglia, Neuschatz, and Goodwin (1999) investigated the effects of a level-of-processing manipulation on memory for DRM lists and found that semantic processing, relative to nonsemantic processing, increased both correct and false recall (see Thapar & McDermott, 2001, for a similar effect in recognition memory). Toglia et al. referred to this as a ‘more is less’ pattern, whereby levels of correct recall increased numerically but were less accurate. In a second experiment, Toglia et al. found that blocked presentation of DRM lists, relative to randomised presentation, also produced this pattern.

In contrast to the ‘more is less’ pattern, other studies have reported increases in true memory without a corresponding increase in false memory. For example, Soraci, Carlin, Toglia, Chechile, and Neuschatz (2003) investigated the generation effect in the DRM paradigm and found that generating study items from fragments led to higher levels of correct recall and recognition memory than reading intact items, but had no effect on false memory. Soraci et al. referred to this effect as ‘generation at no cost’. Soraci et al. concluded that this pattern occurs because generation encourages item-specific processing rather than relational processing at study and enhances discrimination between targets and lures at test.

In the experiment reported below, we examined the effect of translation on true and false memories. Based on the work of Conway and Gathercole (1990) and of Rackie et al. (2015), we anticipate a translation effect in correct recognition whereby writing will increase the recognition of DRM list items following auditory but not visual presentation. Neither Conway and Gathercole nor Rackie et al. reported analyses of false memory because the stimuli they used were not designed to produce high false alarm rates. In the current study, however, the framework proposed by Soraci et al. (2003) predicts that the increase in correct recognition will not come at the cost of increased false recognition. Although translation between modalities is not a generation task, it is likely to enhance the distinctiveness of encoding of studied items and enhance their discriminability from critical lures at test. The current study incorporated the remember/know procedure (Tulving, 1985) to measure distinctiveness. Based on the findings of Rackie et al. (2015), it was expected that translation would lead to a selective increase in remember responses. Based on previous investigations of modality effects on false memory (e.g., Smith & Hunt, 1998), we expected levels of false recognition to be higher following auditory presentation, regardless of the encoding task.

Method

Participants

Eighty students (63 females) in the age range 18-29 took part for course credit. All were native English speakers with normal or corrected vision and no known hearing impairments. Upon arrival, each participant read and signed a consent form detailing the purpose of the study and their right to withdraw at any point. Previous research indicates that a sample of 80 participants will provide sufficient power to detect translation effects in both correct and false recognition. A power analysis based on data from Rackie et al. (2015) with Cohen’s f of .59 and power (1-β err prob) = .95 indicated that group sizes of 21 would be sufficient to find a translation effect in correct recognition. Although there have been no previous investigations of the effects of translation in false memory, Smith and Hunt (1998; Experiment 3) found that a between-subjects manipulation of modality with a within-subjects manipulation of encoding task (intentional learning versus pleasantness rating) produced significant main effects of both variables in false recognition from a sample of 20 participants.

Materials and Design

Twenty DRM lists containing ten words each were selected from Stadler, Roediger and McDermott (1999). Each participant studied ten lists, with modality of presentation (auditory versus visual) manipulated between groups. Encoding task (writing versus non-writing) was manipulated within groups with each participant writing five lists (presented in a block) and reading or listening to the other five in silence. Allocation of lists to the manipulations of modality and encoding task and the order of the encoding tasks were fully counterbalanced across participants. The recognition test consisted of two studied words from each list, the critical lure from each studied list, and three words (including the critical lure) from each of the ten unstudied lists presented in a random order.

Procedure

Upon arriving at the research lab, participants were randomly assigned to the auditory or visual presentation group. Timed PowerPoint slides were used to display the words in the visual condition, with each word appearing on screen for 2 secs in the non-writing condition and 7 secs in the writing condition, with a 1 sec interval between words. Recorded audio tracks of the lists were used for the auditory condition with the same timings. Longer presentation durations in the writing condition were necessary to allow participants sufficient time to write each word. Participants wrote each word on an individual response sheet which they then placed face down in an empty box to the right-hand side of the keyboard.

After the presentation of the final list, participants were engaged in a 5-minute filler task in which they circled the vowels on a sheet of random letters. They were then given the recognition test in which the 60 test items were presented in two columns on both sides of a response sheet. Printed underneath each word were the four response options of remember, know, new, or guess. Participants were asked to make a ‘remember’ response if they could remember something specific about seeing or hearing each word, such as an image, memory, or association that came to mind when they studied the word, and a ‘know’ response if they recognised the word but could not recollect any specific details of its study presentation. If they believed the word was not presented at study, participants circled the option ‘new’. Finally, participants had the option of making a ‘guess’ response if they were unsure whether or not the word appeared in the study phase. The recognition test was self-paced.

Results

Table 1 shows mean proportions of studied items correctly recognized and critical lures falsely recognized. The data were analysed in a series of 2 (study modality: auditory versus visual) x 2 (encoding task: writing versus non-writing) mixed ANOVAs with repeated measures on the second factor. Separate analyses were conducted on total hits and false alarms (R+K) and on correct and false remember and know responses. Guess responses were not included in the analyses as they were made below chance levels and may have included low confidence correct rejections as well as low confidence hits. The analysis of overall hits showed no significant effect of modality, $F < 1$, but a significant main effect of encoding task, F (1,78) = 5.73, MSE = 2.21, p = .019, η_p^2 = .07. The effect of encoding task was qualified by a significant interaction with modality, F (1,78) = 4.76, MSE = 2.21, p = .032, η_p^2 = .06. Bonferroni-adjusted pairwise comparisons showed that writing significantly enhanced correct recognition following auditory presentation, p = .002, but not following visual presentation, p = .88.

A separate analysis of correct remember responses produced a nonsignificant main effects of modality. F<1, and encoding task, F (1,78) = 2.80, MSE = 3.57, p = .10, η_p^2 = .04. These null effects were qualified by a significant interaction, F (1,78) = 12.80, MSE = 3.57, p = .001, η_p^2 = .14. Bonferroni-adjusted pairwise comparisons showed that writing significantly enhanced correct remember responses following auditory presentation, $p < .001$, but not following visual presentation, p = .18. The analysis of correct know responses also showed nonsignificant main effects of modality and encoding task, both $F < 1$, and a significant interaction, F (1,78) = 8.07, MSE = 1.71, p = .006, η_p^2 = .09. Bonferroni-adjusted pairwise comparisons showed that writing led to a significant increase in correct know responses following visual presentation, p = .02, and a nonsignificant decrease following auditory presentation, p = .09.

The analysis of false alarms (R+K) showed a significant main effect of modality, whereby false alarm rates were higher for lists presented auditorily rather than visually, F (1,78) = 6.23, MSE = 2.93, p = .015, η_p^2 = .07. Neither the main effect of encoding task nor the interaction between encoding task and modality were significant, both F < 1, p = .67. The analysis of false remember responses showed a significant main effect of encoding task whereby writing studied words reduced the incidence of such errors, F (1,78) = 4.26, MSE = 1.07, p = .04, η_p^2 = .05. Neither the main effect of modality, F (1,78) = 2.31, MSE = 2.60, p = .13, η_p^2 = .03, nor the interaction, F < 1, were significant. The analysis of false know responses yielded nonsignificant effects of modality F (1,78) = 1.96, MSE = 1.70, p = .16, η_p^2 = .03, and encoding task, F (1,78) = 2.89, MSE = .95, p = .09, η_p^2 = .04, and a nonsignificant interaction, F (1,78) = 1.48, MSE = .95, p = .23, η_p^2 = .02. The mean false recognition proportion for unrelated distractors was .05.

Discussion

The current study produced two novel findings. The first is that the mnemonic benefit of translation between processing domains extends to lists of words that are highly associated. The increase in correct recognition scores is unlikely to be the result of writing per se, as writing did not enhance the recognition of words presented visually. The null effect of writing in the visual condition also rules out the possibility that the translation effect was due to the longer presentation duration in the writing condition. As Conway and Gathercole (1990) concluded, it is the translation between auditory input and visual output that enhances memory. Consistent with the findings of Rackie et al. (2015), the translation effect was observed in correct remember responses, based on conscious recollection, but not in correct know responses, based on familiarity.

The second novel finding is that translation did not produce the corresponding increase in false memory that has been found with other tasks that increase correct memory, a pattern described by Toglia et al. (1999) as ‘more is less’. Instead, translation increased correct recognition ‘at no cost’ in terms of false memory. This is analogous to the effects of generation on the DRM paradigm reported by Soraci et al. (2003) whereby generating study items from fragments increased correct recognition without reducing accuracy. The null effect of writing in false recognition following auditory presentation is unlikely to be due to insufficient power, given that the means show a reversed effect whereby false recognition rates were lower for written words than for words encoded passively. This pattern shows up more clearly in false remember responses, which were significantly lower when the lists were written. However, the nonsignificant interaction with modality suggests that this effect occurred for both visual and auditory presentation and was not, therefore, due to translation. It is possible that the overall reduction in false recognition was due to the longer presentation intervals in the writing conditions. This would be consistent with findings by McDermott and Watson (2001) that levels of false memory decline as presentation durations increase beyond 1000ms per word.

Soraci et al. (2003) compared the ‘at no cost’ pattern produced by generation with the effects of other encoding manipulations. They argued that generation is not simply a deeper or more elaborate level of processing, as level of processing manipulations have been shown to produce a ‘more is less’ pattern (e.g., Thapar & McDermott, 2001; Toglia et al., 1999). Nor is the generation effect due entirely to enhanced item-specific processing, as this has been shown to increase true memory and reduce false memory. For example, Benjamin (2001) showed that repetition of study items led to higher levels of correct recognition and lower levels of false recognition. Soraci et al. proposed that the ‘generation at no cost’ pattern was due to the effects of generation and increased storage strength, which combine to enhance the distinctiveness of the generated items. The notion of storage strength was based on the multinomial model of the generation effect developed by Chechile and Socaci (1999) in which sufficient storage is defined as “any representation of the target that enables the person to reproduce the entire target item in full detail whenever the person accesses the representation” (p. 487). Soraci et al. concluded that encoding activities that enhance both storage strength and distinctiveness should produce a no cost pattern. The same explanation can account for the effects of translation observed in the current study. The finding that the translation effect was located in remember responses, based on conscious recollection, strongly suggests that translation also enhances the distinctiveness of encoding (see Rackie et al., 2015, for similar findings).

In contrast to the effects observed in correct remember responses, correct know responses showed a reversed translation effect whereby writing enhanced know responses following visual but not auditory presentation. It is likely that writing visually presented words enhanced memory for perceptual details, which are typically manifest in know responses (Gregg & Gardiner, 1994). The reversed effects in remember and know responses further indicate the value of the remember/know procedure in providing a more fine-grained analysis of the effects of experimental variables on recognition memory.

In terms of activation-monitoring theory (Roediger et al., 2001), the current findings indicate that translation does not affect the activation of associated items at study. Without an effect of translation on activation processes at encoding, there will be no effects on the accuracy of source monitoring processes at retrieval. As activation-monitoring theory was proposed to account for the false memories produced by the DRM paradigm, it does not speak to the effects of translation on correct recognition. In contrast, fuzzy trace theory (see Brainerd et al., 2008) aims to explain both true and false memories in the DRM paradigm. True memories are supported by verbatim traces that represent specific details of a studied item and its encoding context, whereas false memories are supported by gist traces that represent relational information about the general theme of a set of studied items. The effects of translation in correct recognition can be explained in terms of verbatim traces, as writing items presented auditorily is likely to create episodically rich, multimodal traces (as indicated by the increase in remember responses). In contrast, neither translation between modalities nor the act of writing is likely to facilitate the creation of a gist trace, therefore neither led to an increase in false recognition.

Another possible reason for the null effect of translation in false recognition is that participants were unable to use a recollection rejection strategy, whereby critical lures can be rejected by recollecting verbatim traces of the corresponding studied items (Brainerd, Reyna, Wright, & Mojardin, 2003). Brainerd et al. discussed the processes that support recollection rejection, one of which is the perception of a mismatch between targets and distractors in terms of verbatim details. In the current study, verbatim traces for half the targets would have featured a perceptual/motor representation of the act of writing. Critical lures should not be associated with such details, though contextual features can sometimes be misattributed to critical lures (see Lyle & Johnson, 2006). However, because writing versus non-writing was manipulated within subjects, not all verbatim traces would have included this information. The fact that perceptual/motor representations were not diagnostic of the old/new status of a test item would have undermined the effectiveness of a recollection rejection strategy.

To summarise, the current study replicated the translation effect first reported by Conway and Gathercole (1990) and confirmed by Rackie et al. (2015), whereby translating between processing domains enhances correct recognition. In contrast, translation did not reliably influence false recognition, thereby eliciting the ‘at no cost’ pattern described by Soraci et al. (2003). These findings are important because any theory of memory must be able to account for the relationship between the true and false memories produced by the DRM paradigm. As discussed above, encoding manipulations have been found to increase true memory while simultaneously increasing (Toglia et al., 1999) reducing (Benjamin, 2001), or having no effect on false memory (Soraci et al.). It is likely that the relationship between true and false memory will reflect the combined effects of encoding factors (e.g., the formation of verbatim versus gist traces, the relative influence of item-specific versus relational processing, between- versus within-subjects designs) and retrieval factors (e.g., type of memory test, source monitoring processes, use of a recollection rejection strategy). A full understanding of the relationship between true and false memories will require further investigation of the effects of these and other factors.

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Table 1

Mean proportions (with standard deviations) of studied items correctly recognized and critical lures falsely recognized as a function of modality, encoding activity, and response type.

Studied items	*Total*	*Remember*	*Know*
Visual write	.85 (.17)	.65 (.26)	.21 (.21)
Visual read	.84 (.14)	.71 (.21)	.14 (.15)
Auditory write	.89 (.11)	.73 (.22)	.16 (.16)
Auditory listen	.79 (.16)	.57 (.24)	.21 (.21)
Critical lures	*Total*	*Remember*	*Know*
Visual write	.50 (.30)	.25 (.22)	.25 (.25)
Visual read	.50 (.33)	.34 (.28)	.16 (.20)
Auditory write	.62 (.28)	.35 (.28)	.27 (.25)
Auditory listen	.65 (.25)	.40 (.30)	.25 (.23)