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Effects of bilateral eye movements on gist based false recognition in the DRM paradigm

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Abstract

The effects of saccadic bilateral (horizontal) eye movements on gist based false recognition was investigated. Following exposure to lists of words related to a critical but non-studied word participants were asked to engage in 30 s of bilateral vs. vertical vs. no eye movements. Subsequent testing of recognition memory revealed that those who undertook bilateral eye movement were more likely to correctly recognise previously presented words and less likely to falsely recognise critical non-studied associates. This result joins other research in demonstrating the conditions in which false memory effects can be attenuated.

Keywords: False recognition; Bilateral eye movements; Episodic memory; Hemispheric interaction; DRM paradigm

1. Introduction

Recent interest in false memories has been revived by the development by Roediger and McDermott (1995) of a procedure initially used by Deese (1959). This technique, called the Deese–Roediger–McDermott (DRM) Paradigm, involves presenting subjects with lists of words, all of which converge or are related to a critical non-studied word. For example, following study of a list comprising the words thread, pin, eye, sew and sharp, subjects falsely recall and recognise the critical non-studied associate needle (e.g., Roediger & McDermott, 1995; Thapar & McDermott, 2001).

A number of explanations for these false memory effects have been developed. One account advanced by some authors claim that during encoding two types of memory trace are created (e.g., Brainerd, Wright, Renya, & Mojardin, 2001; Koutstaal & Schacter, 1997; Payne, Elie, Blackwell, & Neuschatz, 1996). The first is the verbatim trace which represents the specific details of the encoded event such as the words visual characteristics or the location of the word on a computer monitor. The second is the gist trace that represents memory for the general meaning of the encoded events and lacks any specific or perceptual detail. In relation to the paradigm presented here, the gist trace would consist of the common semantic features of the word list. False memory occurs when during testing more emphasis is placed upon the retrieval or use of the gist based representation. This leads subjects to falsely remember related non-studied items as these items match the characteristics of the gist memory trace.

The gist memory trace is considered to be resilient to forgetting (Renya & Brainerd, 1995) and may in part explain why the DRM procedure produces remarkably robust false recall and recognition. In fact many attempts to reduce such false memory errors have met with only limited success, often reducing but not eliminating false memories. For example, Gallo, Roberts, and Seamon (1997) informed subjects about the nature of the false memory effect and instructed them to avoid making this type of error. In spite of this explicit forewarning, false recognition rates were still significant (although somewhat reduced compared to control groups). Hicks and Marsh (1999) demonstrated that

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source monitoring instructions (e.g., deciding whether the test words were originally spoken by a male or female voice during the encoding phase) reduced false recall but only when the sources were highly discriminable. However, even under these conditions false recall was not completely eliminated and later work by these authors demonstrated that false recognition can even increase with source monitoring instructions (Hicks & Marsh, 2001). Other experiments show that false memories can be reduced by making the words more distinctive during encoding by having subjects speak them out aloud (Dodson & Schacter, 2001), pairing the words with pictures (Israel & Schacter, 1997), or some other form of visual or verbal context (Bruce, Phillips-Grant, Conrad, & Bona, 2004).

One particularly novel way in which false *recall* can be reduced was demonstrated by Christman, Propper, and Dion (2004). Following study of the related word lists, subjects were asked to perform 30 s of bilateral eye movements. As previous research by these authors has shown that bilateral eye movements can increase true memory (Christman, Garvey, Propper, & Phaneuf, 2003), it was predicted that this would lead to a reduction in the number of words falsely recalled. This was indeed found; subjects who engaged in bilateral eye movements showed significant reductions in false recall compared to those who maintained eye fixation on a central flashing circle. Christman et al.'s (2003, 2004) explanation for these results is that: (i) Lateral eye movements lead to increased activation of the contralateral hemisphere (Baken & Svorad, 1969) and as a consequence that saccadic bilateral eye movements increase hemispheric interaction. (ii) Successful episodic memory is dependent upon such interactions (Habib, Nyberg, & Tulving, 2003). Successful retrieval of studied information may then be used to suppress or reduce false memory, perhaps by influencing what information is retrieved or used prior to making a response.

Manipulations generally have similar effects on both false recall and false recognition (e.g., Thapar & McDermott, 2001; Roediger, McDermott, & Robinson, 1998). In addition, analyses of the predictors of false recall and false recognition, such as the backward associative strength between the list words and the falsely remembered word, reveal similar contributions to both types of memory test (Roediger, Watson, McDermott, & Gallo, 2001).

The aim of this experiment is to assess the generality of false memory reduction following bilateral eye movements to *recognition* memory. Testing by recognition appears to be particularly susceptible to producing false memory errors with rates of false recognition often at similar levels to or even greater than true recognition (e.g., Dodd & MacCleod, 2004; Gallo, Roediger, & McDermott, 2001; Seamon, Luo et al., 2002; Roediger & McDermott, 1995). As a consequence, if mere bilateral eye movements were to reduce such errors this would be rather remarkable. In the current experiment subjects were exposed to lists of associated words during the encoding phase. Following this, subjects were assigned to one of three conditions; bilateral eye movement, vertical eye movement or no eye movement. They were then presented with a recognition memory test containing studied words, critical non-presented words and non-presented words not related to the list. Subjects were asked to indicate which items they recognised. It is predicted that engaging in 30 s of bilateral eye movements will reduce gist based false recognition and increase true recognition.

2. Method

2.1. Design

The experiment had one independent variable with three levels: bilateral eye movement, vertical eye movement and central fixation. This was manipulated as a between subjects design.

The dependent variables were hit rate, false alarm rate to critical lures, false alarm rate to non-critical lures and signal detection measures of true (verbatim) memory, false (gist) memory and response bias (β).

2.2. Participants

The participants were 102 (34 in each between subjects condition) students from the department of psychology and speech pathology who took part on a voluntary basis. None had taken part in any similar research.

2.3. Materials and apparatus

Twenty lists each of 15 words were selected from the published norms of Stadler, Roediger, and McDermott (1999). These were divided into two sets of 10 lists for the purposes of counterbalancing. Only one set served as study stimuli, whilst the remaining set was used to create distractors in the recognition test. The recognition test consisted of the 10 critical lures, 40 studied words from serial positions 1, 5, 10 and 15 of the lists together with 40 non-presented words (4 taken from each of the non-presented lists from serial positions 1, 5, 10 and 15).

A computer programme was designed to initiate eye movements in the appropriate manner. This was achieved by flashing a black circle against a white background from side to side (bilateral condition), up and down (vertical condition), or on and off in the centre of the screen (fixation condition). The circle moved (flashed) once every 500 ms and in the eye movement conditions was located approximately 27° of visual angle apart.

2.4. Procedure

All participants were tested individually. The lists were recorded onto a tape with each word from each presented list spoken by a male voice at the rate of one word every 1 s. Lists were presented in descending order (minus the critical word). A pause of five seconds was placed between each of

the studied lists and the start of the next list was signalled by the phrase "next list". Different versions of presentation order were created to avoid any order effects. Following the presentation of the final study list, subjects were randomly assigned to one of the three eye movement conditions and sat in front of a computer monitor. In the bilateral eye movement condition instructions were provided to follow the dot as it appears back and forth on the right and left of the screen. In the vertical eye movement condition the instructions were to follow the dot as it appears top and bottom of the screen. In both these conditions it was emphasised that following the dot should be done by moving their eyes whilst keeping their heads stationary.

Compliance with these instructions was monitored by the experimenter. The instructions in the central fixation condition were to stare at the dot as it flashes on and off in the centre of the screen. Following 30 s of eye movements (or central fixation), the recognition test began. Subjects were provided with a recognition test booklet with the instructions to read through the list of words and indicate which they believed to have been presented during the study phase and which were new or unstudied. A space was provided next to each word for an appropriate response to be made.

3. Results

Measurement of verbatim and gist recognition was assessed by the hit rate to presented words (verbatim memory) and the false alarm rate to critical lures (gist based memory). In addition, the signal detection measure d′ was used to measure both verbatim and gist memory. In relation to gist based false memory the typical approach is to treat yes responses to non-presented critical words as "hits" and yes responses to unrelated words as false alarms and calculating d′ accordingly (e.g., Koutstaal & Schacter, 1997; Seamon, Lee et al., 2002; Seamon, Luo et al., 2002). Higher scores are taken to indicate that subjects are more reliant upon gist based memory. The criterion measure β was also calculated to assess response bias. The means and SDs for all conditions across all measures can be seen in Table 1.

A one way ANOVA was performed on the proportion of yes responses to studied words (hits). This revealed a significant effect of eye movement, $F(2, 99) = 14.24$, $p < .001$. Follow up tests indicated that the hit rate following bilateral eye movements were significantly greater then either vertical, $t(66) = 4.13$, $p < .001$, or central fixation conditions, $t(66) = 4.90$, $p < .001$. The latter two conditions did not differ from one another, $t < 1$.

Analyses on the proportion of yes responses to critical non-studied lures (false memory) revealed a significant effect of eye movement, $F(2, 99) = 18.03$, $p < .001$. Follow up tests indicated that the false alarm rate following bilateral eye movements were significantly lower then either vertical, $t(66) = -4.75$, $p < .001$, or central fixation conditions, $t(66) = -5.30$, $p < .001$. The latter two conditions did not differ from one another, $t < 1$.

Analyses on the proportion of yes responses to non-studied non-critical words revealed a significant effect of eye movement condition, $F(2, 99) = 5.14$, $p = .007$. Follow up tests indicated that the false alarm rate following bilateral eye movements were significantly lower then either vertical, $t(66) = -2.41$, $p = .009$, or central fixation conditions, $t(66) = -3.29$, $p = .001$. The latter two conditions did not differ from one another, $t < 1$.

As noted earlier, the current research also made use of d′ measures of true and false memory. The d′ measure of true memory was placed into a one way ANOVA. This produced a significant effect of eye movement, $F(2, 99) = 18.83$, $p < .001$

Follow up tests indicated that d′ scores following bilateral eye movements were significantly greater then either vertical, $t(66) = 4.75$, $p < .001$ or central fixation conditions, $t(66) = 5.77$, $p < .001$, with the latter two conditions not differing significantly from one another, $t < 1$.

The criterion measure, β, was positively skewed and thus log transformed values were used for all analyses. For true or verbatim memory, no effect was found following any of the eye movement conditions, $F(2, 99) = 1.83$, $p = .16$.

Finally, the d′ measure for false memory produced a significant effect, $F(2, 99) = 5.17$, $p = .007$. Follow up tests indicated that subjects in the bilateral condition were less likely to rely upon gist based memory compared to either vertical, $t(66) = -2.94$, $p = .002$, or central fixation conditions, $t(66) = -2.80$, $p = .007$. Vertical and central conditions did not differ from one another, $t < 1$. For β, a significant effect was found, $F(2, 99) = 9.30$, $p < .001$. Follow up tests revealed this was due to the criterion becoming more conservative following bilateral eye movements compared to both vertical eye movements, $t(66) = 3.66$, $p = .001$, and central fixation conditions, $t(66) = 4.30$, $p < .001$. No other effects were significant.

In summary, bilateral eye movements appear to enhance true (verbatim) memory and decrease the extent to which subjects rely or make use of gist based false memory.

Table 1
Mean (SD) proportion of hits, false alarms, accuracy (d′) and response criterion (log β) scores as a function of eye movement condition

	Eye movement condition		
	Bilateral	Vertical	Central
Measure			
Hits (presented words)	0.66 (0.15)	0.53 (0.13)	0.50 (0.14)
False alarms (critical words)	0.50 (0.24)	0.76 (0.20)	0.78 (0.18)
False alarms (non-critical words)	0.07 (0.07)	0.13 (0.11)	0.15 (0.12)
d′ true	2.10 (0.61)	1.39 (0.63)	1.19 (0.70)
Log β true	0.51 (0.37)	0.42 (0.33)	0.35 (0.32)
d′ false	1.63 (0.77)	2.27 (1.02)	2.20 (0.91)
Log β false	0.50 (0.33)	0.09 (0.57)	0.07 (0.58)

4. Discussion

The current results revealed that engaging in 30 s of bilateral eye movement was sufficient to decrease gist based false

recognition. This joins a number of findings that reveal the conditions under which false memory effects can be attenuated (e.g., Gallo et al., 1997; Hicks & Marsh, 1999; Dodson & Schacter, 2001; Israel & Schacter, 1997; Bruce et al., 2004). Our results extend those of Christman et al. (2004) to recognition memory. In addition we also found bilateral eye movements to increase true or verbatim memory. In the Christman et al. (2004) study bilateral eye movements did not increase accuracy in free recall of DRM lists. One potential reason for this difference may relate to the fact that Christman et al. (2004) used free recall whereas the current study used recognition testing. However, such an explanation is weakened by the fact that bilateral eye movements did result in enhanced recall accuracy in an earlier experiment (Christman et al., 2003), however the latter experiment did not use DRM word lists. Another potential reason for the difference is that Christman et al. (2004) assessed recall after the presentation of each list in contrast to the current study which assessed memory following presentation of all lists. The latter procedure is more typical when recognition memory is assessed. Further research may clarify the explanation for these differences.

Previous studies have often found false recognition to be greater than true recognition (e.g., Dodd & MacCleod, 2004; Gallo et al., 2001; Seamon, Luo et al., 2002; Roediger & McDermott, 1995). This was also found in the current results but was limited to the vertical eye movement and central fixation conditions. Following bilateral eye movement this effect was reversed and true recognition became greater than false recognition. Given the magnitude of false recognition effects often obtained using the DRM paradigm the current results are quite noteworthy.

Explaining how bilateral eye movements produce such results is as yet relatively unexplored, both in terms of the neural activity and cognitive processes likely to be responsible. In terms of neural activity, as noted in the introduction, Christman et al. (2003, 2004) refer to increased interhemispheric communication as a basis for the effect. This idea is premised upon the finding that lateral eye movements lead to increased activation of the contralateral hemisphere (Baken & Svorad, 1969) and neuroimaging research that indicates episodic memory to be associated with bihemispheric activity, particularly in prefrontal regions (e.g., Habib et al., 2003). Thus engaging in bilateral eye movements increases interhemispheric interactions that facilitate performance on tasks that are considered to be dependent upon the cooperation between hemispheres. Christman et al. (2004) further suggest that bilateral eye movements may reduce false memory by facilitating source monitoring abilities. Previous work has interpreted conservative shifts in the criterion to reflect increased metacognitive/source monitoring (Schacter, Israel, & Racine, 1999). The finding of a more conservative response criterion to critical items following bilateral eye movements in the current experiment can be interpreted in a similar manner and thus provides support for Christman et al.'s (2004) suggestion.

However, increases in monitoring processes may not be sufficient to account for the increase in true memory found in this study. This is so because conditions that are likely to enhance source monitoring are primarily associated with decreases in false alarms as opposed to increases in the hit rate (e.g., Bruce et al., 2004; Israel & Schacter, 1997). Instead, enhanced true memory may result from increased ability to retrieve or reactivate perceptual or contextual information associated with the studied items.

In terms of neural processes, prefrontal regions have been demonstrated to be of importance during tasks that require close scrutiny of the source of the memory (Cabeza, Rao, Wagner, Mayer, & Schacter, 2001; Curran, Schacter, Johnson, & Spinks, 2001). In addition, neural regions that show greater activations for true (vs. false) memory include the parahippocampal gyrus (Cabeza et al., 2001) and cortical visual regions (Slotnick & Schacter, 2004). Perhaps bilateral eye movements are able to enhance such activations through the functional coupling of prefrontal regions with regions in which the memory trace is stored (Simons & Spiers, 2003; Summerfield & Mangels, 2005).

The current results have been explained in terms of the distinction between gist and verbatim memory. It must be pointed out that this is not the only theoretical framework that can potentially accommodate the results. Another explanation, referred to as the activation-monitoring framework (Roediger et al., 1998), accounts for false memory effects by assuming that presentation of lists of related words leads to the covert or overt activation of the critical word. During retrieval, the critical item is falsely recalled or recognised because of this increased activation and the failure to monitor the fact that the item was not actually presented but self generated during the study phase. As the eye movement manipulation took place following encoding then presumably the effects cannot be due to the activation process, at least not in any simple sense.

More recently, Zeelenberg, Boot, and Pecher (2005) have introduced an account based upon global matching models of recognition memory. This assumes that both true and false recognition is achieved by a global matching process between the recognition test cue and items stored in memory. The matching process results in the return of a global familiarity signal which, if above some critical value, leads to a yes response. The false memory effects obtained with the DRM paradigm arise because the critical targets share semantic features with the list items stored in memory and thus result in the return of a high familiarity value. In the terms of this theory, bilateral eye movements may reduce the extent to which global familiarity is used as a basis for recognition decisions to critical items.

Finding that mere bilateral eye movements can increase true memory and decrease false memory is intriguing and it is hoped that future research will be undertaken to assess the cognitive processes by which eye movements influence component processes in memory.

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