Brain and Cognition 69 (2009) 89–97

Contents lists available at ScienceDirect

Brain and Cognition

journal homepage: www.elsevier.com/locate/b&c

Reduced misinformation effects following saccadic bilateral eye movements

Andrew Parker *, Sharon Buckley, Neil Dagnall

Manchester Metropolitan University, School of Psychology & Social Change, Hathersage Road, Manchester M13 OJA, United Kingdom

ARTICLE INFO

Article history:
Accepted 27 May 2008
Available online 16 July 2008

Keywords:
Bilateral eye movements
Misinformation effects
False memory
Hemispheric interaction
Source memory

ABSTRACT

The effects of saccadic bilateral (horizontal) eye movements on memory for a visual event narrative were investigated. In the study phase, participants were exposed to a set of pictures accompanied by a verbal commentary describing the events depicted in the pictures. Next, the participants were asked either misleading or control questions about the depicted event and were then asked to engage in 30 s of bilateral vs. vertical vs. no eye movements. Finally, recognition memory was tested using the remember–know procedure. It was found that bilateral eye movements increased true memory for the event, increased recollection, and decreased the magnitude of the misinformation effect. The findings are discussed in terms of source monitoring, dual-process theories of memory and the potential neural foundations of such effects.

1. Introduction

Several independent lines of research have suggested that interhemispheric interactions provide an important basis for accurate episodic memory. For example, one line of investigation has made use of individuals for whom interhemispheric processing has been curtailed by the bisection of the corpus callosum. It has been found that performance on tests of episodic memory are typically reduced compared to tests of semantic or implicit memory (e.g., Cronin-Golomb, Gabrieli, & Keane, 1996; Zaidel, 1995). In another set of studies, Propper, Christman, and Phaneuf (2005), argued that mixed (vs. right) handedness is associated with increased hemispheric interaction. As a consequence, mixed handed individuals were predicted to show superior performance on episodic tasks. Across two experiments it was found that mixed handed individuals outperformed right handed individuals both on laboratory based episodic tests and memory for real-world events.

Another line of investigation has found that experimental manipulations, which are thought to increase interhemispheric processing, have also enhanced episodic memory. For example, Christman and Propper (2001) presented participants with words to either the right or left hemisphere. Later, memory for these words was tested in either the same (vs. opposite) hemisphere. They found that episodic memory was improved when encoding and retrieval took place in opposite hemispheres. A rather novel and interesting technique, claimed to induce interhemispheric interaction, is saccadic bilateral eye movements (Christman, Garvey, Propper, & Phaneuf, 2003). Using this technique, Christman et al. (2003), experiment 1, found recognition memory for words to be improved in terms of an increase in the hit rate and a decrease in the false alarm rate. Bilateral eye movements have also been shown to reduce the false alarm rate in experimental paradigms that are designed to elicit particularly high rates of false memories. For example, following the study of related words such as thread, pin, eye, sew and sharp, subjects falsely recall and recognise associated but non-presented words such as needle (e.g., Roediger & McDermott, 1995). Following thirty seconds of bilateral eye movement, Christman, Propper, and Dion (2004) and Parker and Dagnall (2007), found significant reductions in the false recall and recognition of the non-presented associates. In addition, saccadic bilateral eye movements have been found to be related to enhanced access to earlier childhood memories (Christman, Propper, & Brown, 2006) and the retrieval of associative and contextual information (Parker, Relph, & Dagnall, 2008). Although the precise neural reasons for these results remain to be explored, Christman et al.(2003, 2004) argue that the effects are likely due to increased interhemispheric communication. Their arguments run as follows; Firstly, lateral eye movements lead to increased activation of the contralateral hemisphere (Baken & Svorad, 1969). This appears to be particularly true for, saccadic eye movements which generate more frontal cortical activity compared to smooth pursuit eye movements (O'Driscoll et al., 1998). Secondly, it is presumed that one possible consequence of sequences of right–left eye movements is the simultaneous activation of both hemispheres. When equalised activation levels of both hemispheres occur, it is assumed that this facilitates hemispheric interaction (see Christman et al., 2003 for discussion of the research relating to this point). Finally, neuroimaging research indicates that episodic memory tends to be associated with bihemispheric activity (e.g., Habib, Nyberg, & Tulving, 2003). Therefore, engaging in saccadic bilateral eye movements increases interhemispheric activity and provides a basis for facilitating episodic memory.

* Corresponding author. Fax: +44 01612476842.
E-mail address: a.parker@mmu.ac.uk (A. Parker).

0278-2626/$ - see front matter © 2008 Elsevier Inc. All rights reserved.
doi:10.1016/j.bandc.2008.05.009

Considered together, the research on bilateral eye movements suggests that such eye movements can improve episodic memory in at least two possible ways. Firstly, by enhancing the retrieval of studied information (thereby increasing the hit rate). Secondly, by promoting the use of post-retrieval monitoring processes (thereby reducing the false alarm rate). One manner by which post-retrieval monitoring processes can reduce false memory is through increasing attention to source specifying information. Memory for source refers to memory for the origin of that information (Johnson, Hashtroudi, & Lindsay, 1993), an example of which would be the perceptual or contextual details relating to who said something or where the information was encountered. Information that is actually encountered possesses, on average, more perceptual and contextual details than imagined information (Conway, Pleydell-Pearce, Whitecross, & Sharpe, 2003; Johnson, Foley, Suengas, & Raye, 1988). As such, the absence of these details in memory can be used to distinguish between actual and merely imagined events (Johnson et al., 1988). In a similar manner, false alarms to non-studied items on a recognition test contain on average less sensory and perceptual details (Mather, Henkel, & Johnson, 1997; Norman & Schacter, 1997; Slotnick & Schacter, 2004). Once more, the presence or absence of such information can be used as a diagnostic cue to reject this information as non-studied (Dodson & Hege, 2005; Dodson & Schacter, 2002).

The finding that bilateral eye movements can reduce false memories, perhaps by enhancing source monitoring, has interesting implications for situations in which source memory confusions may lead to false memories. One such situation arises in the misinformation paradigm. In this paradigm participants are exposed to a scenario that describes a series of events. Following this exposure, some misleading information about the event is presented. Finally, memory for the event is tested. For example Loftus, Miller, and Burns (1978), exposed participants to an event where a car is depicted at a stop sign. Later, some participants are asked a question in which the stop sign is subtly referred to as a yield sign. The typical finding is that the suggestions contained within the misleading information are later accepted as being true. That is, participants develop false memories for the yield sign or for events that were only suggested.

Research has attempted to uncover why these effects are observed. One explanation, called the substitution hypothesis, is that the original memory is overwritten by the misinformation (Loftus & Loftus, 1980). This implies that memory for the original event is permanently lost and thus irretrievable. However, this explanation is not widely accepted as it appears to contradict what we know about memory processes (Greene, 1992). In addition, other research demonstrates that the original event is not actually lost but becomes less accessible and thus more difficult to retrieve (Beli, Windschitl, McCarthy, & Winfrey, 1992; Berkerian & Bowers, 1983; Chandler, 1991). Another explanation is that misled participants are unable to discriminate between the two separate sources of information when tested. One source of the information is the original event itself. The other source is the post-event questions. As a consequence, misleading information is accepted as true not because the original information has been erased, but because of a source monitoring or source memory failure (Lindsay, Allen, Chan, & Dahl, 2004; Lindsay & Johnson, 1989; Zaragoza & Lane, 1994). Findings indicate that when the situation encourages scrutiny of the source of the original and misleading information, then misinformation effects are reduced or eliminated. For example, Lindsay and Johnson (1989) found that when misled participants were asked to retrieve and consider from which source they encoded the tested information (the original event or the post-test questions) then misinformation effects were significantly reduced. As a consequence, it may be more desirable to consider misinformation effects as a form of source misattribution (Lindsay et al., 2004; Zaragoza & Lane, 1994). This simply implies that exposure to information from one source (e.g., post-event questions) are remembered and attributed to another source (the original event). This occurs because the source of a memory is not typically encoded as a mnemonic 'tag' that allows for accurate and unambiguous discrimination between the encoded events (Johnson et al., 1993). Instead, memories are evaluated on the basis of the characteristics they contain (e.g., visual content). Depending upon the nature of the information retrieved, individuals can either correctly or incorrectly attribute it to one or other sources.

Interestingly, research has also found that information that was only implied can sometimes be vividly remembered. For example, participants are often willing to indicate the visual appearance of implied objects or where they were located (Karpel, Hoyer, & Toglia, 2001; Keogh & Markhan, 1998; Schooler, Gerhard, & Loftus, 1986). This suggests that memory for misinformation is accompanied by recollection. The term 'recollection' is often used in the context of dual-process theories of recognition to denote a form of memory that is dependent upon a recall-like mechanism (e.g., Diana, Reder, Arndt, & Park, 2006; Jacoby, 1991; Mandler, 1980; Yonelinas, 2002). This involves the retrieval of elaborative or associative information and could include the perceptual or contextual detail of a study episode. This form of memory is contrasted with familiarity, which is taken to reflect a form of recognition based upon an automatic process that is brought about by the matching of the test item to all other items stored in memory. This process results in a single overall familiarity signal, which is then used to make the recognition decision. Importantly, this form of memory lacks the associative and elaborative details accompanying recollection based memory.

One method of measuring recollection and familiarity is the remember/know procedure (Gardiner, 1988; Tulving, 1985). This method involves asking participants to make, firstly, old/new judgements to the test items. Then, if a test item is recognised, participants are asked to make 'remember' or 'know' responses. A remember response indicates that they are able to retrieve additional details surrounding the presentation of the studied item such as associative and contextual information. A know response indicates that they recognise the word in the absence of such details. Remember and know responses are taken to reflect the contribution of recollection and familiarity based processes, respectively (but see Gardiner & Richardson-Klavehn, 2000). Supporting the suggestion made earlier, when this procedure is employed, participants often make remember responses to items that were never actually presented (Frost, 2000; Roediger, Jacoby, & McDermott, 1996; Sondhi & Gupta, 2007; Zaragoza & Mitchell, 1996).

Both misinformation effects and the role of recollection and familiarity based processes in memory have interesting implications when considered within the context of research on the effects of bilateral eye movements. In particular, if misinformation effects are due to source memory errors, and bilateral eye movements enhance source memory monitoring, then bilateral eye movements should reduce the magnitude of misinformation effects. In addition, previous research has shown that bilateral eye movements selectively increase remember responses in a standard item recognition task (Parker et al., 2008). Consequently, it is of interest to consider whether such effects can be observed in a more complex memory situation in which participants are required to discriminate between actual and suggested information. If bilateral eye movements selectively influence recollection, then this should be seen by an increase in remember responses for studied information. The research presented here assesses the effects of bilateral eye movements on memory for details of an actual studied event and for information that was only suggested by a set of post-event questions.

During the first phase of the experiment, participants were exposed to a photographic sequence of events accompanied by a spoken narrative describing those events. Following a short delay, participants were asked a series of questions about the photographic sequence. Some of these questions made reference to objects that actually appeared in the sequence. However, other questions implied the presence of objects that were not in actual fact presented. Subsequent to the post-event questioning phase was a period of 30 s of bilateral (vs. vertical vs. central fixation) eye movements. Finally, participants undertook a recognition memory test. Some of the test items were the names of objects that were present (true memory), whilst some were those that were only implied (false memory). Other test items were of objects that were neither presented, nor implied but consistent with the original scenario (these acted as an additional measure of false alarms). If participants claimed to recognise a test item, they were then asked to make remember/know responses. The remember/know procedure is used in the current experiment for a number of reasons: firstly, to assess the quality of both true and false memories; secondly, to ascertain the effects of eye movements on recollection and familiarity based processes; and thirdly, to provide a theoretical framework for considering the effects of eye movements on memory.

We did not specifically instruct participants to make source memory judgements in the current experiment because, as noted earlier, previous research has shown that such instructions can reduce or even eliminate misinformation effects (Lindsay & Johnson, 1989). Thus using specific source memory instructions may pose the risk of eliminating the very effect we wished to detect and reduce by the eye movement manipulation.

The predictions are based upon the premise that saccadic bilateral eye movements increase true memory and decrease false memory. In particular, bilateral eye movements are hypothesised to enhance memory for the studied event and decrease the extent to which suggested items are accepted as being studied. In other words, it is predicted that bilateral eye movements will reduce the magnitude of the misinformation effect. Finally, if bilateral eye movements enhance recollection (vs. familiarity), then accurate responses to studied information should be accompanied by an increase in remember (vs. know) responses. When misinformation items are accepted as studied (i.e., a misinformation effect) it is predicted that bilateral eye movements should reduce the probability that such responses are accompanied by recollection.

2. Method

2.1. Design

The experiment had one between participants independent variable with three levels: bilateral eye movement, vertical eye movement and central fixation.

The dependent variables were: (i) ‘yes’ responses to studied items, followed by remember, know and guess responses. This constitutes a measure of true memory. (ii) ‘yes’ responses to misinformation items followed, by remember, know and guess responses to these items. This constitutes a measure of the misinformation effect. (iii) ‘yes’ responses to items consistent with the narrative/photographic sequence but were not present in ether of these. This was also followed by remember know and guess responses. Yes responses to the latter items provided an additional measure of the false alarm rate.

2.2. Participants

The participants were 72 students from the school of psychology who took part on a voluntary basis. Twenty-four were assigned to each of the between participant conditions. None had taken part in any similar research.

2.3. Materials

The materials comprised of a narrative, an associated photographic sequence, a post-event questionnaire, and a recognition test booklet. Each of these is described below.

2.3.1. The narrative

The narrative was loosely based on that used by McCloskey and Zaragoza (1985). The 550 word long story described an account of a plumber who had made a prior arrangement with a customer to collect house keys from a neighbour in order that he might let himself into a house to fix a dishwasher. Once inside the house, the plumber places the keys down near a vase of flowers and proceeds to survey the surroundings. Whilst making a coffee he reads a newspaper and accidentally knocks a can of pop over the paper. After cleaning the mess, he disposes of the paper into a carrier bag that is being used as a rubbish bin. After fixing the dishwasher, he endeavours to find something to write with. However his attention is caught by some cash left out by the owner. The narrative refers to some items that are depicted visually in the photographic sequence. When this occurs, the description of the item in question is always at a general level. For example, the narrative makes reference to a can of pop, whilst the photograph depicts a particular brand of pop (e.g., a can of Sprite or 7-Up). A total of twelve target items were selected for this purpose. For each of these items, two specific examples were identified. The target items and specific examples were: The plumbers attire (hat or cap), a tool box (red or grey), a vase of flowers (dried or fresh), a blind (up or down), a coffee jar (Nescafe or Kenco), a newspaper (Sunday Mirror or Sunday Express), a can of pop (7-Up or Sprite), a cleaning implement (sponge or cloth), a carrier bag (Asda or Tesco), a tool (spanner or pliers), a writing instrument (pen or pencil), and an accessory to hold money (purse or wallet). The narrative was spoken by a female voice and recorded onto a computer.

2.3.2. The photographs

To illustrate the narrative, a total of twelve pairs of images were created. Each pair depicted one of the target items. For each pair, one image contained one of the examples of the target object, and the second member of the pair contained the alternate example. Thus, two separate versions of each image were created. For example, for the target item ‘pop’, one image contained a can of 7-Up, and the alternative image contained a can of Sprite. All the pictures were presented amidst the background context of the rooms in the house. These twelve pairs of images were divided into two sets (A and B) for the purpose of counterbalancing. Each set contained one example of the target object. Thus participants were only exposed to a total of twelve images and one example of each target object. The photographic sequence was printed in colour and formed into a booklet.

2.3.3. The post-event information questionnaire

The misinformation was presented in the form of a set of post-event questions, similar to those employed by Zaragoza and Lane (1994). Participants were required to answer Yes or No to a total of eighteen questions. Of these, six were misinformation questions, six were control questions and six were filler questions. The misinformation questions referred to the photographic sequence but mentioned the alternate example of the target item not seen by the participant. For instance, if the participant had seen the slide containing a can of 7-Up, then the misinformation question would refer to this as being a can of Sprite. In this case, the question read “The plumber spilt a can of Sprite onto the newspaper. Do you remember this incident?" The control questions referred to items that had actually appeared in the sequence. For example, if the participant saw a slide containing fresh flowers, then the question would refer to fresh flowers. In this case, the question read "The plumber placed the key down next to the vase of fresh flowers. Do you remember him placing down the key?" The selection of items for the misleading (vs. control) questions was counterbalanced across participants. The filler questions asked about information that had been conveyed verbally or visually but were not related to any of the recognition test items. An example of a filler question read "Why was the plumber at Mrs. James' house, was it to fix the dishwasher?"

2.3.4. The recognition test

The recognition test was verbal and consisted of eighteen items. Six of these were true items that had actually appeared in the photographic sequence (and to which the control questions made reference), six items were misleading items that had been suggested by the post-event questions (and thus were not actually present in the photographic sequence), and six were items unrelated to either the narrative or the photographic sequence. These unrelated items were objects that could easily be found around a house and were thus schematically consistent with the items depicted in the narrative/photographic sequence (e.g., radio, clock, iron, fork and toaster). The unrelated items were included as a means to measure the false alarm rate for information not contained within the photographic sequence, narrative or any of the questions. The items that were designated as true or misleading depended upon which photographic sequence and questions the participant had seen. This was counterbalanced across conditions. The unrelated items were the same across all versions of the recognition test. The items for recognition appeared down the left side of the page. To the right of each item was the option YES or NO. Further to the right were the response options R, K and G to indicate remember, know or guess.

A laptop computer was used to play a recording of the narrative and to initiate the eye movements. The latter was achieved via a computer programme that flashed 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 and informed that they were about to take part in a study about memory for a witnessed event. Once inside the experimental cubicle, participants were told that they were going to hear a story presented by the computer. In addition, whilst listening to the story, they were going to view a series of photographs illustrating the story. They were asked to pay attention to both the story and the photographs. The experimenter sat to the side of the participant and initiated the presentation of the narrative by pressing the return key of the computer. As the narrative unfolded, short pauses were located in the story and at these points the experimenter presented the relevant photograph in the booklet for a duration of 4 s.

When the narrative ended, the participant was presented with a blank sheet of paper and asked to write down as many European cities as possible within the space of ten minutes. This served as a distractor task and to impose a delay between the narrative and the post-event question phase.

Once 10 min had elapsed, the experimenter presented a sheet of paper upon which were written the post-event questions. Participants were asked to answer each question in turn. Following this was a short pause of one minute. Participants were then randomly assigned to one of the 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 the eye movement 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 observed by the experimenter. The instructions for 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.

The test instructions were described by the experimenter. Participants were informed that they were about to read a set of eighteen words, some of which were presented in the photographic sequence seen earlier in the study. Their task was to indicate which objects they had seen by answering 'yes'. If they did not remember seeing the object then they were to answer 'no'. The instructions emphasised that a 'yes' response should be provided *only* if the object was earlier seen in the photographic sequence. If a 'yes' response was made, participants were asked to make a further judgment about the quality of their memory by providing a 'remember', 'know' or 'guess' response. These instructions were modelled upon Gardiner and Richardson-Klavehn (2000). A 'remember' response was defined as recognition that is accompanied by some recollective experience such as an image of the object as it appeared in the photographic sequence. A 'know' response was described as recognition accompanied by strong feelings of familiarity in the absence of recollection. Participants were asked to produce a know response if they were sure that the object had appeared in the photographic sequence but could not recollect the object. A 'guess' response was defined as an option to use only if participants felt they could not provide a 'remember' or 'know' response. The guess alternative was provided to ensure the 'know' option was not used to guess and that the remember/know distinction is not used to simply indicate variations in recognition confidence (Eldridge, Sarfatti, & Knowlton, 2002). Before, moving onto the actual test, the experimenter ensured that all participants understood the instructions and the responses that were required.

3. Results

All results were analysed by one-way ANOVAs with the eye movement condition as a between participants factor. Planned comparisons were used with Bonferroni correction and an alpha level set at .05 throughout.

3.1. Memory for studied information

The proportion of items correctly recognised from the photographic sequence (hits) was calculated and can be seen in Table 1 and Fig. 1. Analysis revealed a significant effect of eye movement condition, $F(2,69) = 7.36$, $MS_e = .04$, $p = .001$. Planned comparisons revealed a significantly higher hit rate in the bilateral compared to the no eye movement condition, $t(46) = 3.86$, $p \leqslant .001$ and the bilateral compared to the vertical eye movement condition, $t(46) = 3.20$, $p = .001$. The difference between the vertical and no eye movement condition did not achieve significance, $t(46) = .34$, $p = .37$.

The proportion of remember response to hits can be seen in Table 1 and Fig. 1. Analysis of these produced a significant effect, $F(2,69) = 23.35$, $MS_e = .06$, $p \leqslant .001$. Planned comparisons revealed a significantly greater proportion of remember responses in the

Table 1
Mean (and *SD*) proportion of hits, false alarms, *d*', *β*, remember, know and guess responses as a function of item type and eye movement condition

Item type and measure	Eye movement condition					
	Bilateral		Vertical		Central	
	M	*SD*	*M*	*SD*	*M*	*SD*
Studied information						
Hits	0.87	0.14	0.70	0.23	0.68	0.20
Remember	0.69	0.23	0.32	0.25	0.22	0.27
Know	0.15	0.18	0.26	0.20	0.27	0.17
Guess	0.03	0.07	0.13	0.17	0.17	0.18
d'	2.28	0.59	1.58	0.83	1.52	0.58
β	1.21	0.37	1.31	0.48	1.55	0.79
Unrelated information						
False alarms	0.06	0.11	0.15	0.11	0.15	0.15
Remember	0.01	0.05	0.03	0.07	0.03	0.06
Know	0.03	0.07	0.02	0.08	0.04	0.10
Guess	0.02	0.06	0.08	0.10	0.06	0.08
Misinformation items						
False alarms	0.30	0.23	0.72	0.17	0.71	0.23
Remember	0.15	0.19	0.27	0.24	0.23	0.24
Know	0.08	0.10	0.31	0.19	0.26	0.19
Guess	0.07	0.11	0.15	0.15	0.22	0.18
d'	0.65	0.57	1.65	0.57	1.62	0.78
β	1.68	0.71	1.35	0.55	1.41	0.73
Independence know proportions						
Studied items	0.48	0.42	0.41	0.33	0.33	0.20
Misinformation items	0.09	0.11	0.43	0.25	0.32	0.23
Unrelated items	0.04	0.07	0.03	0.08	0.05	0.11

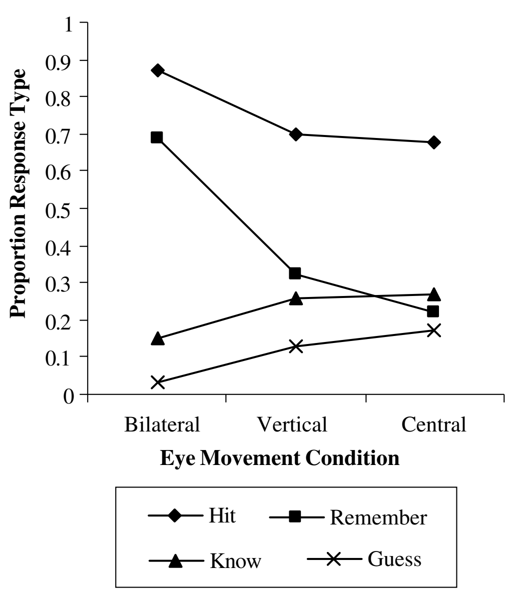

Fig. 1. Mean proportion response type for studied items (true memory) as a function of eye movement condition. These represent yes responses to studied items further broken down into remember, know and guess responses.

bilateral condition compared to the no eye movement condition $t(46) = 6.43$, $p \leqslant .001$. The difference between the bilateral and vertical eye movement condition was also significant $t(46) = 5.40$, $p \leqslant .001$. In both comparisons, the bilateral group produced higher proportions of remember responses. However, the difference between the vertical and no eye movement conditions was not significant, $t(46) = 1.30$, $p = .10$.

Analysis of the proportion of know responses approached significance, $F(2,69) = 2.98$, $MS_e = .03$, $p = .06$. As this finding was close to significance, comparisons between each of the conditions were assessed. This revealed a significant difference between the bilateral and no eye movement condition, $t(46) = -2.32$, $p = .025$, indicating a lower proportion of know responses in the bilateral group. The difference between the bilateral and vertical conditions was marginally significant, $t(46) = -1.90$, $p = .06$. The difference between the vertical and no eye movement condition was not significant $t(46) = -.26$, $p = .79$. Analysis of the guess responses was significant, $F(2,69) = 5.34$, $MS_e = .02$, $p = .007$. Planned comparisons indicated that participants claim to be guessing less often in the bilateral condition compared to the no eye movement condition and vertical eye movement condition, $t(46) = -3.52$, $p \leqslant .001$ and $t(46) = -2.39$, $p = .01$, respectively. There was no significant difference between the vertical and no eye movement conditions, $t(46) = -0.95$, $p = .17$.

The signal detection measure of *d*' was calculated using hits to studied items and false alarms to unrelated (non-suggested) items. This produced a significant effect of eye movement condition, $F(2,69) = 9.24$, $MS_e = .45$, $p \leqslant .001$. Planned comparisons revealed that *d*' scores were higher in the bilateral group compared to the vertical and no eye movement groups, $t(46) = 3.37$, $p = .001$ and $t(46) = 4.43$, $p \leqslant .001$, respectively. The vertical and no eye movement group did not differ from one another, $t(46) = 0.24$, $p = .41$. This finding shows that the bilateral group were more accurate at discriminating between the studied (pictorial) information and the unrelated (non-suggested) information. Analysis of beta revealed no significant effects, $F(2,69) = 2.14$, $MS_e = .33$, $p = .13$. Together, these findings indicate that the increased hit rate in the bilateral group was not due to the adoption of a more lenient response criterion.

3.2. Memory for unrelated information

The proportion of yes responses to unrelated information (false alarms) can be found in Table 1. Analysis of these responses supports further the conclusion that those in the bilateral condition were not adopting a more lenient response criterion, as no overall significant effect was found; $F(2,69) = 2.97$, $MS_e = .02$, $p = .06$. Although this approached significance, the direction of the results is *opposite* to that which would be expected if participants in the bilateral condition were adopting a more lenient response strategy. In other words, the false alarm rate was lower for the bilateral group compared to the no eye movement and vertical eye movement groups. Further analysis demonstrated that the proportion of remember and know responses did not differ for unrelated items, $F(2,69) = 0.73$, $MS_e = .004$, $p = .48$ and $F(2,69) = .37$, $MS_e = .007$, $p = .69$, respectively. The proportion of guess responses to unrelated items was significant, $F(2,69) = 3.90$, $MS_e = .007$, $p = .03$. This was due to guessing being lower in the bilateral group compared to the no eye movement and vertical eye movement groups, $t(46) = -2.36$, $p = .01$ and $t(46) = -2.70$, $p = .005$, respectively. The difference between the no eye movement and vertical eye movement conditions was not significant $t(46) = .53$, $p = .30$.

3.3. Memory for misinformation

The proportion of suggested items incorrectly recognised as coming from the photographic sequence (misinformation items) was calculated and can be seen in Table 1 and Fig. 2. Analysis revealed a significant effect of eye movement condition, $F(2,69) = 31.71$, $MS_e = .04$, $p \leqslant .001$. Further comparisons revealed a significantly lower proportion of misattributions in the bilateral group compared to both the no eye movement and vertical eye movement groups, $t(46) = -6.23$, $p \leqslant .001$ and $t(46) = -7.38$, $p \leqslant .001$, respectively. No difference was observed between the no eye movement and vertical groups, $t(46) = .24$, $p = .41$.

Analysis of remember responses associated with misinformation items revealed no significant effect, $F(2,69) = 2.03$, $MS_e = .05$, $p = .14$.

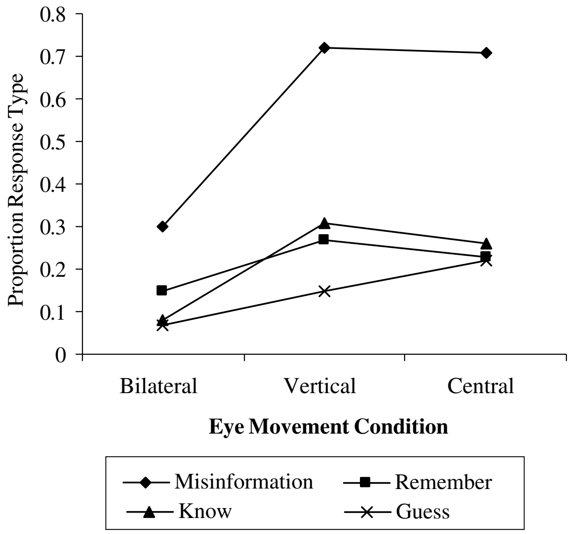

Fig. 2. Mean proportion response type for misinformation items (false memory) as a function of eye movement condition. These represent yes responses to misinformation items further broken down into remember, know and guess responses.

Know responses showed a significant effect, $F(2,69) = 12.79$, $MS_e = .03$, $p \leqslant .001$. Planned comparisons indicated that the difference between the bilateral and the no eye movement group, and the bilateral and vertical group were significant, $t(46) = -3.97$, $p \leqslant .001$ and $t(46) = -5.34$, $p \leqslant .001$, respectively. In both comparisons, know responses were lower in the bilateral group. There was no significant difference between the no eye movement and vertical eye movement groups, $t(46) = 1.02$, $p = .16$. Guess responses also showed a significant effect, $F(2,69) = 6.12$, $MS_e = .03$, $p = .004$. Planned comparisons demonstrated that the difference between the bilateral and the no eye movement group, and the bilateral and vertical eye movement group were significant, $t(46) = -3.53$, $p \leqslant .001$ and $t(46) = -2.16$, $p \leqslant .02$, respectively. In both cases the bilateral group showed lower proportions of guess responses. There was no significant difference between the no eye movement and vertical eye movement groups, $t(46) = -1.42$, $p = .08$.

Signal detection analyses were also calculated for the misinformation items. In this, yes responses to misinformation items were treated as "hits" and the yes responses to unrelated items were used as false alarms (see Koutstaal & Schacter, 1997; Parker & Dagnall, 2007; Seamon et al., 2002 for similar procedures). Higher *d*' scores using this procedure indicate greater misinformation effects. Analysis revealed a significant effect of eye movement condition, $F(2,69) = 18.60$, $MS_e = .42$, $p \leqslant .001$. This was due to lower *d*' scores (lower misinformation effects) in the bilateral condition compared to both the vertical and no eye movement conditions, $t(46) = -6.12$, $p \leqslant .001$ and $t(46) = -4.91$, $p \leqslant .001$, respectively. The difference between the vertical and no eye movement conditions was not significant, $t(46) = 0.18$, $p = .43$. The effect of eye movements on the response bias was not significant, $F(2,69) = 1.67$, $MS_e = .45$, $p = .20$. Overall, the results indicate that saccadic bilateral eye movement reduce susceptibility to misinformation effects.

3.4. Independence analyses of know responses

In the foregoing results, the calculation of know responses was based on the assumption of exclusivity (Richardson-Klavehn, Gardiner, & Java, 1996; Yonelinas, 2002). This makes sense to the extent that participants are required to make either remember *or* know responses. However, if know responses are taken to be a measure of underlying familiarity based processes then this assumption may be questionable. According to certain dual-process theories of memory, recollection and familiarity represent *independent* processes (Jacoby, 1991, 1998; Jacoby, Begg, & Toth, 1997; Yonelinas, 2002). This means that both recollection and familiarity based processes can operate in parallel. If this is true then know responses underestimate the contribution of familiarity to memory. This is because familiarity based processes are effectively masked by the instructions to produce a know response only when recollection fails. Mathematically, this can be represented as $K = F(1 - R)$, where K equals the probability of a know response, F represents familiarity and R represents recollection. To correct this, Yonelinas and Jacoby (1995) recommend calculating familiarity by rearranging the preceding formula. Thus an unbiased measurement of familiarity is given by $F = K/(1 - R)$. This formula was used to recalculate know responses to both studied and misinformation items and can be seen in the lower part of Table 1. Analysis of the independence know responses to studied items produced no significant effect, $F(2,69) = 1.33$, $MS_e = .11$, $p = .27$. Analysis of the know responses to misinformation items produced a significant effect, $F(2,69) = 16.77$, $MS_e = .04$, $p \leqslant .001$. Multiple comparisons revealed lower know responses in the bilateral group compared to the no eye movement group, $t(46) = -4.35$, $p \leqslant .001$ and the bilateral group compared to the vertical eye movement group, $t(46) = -6.08$, $p \leqslant .001$. The difference between the vertical and no eye movement groups approached significance, $t(46) = 1.62$, $p = .06$. Analysis of the know responses to unrelated items produced no effect, $F(2,69) = .43$, $MS_e = .008$, $p = .66$.

4. Discussion

The results of the current experiment both replicate and extend previous research. Replicating previous research, saccadic bilateral eye movements enhanced the retrieval of studied information. This also extends previous findings to cover different encoding contexts and materials. Earlier work has found effects for word lists (Christman et al., 2003; Parker & Dagnall, 2007) and also for autobiographical memories (Christman et al., 2003, 2006). Here, bilateral eye movements were found to enhance the retrieval of complex visual information in the form of a narrative event. The increase in the hit rate was not due to those in the bilateral condition adopting a more lenient response criterion; analysis of responses to unrelated items and the signal detection measure β showed no significant difference between the conditions. Instead, the higher hit rate in the bilateral condition was due to an increased ability to discriminate between studied and non-studied information as indicated by larger *d*' scores.

To be more specific, bilateral eye movements selectively enhanced the recollective component of episodic recognition memory as measured by remember responses. Some have argued that recollection represents a 'purer' form of episodic memory, as it depends upon the retrieval of associative and contextual information that goes beyond mere familiarity (Aggleton & Brown, 2006; Roediger et al., 1996; Tulving, 1985). If this is accepted, then bilateral eye movements clearly enhance the retrieval of episodic information. In the current experiment this presumably takes the form of the visual contextual and associative details from the scenario. That recollection/associative memory are enhanced is in agreement with other research both on the effects of eye movements and handedness. In particular, Parker et al. (2008) found bilateral eye movements to increase remember responses in a test of item recognition. Propper and Christman (2004) found remember responses were enhanced in mixed handed individuals. Lyle, McCabe, and Roediger (in press) found mixed handed participants display superior performance on tasks of paired associate recall and source memory. Finally, Lyle, Logan, and Roediger (2008) found that bilateral eye movements may be especially beneficial for strongly right handed individuals as these have most to gain from increasing the amount of hemispheric interaction. These examples, together with the current findings, are consistent with Christman et al. (2003) contention that hemispheric interaction is important for episodic memory.

With regard to studied information, know responses were numerically lower following bilateral eye movements compared to the two other conditions. This may indicate reduced reliance upon familiarity following bilateral eye movements. However, these conclusions are critically dependent upon the assumptions one makes about how familiarity and recollection operate in any given retrieval context. When know responses are analysed according to the assumption of independence, then the estimates of familiarity based processes in the bilateral condition were numerically *larger* than the two other conditions. Clearly, the theoretical assumptions that are made about know responses are important with respect to estimating the contribution of familiarity to recognition. Additionally, these conclusions need to be treated with caution as the numerical differences did not reach conventional levels of significance.

Most importantly, from the perspective of the current paper, bilateral eye movements reduced the magnitude of the misinformation effect.[1] Furthermore, the magnitude of the decrease in the misinformation effect (a form of false memory or false alarm) was greater than the magnitude of the increase in the hit rate. This difference has been found on previous occasions (Christman et al., 2003, 2004; Parker & Dagnall, 2007; Parker et al., 2008) and may be an important clue as to the mechanisms underlying bilateral eye movements. Christman et al. (2003) claim that one-way by which bilateral eye movements can enhance the accuracy of memory is by augmenting source monitoring strategies. These strategies are akin to decision rules that can be applied to retrieved information in order to distinguish between studied from non-studied information.

For example, one strategy called disqualifying monitoring describes a recall-to-reject type mechanism whereby actual recollection of a studied item can be used to reject a non-studied item (Gallo, 2004). In other words, increases in recollection can be used to suppress or avoid false memory (Jacoby, Kelley, Brown, & Jasechko, 1989; Schacter, 1999). Recent research indicates direct evidence for this idea. In an fMRI study, Mitchell, Dodson, and Schacter (2005) found that enhanced activations in the hippocampus and ventrolateral prefrontal cortex (areas known to be associated with recollection) were associated with reduced false memory. In the current study, this could depict a situation whereby the participant recollects a studied item from the scenario (e.g., Nescafe) and uses this as a basis to reject the suggested item (e.g., Kenco). This could explain the current findings as bilateral eye movements enhanced recollection of studied items; this could then be used to suppress false memory for the suggested items.

Disqualifying monitoring can only be used in situations where the recall of one item logically entails the rejection of the suggested item. Another strategy, called diagnostic monitoring, can be used even when the specific details of the studied item cannot be recalled. It has been used to explain how false memories can be reduced when those memories lack certain forms of information that would typically be expected (Gallo, 2004). As memories for presented (vs. non-presented) information are more likely to contain perceptual details (Conway et al., 2003; Johnson et al., 1988), the lack of perceptual details can be used as a diagnostic cue to reject the test item as non-studied. In the current experiment, participants were asked to endorse only those test items that appeared in the photographic sequence. Presumably, the encoding of these items would have included their visual characteristics. The items that were only suggested are much less likely to contain visual information as they were presented only verbally. Thus if source monitoring processes, like diagnostic monitoring, are engaged during the test, the presence (vs. absence) of visual information could be used as a cue to accept or reject the test item. Some support for this comes from the analysis of the know responses. In particular, know responses to misinformation items were significantly *lower* following bilateral eye movement. This was found irrespective of how know responses were analysed. Thus for misinformation at least, the contribution of familiarity based processing appears to be reduced as a result of bilateral eye movements. In terms of diagnostic monitoring, one interpretation of the results is that the use of such monitoring processes reduces reliance upon familiarity based recognition and hence decreases the number of false alarms.

The proportion of guess responses was decreased by bilateral eye movements compared to both other conditions. This occurred for studied and misinformation items. The role of guessing has been discussed previously in relation to misinformation effects (McCloskey & Zaragoza, 1985). Principally, this account holds that misinformation effects arise as a result of lower rates of correct guessing in the misinformation (vs. control) condition. Although guessing may play a role in producing false memories in the misinformation paradigm, it does not explain adequately the entire range of results that clearly implicate a significant role for source monitoring (Lindsay, 1990; Lindsay et al., 2004; Mitchell & Johnson, 2000).

Although the current findings are framed in terms of source memory, participants were not asked to make actual source judgements. The reason for this, as noted in the introduction, is that previous research has shown that source monitoring reduces or even eliminates the misinformation effect (Lindsay & Johnson, 1989). As a consequence requesting such judgements may have eliminated the very effect we wished to detect *and* reduce via bilateral eye movements. Nevertheless, future research should consider the effect of bilateral eye movements on source memory more directly, perhaps using alternative techniques such as the 'who said what' paradigm.

An assumption made in this study is that source memory and recollection are in some way related. In particular, the retrieval of source specifying information will lead to a recollection response. Some previous work does indeed support this idea (e.g., Perfect, Mayes, Downes, & Van Eijk, 1996). However, it is also becoming clear that vaguer feelings of familiarity can, under some conditions, support accurate source discrimination (Hicks, Marsh, & Ritschel, 2002). In terms of the findings presented here, we would argue that source memory and recollection are more likely to be related as the recollection of perceptual information is most likely to provide the most accurate means of discriminating between presented and suggested information. In spite of this, future studies may like to consider more specifically the relationship between source memory and recollection/knowing following bilateral eye movements.

The precise neural reasons why bilateral eye movements improve memory are not fully understood and remain an important

[1] One of the reviewers noted that some of the misinformation items referred to purely visual objects (e.g., a red vs. grey tool box) whilst other items had both a visual and verbal component (e.g., Asda vs. Tesco carrier bag). It was suggested that we perform a post hoc analysis with separate scores for each of these item types. Thus the number of yes responses to each item type was calculated and submitted to a 3 (eye movement: bilateral vs. vertical vs. no eye movement) between participants by 2 (misinformation item type (visual vs. visual and verbal) within participant mixed ANOVA. The only significant effect was that of eye movement, $F(2,69) = 23.53$, $MS_e = .12$, $p \leqslant .001$. Neither the main effect of item type or the interaction approached significance [$F(1,69) = .09$, $MS_e = .01$, $p = .76$ and $F(2,69) = .38$, $MS_e = .03$, $p = .69$, respectively]. Thus it would appear that eye movements reduced the acceptance of both purely visual and visual/verbal item types. However, as these analyses were post hoc, caution must be exercised with respect to interpreting these specific findings. Future work might want to incorporate the type of item as a manipulated factor to assess the importance of this variable in a more systematic manner.

avenue for future investigation. The original suggestion was premised upon work that demonstrated a role for interhemispheric processing in episodic memory (e.g., Habib et al., 2003). As bilateral eye movements are hypothesised to increase interhemispheric interaction then such eye movements should influence episodic memory (Christman et al., 2003). One study assessed this idea by measuring interhemispheric EEG coherence in the gamma band following bilateral eye movements (Propper, Pierce, Geishler, Christman, & Bellorado, 2007). Contrary to predictions, they found *decreased* interhemispheric coherence following bilateral eye movements. However, as noted by the authors, EEG coherence may not map directly onto hypothesised cognitive processes; decreased coherence does not mean reduced functional interactions. Increased EEG coherence implies that both hemispheres are performing similar activities in a coordinated manner. Functional interaction however, can indicate that the two hemispheres are working together but not necessarily performing similar activities. Nevertheless, at a more general level, some recent work in neuroimaging supports the idea that prefrontal bihemispheric activity is important for episodic memory. This includes the retrieval of associative information, that would be useful for source monitoring, and in recollection (e.g., Achim & Lapage, 2005; Cabeza, Rao, Wagner, Mayer, & Schacter, 2001; Wheeler & Buckner, 2003; Yonelinas, Otten, Shaw, & Rugg, 2005).

It could be noted at this juncture that only the bilateral eye movement condition significantly enhanced true memory and decreased false memory. That vertical eye movements did *not* bring about any appreciable effects is also important from the perspective of Christman et al. (2003) original account. The absence of an effect for the vertical eye movement condition eliminates the hypothesis that the observed eye movement results were simply due to a non-specific effect of eye movement activity. According to Christman et al. (2003) only saccadic bilateral eye movements should influence memory because only these types of eye movements are expected to increase hemispheric interaction.

Although the above account stresses the importance of interhemispheric interactions, a growing body of research indicates that interactions between the prefrontal regions and the medial temporal lobes are important for episodic memory (Simons & Spiers, 2003). Thus it may be the case that bilateral eye movements enable more efficient engagement between prefrontal and posterior regions during retrieval. This could take the form of different more effective retrieval strategies or monitoring processes. For example, Summerfield and Mangels (2005) found increased EEG coherence in the gamma band between parietal and frontal regions during recognition memory. This was interpreted as indicating the operation of frontal mechanisms accessing episodic information stored in posterior regions. As the current study found bilateral eye movements to enhance recollection, and recollection is associated with increased hippocampal activity (Yonelinas et al., 2005), then bilateral eye movements may increase interactions between frontal cortical regions the hippocampus. Of course this is somewhat speculative, but worthy of consideration in future work given the importance of frontal–posterior interactions in episodic retrieval.

Overall, the current findings are consistent with previous research in which bilateral eye movements bring about dual effects on memory; both increasing the hit rate and decreasing the false alarm rate. More specifically, this experiment is the first to demonstrate that saccadic bilateral eye movements can reduce the magnitude of misinformation effects. It extends previous work by indicating that the effects of bilateral eye movements are not limited to the study and retrieval of word lists and illustrates some important consequences in a novel experimental setting. However, much work remains to be done to fully elucidate the nature, magnitude and applicability of these findings with respect to both cognitive and neural mechanisms.

Acknowledgments

The authors thank Keith Lyle and Ruth Propper for helpful comments on an earlier version of the article.

References

Achim, A. M., & Lapage, M. (2005). Dorsolateral prefrontal cortex involvement in memory post-retrieval monitoring revealed in both item and associative recognition tests. *Neuroimage, 24*, 1113–1121.

Aggleton, J. P., & Brown, M. W. (2006). Interleaving brain systems for episodic and recognition memory. *Trends in Cognitive Sciences, 10*, 455–463.

Baken, P., & Svorad, D. (1969). Resting EEG alpha asymmetry of reflective lateral eye movements. *Nature, 223*, 975–976.

Beli, R. F., Windschitl, P. D., McCarthy, T. T., & Winfrey, S. E. (1992). Detecting memory impairment with a modified test procedure: Manipulating retention interval with centrally presented item events. *Journal of Experimental Psychology: Learning, Memory & Cognition, 18*, 356–367.

Berkerian, D. A., & Bowers, J. M. (1983). Eyewitness testimony: Were we misled? *Journal of Experimental Psychology: Learning, Memory & Cognition, 9*, 139–145.

Cabeza, R., Rao, S. M., Wagner, A. D., Mayer, A. R., & Schacter, D. L. (2001). Can medial temporal lobe regions distinguish true from false? An event-related functional MRI study of veridical and illusory recognition memory. *Proceedings of the National Academy of Sciences of the United States of America, 98*, 4805–4810.

Chandler, C. C. (1991). How memory for an event is influenced by repeated events: Interference in Modified recognition tests. *Journal of Experimental Psychology: Learning, Memory & Cognition, 17*, 115–125.

Christman, S. D., Garvey, K. J., Propper, R. E., & Phaneuf, K. A. (2003). Bilateral eye movements enhance the retrieval of episodic memories. *Neuropsychology, 17*, 221–229.

Christman, S. D., & Propper, R. E. (2001). Superior episodic memory is associated with interhemispheric processing. *Neuropsychology, 15*, 607–616.

Christman, S. D., Propper, R. E., & Brown, T. J. (2006). Increased interhemispheric interaction is associated with earlier offset of childhood amnesia. *Neuropsychology, 20*, 336–345.

Christman, S. D., Propper, R. E., & Dion, A. (2004). Increased interhemispheric interaction is associated with deceased false memories in a verbal converging semantic associates paradigm. *Brain & Cognition, 56*, 313–319.

Conway, M. A., Pleydell-Pearce, C. W., Whitecross, S. E., & Sharpe, H. (2003). Neurophysiological correlates of memory for experienced and imagined events. *Neuropsychologia, 41*, 334–340.

Cronin-Golomb, A., Gabrieli, J. D. E., & Keane, M. M. (1996). Implicit & explicit memory retrieval within and across the disconnected cerebral hemispheres. *Neuropsychology, 10*, 254–262.

Diana, R. A., Reder, L. M., Arndt, J., & Park, H. (2006). Models of recognition: A review of arguments in favour of a dual-process account. *Psychonomic Bulletin & Review, 13*, 1–21.

Dodson, C. S., & Hege, A. C. G. (2005). Speeded retrieval abolishes the false-memory suppression effect: Evidence for the distinctiveness heuristic. *Psychonomic Bulletin & Review, 12*, 726–731.

Dodson, C. S., & Schacter, D. L. (2002). When false recognition meets metacognition: The distinctiveness heuristic. *Journal of Memory & Language, 46*, 782–803.

Eldridge, L. L., Sarfatti, S., & Knowlton, B. J. (2002). The effect of testing procedure on remember–know judgements. *Psychonomic Bulletin & Review, 9*, 139–145.

Frost, P. (2000). The quality of false memory over time: Is memory for misinformation remembered of known? *Psychonomic Bulletin & Review, 7*, 531–536.

Gallo, D. A. (2004). Using recall to reduce false recognition: Diagnostic and disqualifying monitoring. *Journal of Experimental Psychology: Learning, Memory & Cognition, 30*, 120–128.

Gardiner, J. M. (1988). Functional aspects of recollective experience. *Memory & Cognition, 16*, 309–313.

Gardiner, J. M., & Richardson-Klavehn, A. (2000). Remembering and knowing. In E. Tulving & F. I. M Craik (Eds.), *The Oxford handbook of memory* (pp. 229–244). Oxford: Oxford University Press.

Greene, R. L. (1992). *Human memory: Paradigms & paradoxes*. Hillsdale, NJ: Erlbaum.

Habib, R., Nyberg, L., & Tulving, E. (2003). Hemispheric asymmetries of memory: The HERA model revisited. *Trends in Cognitive Sciences, 7*, 241–245.

Hicks, J. L., Marsh, R. L., & Ritschel, L. (2002). The role of recollection and partial information in source monitoring. *Journal of Experimental Psychology: Learning, Memory & Cognition, 28*, 503–508.

Jacoby, L. L. (1991). A process dissociation framework: Separating automatic from intentional uses of memory. *Journal of Memory & Language, 30*, 513–541.

Jacoby, L. L. (1998). Invariance in automatic influences of memory: Towards a users guide for the process dissociation procedure. *Journal of Experimental Psychology: Learning, Memory & Cognition, 24*, 3–26.

Jacoby, L. L., Begg, I. M., & Toth, J. P. (1997). In defence of functional independence: Violations of assumptions underlying the process-dissociation procedure? *Journal of Experimental Psychology: Learning, Memory & Cognition, 23*, 484–495.

Jacoby, L. L., Kelley, C., Brown, J., & Jasechko, J. (1989). Becoming famous overnight: Limits on the ability to avoid unconscious influences of the past. *Journal of Personality & Social Psychology, 56*, 326–338.

Johnson, M. K., Foley, M. A., Suengas, A. G., & Raye, C. L. (1988). Phenomenal characteristics of memories for perceived and imagined autobiographical events. *Journal of Experimental Psychology: General, 117*, 371–376.

Johnson, M. K., Hashtroudi, S., & Lindsay, D. S. (1993). Source monitoring. *Psychological Bulletin, 114*, 3–28.

Karpel, M. E., Hoyer, W. J., & Toglia, M. P. (2001). Accuracy & qualities of real & suggested memories: Nonspecific age differences. *Journal of Gerontology: Psychological Sciences, 56B*, P103–P110.

Keogh, L., & Markhan, R. (1998). Judgements of other peoples memory reports: Differences in reports as a function of imagery vividness. *Applied Cognitive Psychology, 12*, 159–171.

Koutstaal, W., & Schacter, D. L. (1997). Gist-based false recognition of pictures in older and younger adults. *Journal of Memory & Language, 37*, 555–583.

Lindsay, D. S. (1990). Misleading suggestions can impair eyewitnesses' ability to remember event details. *Journal of Experimental Psychology: Learning, Memory & Cognition, 16*, 1077–1083.

Lindsay, D. S., Allen, B. P., Chan, J. C. K., & Dahl, L. C. (2004). Eyewitness suggestibility and source similarity: Intrusions of details from one event into memory reports of another event. *Journal of Memory & Language, 50*, 96–111.

Lindsay, D. S., & Johnson, M. K. (1989). The eyewitness suggestibility effect and memory for source. *Memory & Cognition, 17*, 349–358.

Loftus, E. F., & Loftus, G. R. (1980). On the permanence of stored information in the human brain. *American Psychologist, 35*, 409–420.

Loftus, E. F., Miller, D. G., & Burns, H. J. (1978). Semantic integration of verbal information into a visual memory. *Journal of Experimental Psychology: Human Learning & Memory, 4*, 19–31.

Lyle, K. B., Logan, J. M., & Roediger, H. L. (2008). Eye movements enhance memory for individuals who are strongly right-handed and harm it for individuals who are not. *Psychonomic Bulletin & Review, 15*, 515–520.

Lyle, K. B., McCabe, D. P., & Roediger, H. L. (in press). Handedness is related to memory via hemispheric interaction: Evidence from paired associate recall and source memory tasks. *Neuropsychology*.

Mandler, G. (1980). Recognizing: The judgement of previous occurrence. *Psychological Review, 87*, 252–271.

Mather, M., Henkel, L. A., & Johnson, M. K. (1997). Evaluating characteristics of false memories: Remember/know judgements and memory characteristics questionnaire compared. *Memory & Cognition, 25*, 826–837.

McCloskey, M., & Zaragoza, M. (1985). Misleading postevent information and memory for events: Arguments and evidence against memory impairment hypotheses. *Journal of Experimental Psychology: General, 114*, 1–16.

Mitchell, J. P., Dodson, C. S., & Schacter, D. L. (2005). fMRI evidence for the role of recollection in suppressing misattribution errors: The illusory truth effect. *Journal of Cognitive Neuroscience, 17*, 800–810.

Mitchell, K. J., & Johnson, M. K. (2000). Source monitoring. In E. Tulving & F. I. M Craik (Eds.), *The Oxford handbook of memory* (pp. 179–196). Oxford: Oxford University Press.

Norman, K. A., & Schacter, D. L. (1997). False recognition in younger and older adults: Exploring the characteristics of illusory memories. *Memory & Cognition, 25*, 838–848.

O'Driscoll, G. A., Strakowski, S. M., Alpert, N. M., Matthysse, S. W., Rauch, S. L., Levy, D. L., et al. (1998). Differences in cerebral activation during smooth pursuit and saccadic eye movements using positron-emission tomography. *Biological Psychiatry, 44*, 685–689.

Parker, A., & Dagnall, N. (2007). Effects of bilateral eye movements on gist based false recognition in the DRM paradigm. *Brain & Cognition, 63*, 221–225.

Parker, A., Relph, S., & Dagnall, N. (2008). Effects of bilateral eye movements on the retrieval of item, associative and contextual information. *Neuropsychology, 22*, 136–145.

Perfect, T. J., Mayes, A. R., Downes, J. J., & Van Eijk, R. (1996). Does context discriminate recollection from familiarity in recognition memory? Quarterly. *Journal of Experimental Psychology: Human Experimental Psychology, 49*, 791–813.

Propper, R. E., & Christman, S. D. (2004). Mixed-versus strong right-handedness is associated with biases towards remember versus know judgements in recognition memory: Role of interhemispheric interaction. *Memory, 12*, 707–714.

Propper, R. E., Christman, S. D., & Phaneuf, K. A. (2005). A mixed-handed advantage in episodic memory: A possible role of interhemispheric interaction. *Memory & Cognition, 33*, 751–757.

Propper, R. E., Pierce, J., Geishler, M. W., Christman, S. D., & Bellorado, B. S. (2007). Effect of bilateral eye movement on frontal interhemispheric gamma EEG coherence: Implications for EMDR therapy. *Journal of Nervous & Mental Disease, 195*, 785–788.

Richardson-Klavehn, A., Gardiner, J. M., & Java, R. I. (1996). Memory: Task dissociations, process dissociations, & dissociations of consciousness. In G. Underwood (Ed.), *Implicit cognition* (pp. 85–158). Oxford: Oxford University Press.

Roediger, H. L., Jacoby, D., & McDermott, K. B. (1996). Misinformation effects in recall: Creating false memories through repeated retrieval. *Journal of Memory & Language, 35*, 300–318.

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

Schacter, D. L. (1999). The seven sins of memory: Insights from psychology & cognitive neuroscience. *American Psychologist, 54*, 182–203.

Schooler, J. W., Gerhard, D., & Loftus, E. F. (1986). Qualities of the unreal. *Journal of Experimental Psychology: Learning, Memory & Cognition, 12*, 171–181.

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 Deese, Roediger and McDermott procedure. *Psychological Science, 13*, 526–531.

Simons, J. S., & Spiers, H. J. (2003). Prefrontal and medial temporal lobe interactions in long-term memory. *Nature Reviews: Neuroscience, 4*, 637–648.

Slotnick, S. D., & Schacter, D. L. (2004). A sensory signature that distinguishes true from false memories. *Nature Neuroscience, 7*, 664–672.

Sondhi, V., & Gupta, A. (2007). The quality of suggested memories. *International Journal of Psychology, 42*, 116–123.

Summerfield, C., & Mangels, J. A. (2005). Functional coupling between frontal and parietal lobes during recognition memory. *Neuroreport, 16*, 117–122.

Tulving, E. (1985). Memory & consciousness. *Canadian Psychologist, 26*, 1–12.

Wheeler, M. E., & Buckner, R. L. (2003). Functional dissociation among components of remembering: Control, perceived oldness, and content. *Journal of Neuroscience, 23*, 3869–3880.

Yonelinas, A. P. (2002). The nature of recollection and familiarity: A review of 30 years of research. *Journal of Memory & Language, 46*, 441–517.

Yonelinas, A. P., & Jacoby, L. L. (1995). The relation between remembering and knowing as bases for recognition: Effects of size congruency. *Journal of Memory & Language, 34*, 622–643.

Yonelinas, A. P., Otten, L. J., Shaw, K. N., & Rugg, M. D. (2005). Separating brain regions involved in recollection and familiarity in recognition memory. *The Journal of Neuroscience, 25*, 3002–3008.

Zaidel, D. W. (1995). Separated hemispheres, separated memories: Lessons on long-term memory from split-brain patients. In R. Campbell & M. A. Conway (Eds.), *Broken memories: Case studies in memory impairment* (pp. 213–224). Oxford: Blackwell.

Zaragoza, M. S., & Lane, S. M. (1994). Source misattributions and the suggestibility of eyewitness memory. *Journal of Experimental Psychology: Learning Memory & Cognition, 20*, 934–945.

Zaragoza, M. S., & Mitchell, K. J. (1996). Repeated exposure to suggestion and the creation of false memories. *Psychological Science, 7*, 294–300.