The Effect of Eye Movements on Traumatic Memories and the Susceptibility to Misinformation: A Partial Replication

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Abstract

The issue of whether certain techniques used in psychotherapy might increase false memories is a major source of contention between cognitive and practising psychologists. Recently, a study by Houben, Otgaar, Merckelbach, and Roelofs (2018) found that bilateral eye movements used in Eye Movement Desensitisation and Reprocessing (EMDR) therapy increase susceptibility to misleading information. EMDR is a popular treatment for posttraumatic stress disorder and is primarily thought to reduce the vividness and emotional intensity of traumatic memories. Individuals who undergo EMDR therapy may be more susceptible to misinformation that is inadvertently introduced by the therapist due to reductions in memory vividness. Despite strong theoretical links between eye movements and false memories, few studies have investigated this effect. The current study addressed this issue by attempting to replicate the study by Houben et al. (2018). This study also investigated the working memory account underlying EMDR by comparing eye movements to an alternative dual-task. An initial pilot study comprising a reaction time task established that attentional breathing taxed working memory most comparably to bilateral eye movements. The main study predicted that eye movements would increase susceptibility to misinformation and that eye movements and attentional breathing would lead to comparable reductions in memory vividness and emotionality. 94 students (M_{age}= 25.74, SD_{age}= 9.68) were recruited to participate in the study at Massey University, Manawatū, New Zealand. Participants viewed a five-minute video depicting a serious car accident. Afterwards, they were randomly assigned to perform either eye movements, attentional breathing, or a control task while simultaneously recalling the car accident. Participants rated the vividness and emotionality of their memory before and after performing the tasks. All participants then received misinformation about the video before completing a recognition test. Results indicated that the misinformation effect was not replicated, with no effect of eye movements on susceptibility to false memories. Findings also suggested that eye movements and attentional breathing were ineffective in reducing the vividness and emotional intensity of the trauma memory. The present study raises questions about the validity of materials and procedures used to instil the misinformation effect. Limitations of the study and key areas for improvement are considered for further investigation.

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CHAPTER 1

Introduction

Memory is a complicated thing, a relative to truth, but not its twin – Barbara Kingsolver (1991) in 'Animal Dreams'

According to Simons and Chabris (2011), a majority of Americans believe that human memory operates the same way as a video camera. Inaccurate beliefs about the properties of memory have far-reaching implications for psychologists and the judicial system. Personal recollections of traumatic events are frequently relied upon in both therapeutic and forensic eyewitness contexts. In such situations, memory is presumed to represent truth and fact. However, there is considerable incongruence between what is commonly believed about memory and what is known from the science of memory.

Since the 1970's, psychological research has increasingly sought to identify important limitations of memory. Rather than providing a veridical account of events (like a video camera), research suggests human memory is highly fallible. A review article by Schacter (1999) identifies several forms of memory errors, which he calls the 'seven sins of memory'. These 'seven sins' include omission of details resulting from transience, absent-mindedness, or temporary retrieval blocking- often experienced as 'tip of the tongue' (Schacter, Chiao, & Mitchell, 2003). They also include errors of commission, such as intrusive recollections or memory distortions resulting from misattribution, suggestibility, and bias.

Our understanding of memory is still continuing to develop, however what decades of research tells us is that memory is fragmented, fragile, and often contains incorrect details (Howe & Knott, 2015). Thus, memory errors include both the absence of details during recollection, as well as the presence of incorrect details; commonly referred to as a false memory. This chapter reviews key arguments in the literature about what false memories are and how they originate, including theoretical explanations and methodological issues about how false memories are studied in laboratory settings. False memories will be explored in the context of psychotherapy, with particular focus on Eye Movement Desensitisation and Reprocessing (EMDR) therapy. EMDR therapy is a common psychotherapy for treating posttraumatic stress disorder (PTSD), and typically involves the client making horizontal eye movements while recalling the traumatic memory that is causing them distress (Shapiro & Laliotis, 2011). Recent evidence suggests EMDR therapy may increase false memories through the eye movement component (Houben et al., 2018). The following literature review aims to highlight the rationale for the current research by identifying an important gap in contemporary understanding of EMDR therapy.

Conceptualisation of False Memories

Memory is crucial to our survival as humans. Memories give us a sense of identity, allow us to learn from past mistakes, and generate meaning from our experiences so that we can adapt our behaviour accordingly. Hence, memory is an adaptive system that has facilitated human development throughout evolution (Howe, 2011). A central feature of memory is its flexibility (Howe, 2011; Newman & Lindsay, 2009). This flexibility allows us to integrate and re-write both incoming and previously-stored information. However, flexibility also leaves memory vulnerable to distortions and illusions, such as those involving false memories.

In psychology, the term ‘false memory’ encompasses a variety of phenomena. For instance, a false memory can refer to the sense of remembering an event that was only imagined (Schacter, 1999). False memories also encompass the integration of misleading information about an event into personal recollection, such learning that you were lost in a mall as a child and developing a memory of the experience, despite the fact it never actually occurred (Loftus, 2005). ‘False memories’ can also include memory distortions that are inferred based on prior knowledge or schemas (Schacter, 1999), for example, falsely remembering that a burglar was wearing a balaclava because this fits with our schema of what a burglar typically looks like. In its most general sense, a false memory refers to recollections of an event that never occurred or recalling the event differently to what actually transpired. Unlike mere lying, the rememberer of a false memory genuinely believes that the non-experienced event actually occurred (Zhu et al., 2010).

Frequently, false memories involve episodic memory. Episodic memory comprises memory for events that are personally experienced (autobiographical events). Information provided by an eyewitness in a legal context often relies on the individual’s episodic memory of the event in question, including detailed descriptions of the perpetrator, crime scene, and sequence of events. Likewise, recollections of traumatic experiences reported by clients in therapy also rely on autobiographical accounts. These events are generally experienced as a continuous sequence of scenes involving interactions between the rememberer and their surroundings within a specific context (Baddeley, Conway, & Aggleton, 2002). Emotions that are experienced during the original event may also be remembered when the episode is later retrieved. Episodic memory is, therefore, largely concerned with the ‘what’, ‘where’ and ‘when’ of personal experience (Nyberg et al., 1996). Episodic memories allow us to re-experience events in our past through conscious introspection.

While the majority of the false memory literature emphasises negative implications, false memories can also serve an adaptive purpose (Howe, 2011; Newman

& Lindsay, 2009; Schacter, Guerin, & St. Jacques, 2011). For instance, Schacter (2013) considers false memories to be adaptive because they reflect the capacity to retain valuable information regarding the meaning of an experience. This capacity enables us to generalise information for use in future situations. Similarly, Howe (2011) suggests false memories may also facilitate self-enhancement and positive self-concept through falsely remembering and revising aspects of one's past. Moreover, false memories that result from imagination inflation can be beneficial as they allow us to simulate potential future experiences and prepare for different versions of events (Schacter, 2013). False memories are not just the result of a glitch in our memory system, but rather, have developed through processes that are essential for survival.

Key Characteristics of False Memories

False memories can be equally as convincing as true memories. False information can often be remembered in rich detail and can seem truly authentic to the rememberer (Loftus, 2003). Distinguishing between true and false memories presents a challenging, and sometimes seemingly impossible, task. For example, there are a number of cases where individuals have come forward with detailed and emotionally-charged recovered memories of childhood abuse, but with no other evidence to support their claims (Bernstein & Loftus, 2009). Judges and juries have the arduous task of deciding whether a recovered memory, alone, is sufficient to make a conviction.

It is perhaps unsurprising that false memories are so difficult to identify, given that Bernstein and Loftus (2009) claim that, to some degree, all memories are false. The very nature of human memory means that our recollections are based on reconstructions of the past, rather than veridical accounts. However, considerable research has focused on identifying specific correlates of false memories in order to enhance distinctions between true and false memories. Such research has addressed aspects such as the phenomenological quality of memory and the relationship between working memory capacity and false memories.

Phenomenological quality of memory. Memories, particularly episodic, tend to form powerful phenomenological experiences. These phenomenological experiences are characterised by the memory's vividness, emotional intensity, meaningfulness, and relatedness to future goals and actions (Sutin & Robins, 2007). Some researchers have identified important differences in the way true and false memories are phenomenologically experienced, which may aid in making decisions about whether a particular memory can be considered reliable. Mather, Henkel, and Johnson (1997) investigated the phenomenological similarities and differences between true and false memories in the Deese-Roediger-McDermott paradigm (DRM; Roediger & McDermott, 1995). In the DRM paradigm, participants are presented with several lists of associated words that are semantically related to a word that was not presented in the list, called a critical lure. For example, a list containing the words *clinic, stethoscope, nurse, patient,* and *sick* are all associated with the non-presented critical lure *doctor*. Subsequently, participants complete free recall and recognition tasks to test their memory for presented items. False memories occur in the DRM paradigm when participants incorrectly report seeing the non-presented critical lure.

In Mather et al.'s (1997) study, word lists were read aloud to participants by two different speakers. Alongside the usual recall and recognition tasks, participants also identified which speaker said each word in the list. Results revealed that true memories in the DRM paradigm were rated as more vivid, and reported with more confidence, higher levels of auditory details and information about associated feelings or reactions compared to false memories. This demonstrates that false memories may be distinguished from true memories based on level of detail and confidence of the rememberer. While false memories can be rich in detail, true memories appear to be characterised by an even higher level of detail.

Heaps and Nash (2001) extended this research using an alternative method for instilling false memories— the 'lost in the mall' technique (Loftus & Pickrell, 1995). This technique involves giving participants brief descriptions of childhood events and asking participants to recall the memories. Unknown to participants, some of the prompts are for true events experienced during childhood, and some are prompts for false events that never occurred (e.g., being lost in a mall). Across several studies using this procedure, approximately 30% of participants tended to produce partial or complete false memories for the suggested event (Lindsay, Hagen, Read, Wade, & Garry, 2004). Using this paradigm, Heaps and Nash (2001) found that people recalled more information about the consequences of true events than false events. Moreover, participants experienced memories of true events as being richer in detail and more emotionally intense than false events.

Many studies investigating the qualitative differences between true and false memories have used the Memory Characteristics Questionnaire (MCQ; Johnson, Foley, Suengas, & Raye, 1988). The MCQ assesses how a memory is experienced, and includes questions related to visual detail, memory complexity, emotional response, and confidence in the memory. Studies using this measure have found that true memories tend to be richer in perceptual details, reported with higher levels of confidence, and more attempts to remember compared to false memories (Gallo & Roediger, 2003; Marche, Brainerd, & Reyna, 2010; Neuschatz, Payne, Lampinen, & Toglia, 2001). Interestingly, Neuschatz et al. (2001) also found that warning participants about the phenomenological differences between true and false memories did not attenuate false memories, though participants tended to be less confident in their false responses. This suggests that despite having knowledge about identifying features, false memories can still be experienced as convincing to the rememberer.

There are significant limitations to using phenomenological quality as a predictive tool when making judgements about the veracity of a memory. In particular, true memories themselves can differ a great deal in terms of how they are subjectively experienced (Lampinen, Neuschatz, & Payne, 1997). Some events may be remembered in more detail than others, they may elicit more intense emotions, or may have more lasting consequences. However, memories lacking in these qualities are not necessarily false. The reality is that many factors contribute to how memories are phenomenologically experienced, and the truthfulness of a memory represents only one of these factors.

Working memory capacity and false memories. Individual differences in a range of cognitive factors have also been implicated in false memories. Of particular significance to this experiment is the link between false memories and working memory capacity (WMC). WMC tasks are generally understood to measure one's executive attention (Engle, 2002). Thus, WMC provides an indication of an individual's ability to actively maintain a goal in the face of distraction and to manage cognitive resources efficiently between tasks (Leding, 2012).

WMC is important in this study because it is thought to be associated with both false memories and the effects of EMDR therapy, which will be discussed later in this chapter. Studies have consistently found that WMC is negatively correlated with false memories for word lists and suggested events (Brydges, Gignac, & Ecker, 2018; Calvillo, 2014; Gerrie & Garry, 2007; Jaschinski & Wentura, 2002; Leding, 2012; Watson, Bunting, Poole, & Conway, 2005). Individuals with low WMC appear to be more vulnerable to developing false memories than individuals with high WMC.

Several different explanations for this relationship have arisen from the literature. Most predominantly, it is claimed that individuals with high WMC are better able to direct their attentional resources during encoding. Therefore, they will retain a more detailed memory of the information, which allows for better discrimination between true and false details at test (Gerrie & Garry, 2007; Jaschinski & Wentura, 2002). In contrast, it is speculated that individuals with poor WMC are more prone to distractions, which disrupt detailed encoding of information. As a result, they become more reliant on general features at test, which are less useful for discriminating between true and false details (Peters, Jelicic, Verbeek, & Merckelbach, 2007).

In summary, there are a number of factors associated with false memories, including the quality and quantity of information recalled, confidence in details remembered, and the rememberer's working memory capacity. Despite these associations, great difficulty still exists in distinguishing between true and false memories outside of the laboratory setting, and a comprehensive model for detecting false memories is yet to be developed.

Overview of False Memory Theory

Due to the vast implications of false memories for psychology and other disciplines, psychological research has increasingly sought to understand the mechanisms responsible. Over the past few decades, three major theories of false memories have gained recognition in the literature; associative activation theory, source monitoring framework, and fuzzy trace theory. This section describes these different perspectives of false memory.

Associative activation theory. According to associative activation theory (AAT; Howe, Wimmer, Gagnon, & Plumpton, 2009), false memories are a consequence of spreading activation throughout a network of related concepts. This theory of false memories is derived from a spreading activation theory of more general memory processes. The spreading activation theory (Anderson, 1983) proposes that information is encoded in networks of nodes. To varying degrees, nodes within a network are associated with one another in terms of their over-arching concepts. Nodes can be activated at any time during memory retrieval, and the level of activation depends on how closely related the node is to the original concept (see Figure 1 for the structure of a network). The more related a node is to the original concept, the faster it will be activated. For example, when looking at a photograph, certain nodes will be activated within a relevant network to retrieve aspects of the memory related to the photograph. Activation will spread throughout the network, with the most relevant nodes being activated first, followed by less-relevant nodes (Brainerd & Reyna, 2005). Thus, particular stimuli can elicit memories for related concepts and events.

AAT posits that associative relations between experienced events and suggested events are critical to the formation of a false memory (Howe et al., 2009). Specifically, because one concept spreads activation to other related concepts, it is possible that concepts that were not actually part of the original experience become activated through their connection with the triggering stimulus. As a result, the individual might misattribute strong activation of incorrect details as evidence that they were experienced during encoding. This is especially likely in situations where memory for the original event has become vague, since distinctions between original details and related details are less clear.

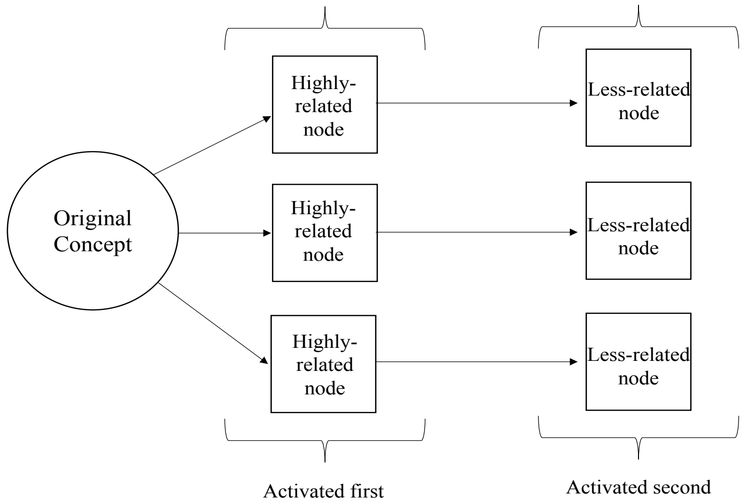

Figure 1. **Structure of nodes within a concept network according to the spreading activation theory of memory.**

Support for the AAT has been evidenced in several empirical studies. Research by Hutchison and Balota (2005) and Howe et al. (2009) found that false recall for word lists in the DRM paradigm was dependent on the associative strength of list items with a non-presented critical word, and unrelated to the thematic consistency of studied words. Similarly, Gallo and Roediger (2003) found that increasing the number of associated words presented in a list increased false recall of non-presented words. Together, these findings suggest that false memories result from automatic processes of associative activation, rather than conscious processing of semantic relatedness.

Source monitoring framework. The source monitoring framework (SMF; Johnson, Hashtroudi, & Lindsay, 1993) provides an alternative explanation of how false memories occur. Rather than attributing false memories to errors in activation, the SMF suggests false memories are the result of a failure to accurately judge the source of information that forms the memory. An example of a source monitoring error would be mistaking an event that occurred in a movie for an event that occurred in reality. A memory's source comprises the features that help to determine the conditions under which the memory was formed, including spatial, temporal, affective, semantic, and contextual details (Johnson et al., 1993). Thus, source monitoring is the process of determining the origins of a memory. Identifying the origins of a memory means that we can make distinctions about whether our memory is based on a true event or an event we dreamed, imagined, or saw in a movie.

There are three main distinctions between source types that can be made in source monitoring. The first involves discriminating between internally and externally generated information (Johnson et al., 1993). Internally-generated information may include details produced through internal thoughts or imagination. Whereas externally-generated information includes memories for experienced or perceived events. A second distinction in source monitoring is between different external sources. For example, distinguishing whether information has come from one person or another, or whether information was obtained from a book or a television show. The final distinction is between different internal sources, such as distinguishing between memories of what was internally thought and what was said aloud. False memories may arise from a failure to accurately discriminate between sources in any one of these elements.

Brainerd and Reyna (2005) propose that errors in source monitoring may occur due to similarities between features of the false memory and the features of the actual experience. Such similarities mean that making distinctions between the true memory and the distorted memory become particularly difficult; increasing the likelihood that false information will be integrated into the true memory. Moreover, Brainerd and Reyna (2005) also suggest false memories may occur due to retrieval of insufficient information to be able to accurately identify the memory's source. This may be due to a number of factors, including lack of information encoded to begin with, complications during memory retrieval, or memory for the original event becoming increasingly vague over time.

SMF has been widely used to explain the mechanisms involved in false memories. Hekkanen and McEvoy (2002) investigated whether differences in criterion for determining the memory's source could explain false memories in the misinformation paradigm (Loftus, Miller, & Burns, 1978). The misinformation paradigm has been widely used to investigate the types of false memories that occur through post-event suggestion, known as the misinformation effect (Loftus, 1975, 1977; Loftus & Hoffman, 1989; Loftus et al., 1978). To produce this effect, three stages are necessary; (1) witnessing an event through slides or a video, (2) receiving misleading post-event information about the witnessed event, and (3) a memory test (Loftus, 2005). False memories occur in the misinformation paradigm when an individual accepts post-event misinformation as part of the original event. In their study, Hekkanen and McEvoy (2002) found that source monitoring errors were more likely to occur when participants used less information to make a judgement about the source of specific details. Therefore, using more lenient criterion for making source decisions may increase susceptibility to the misinformation effect.

Lindsay, Allen, Chan, and Dahl (2004) also used the misinformation paradigm to investigate the effect of source monitoring on false memories. They found that participants were more likely to produce false memories when misinformation was more similar to the perceived event, compared to misinformation that deviated from the perceived event. Such research indicates that false memories may be produced through a combination of more relaxed criteria for accepting information as well as a lack of distinctiveness between perceived and suggested information.

More recently, Horry, Colton, and Williamson (2014) investigated the effect of short and long retention intervals on source monitoring for false memories. Results showed that participants recalled fewer diagnostic features of a memory's source after a long retention interval, resulting in greater reliance on retrieval fluency for making decisions about the memory's source. Thus, source information for a particular memory appears to become less distinctive over time (Horry et al., 2014). The authors concluded source monitoring has significant implications in the forensic context, suggesting that over time eyewitness accounts may deteriorate and become more susceptible to incorporating misinformation from secondary sources.

Fuzzy trace theory. Of the theories discussed so far, fuzzy-trace theory (FTT; Brainerd & Reyna, 2002) is the most recent theoretical account of false memories. Unlike associative activation and source monitoring, FTT proposes an opposing-processes view of false memory formation. The opposing-processes perspective makes a distinction between memory characterised by vague familiarity and memory characterised by vivid recollections of specific events. In terms of true memory, it is theorised that these two memory mechanisms (familiarity and recollection) work in collaboration to support recognition processes. In other words, true memory is contingent on accurately remembering both the general gist of an event as well as the specific details. Conversely, FTT posits that false memories are the result of reliance on the general gist of an event due to an inability to recall specific details (Brainerd & Reyna, 2005). Therefore, like AAT and SMF, FTT also suggests that false memories are more likely to occur when memory has become vague.

A fundamental assumption of FTT is that gist and verbatim memory traces are stored parallel to one another. Gist traces are representations of the concept or meaning of an experience, which can vary in specificity, such as that a burglary occurred in a shop, and the perpetrator was wearing a t-shirt. In contrast, verbatim memory traces are episodic representations of item-specific characteristics of an experience, (Brainerd & Reyna, 2005; Brainerd & Reyna, 2002), such as the name of the shop that was burgled or the colour of the perpetrator's t-shirt. The parallel storage of these memory traces essentially means that representations of specific details (e.g., K-Mart and blue t-shirt) are stored and processed separately to representations of more global and conceptual details (e.g., shop and t-shirt).

FTT also holds that gist and verbatim memory traces are retrieved independently. At retrieval, either gist or verbatim retrieval can be supported depending on the relative strength of one trace over the other. This means that a witness can be correct about the general gist of an event (e.g., that a man wearing a t-shirt burgled a shop), but incorrect about specific details of the event (e.g., the colour of the t-shirt and which shop was burgled). Additionally, verbatim traces are thought to deteriorate and become inaccessible more rapidly than gist traces, indicating greater reliance on gist retrieval over time (Reyna, Corbin, Weldon, & Brainerd, 2016).

Central to FTT is the dual-opponent process, which conceives that true and false memories are caused by different interactions between gist and verbatim memory traces. True memory retrieval is supported by both verbatim and gist traces through either recollection of specific details or through familiarity of an experience's meaning. On the other hand, false memory is supported by gist retrieval through a sense of familiarity and mitigated by verbatim retrieval (Brainerd & Reyna, 2002; Reyna et al., 2016). When false memories arise due to post-event suggestion, both gist and verbatim retrieval of suggested information bolsters false memory, while verbatim retrieval of the original experience abates acceptance of misleading details.

Over the past few decades, FTT has increasingly gained support in the false memory literature. Empirical findings regarding the effects of age and time on false memory, and the independence of true and false memories have been well-accounted for by FTT's central principles. Moreover, FTT has been used to explain findings of false memory research using a variety of experimental paradigms, including the DRM paradigm (Barnhardt, Choi, Gerkens, & Smith, 2006; Brainerd, Reyna, Wright, & Mojardin, 2003) and misinformation paradigm (Calvillo, Parong, Peralta, Ocampo, & Van Gundy, 2016; Holliday, 2003). Thus, FTT is considered to be a particularly comprehensive account of false memory.

In summary, the three major theories of false memories (AAT, SMF, and FTT) each provide a unique account of how false memories are produced. Although there are clear differences between these accounts, each theory makes the same key assumption: that false memories are more likely to occur when memory for the original event has become vague. When memory is vague, less discrepancies can be made between true and false details; thus, misinformation is more likely to be accepted through activation of false details, source monitoring errors, and increased reliance on gist traces over verbatim traces.

False Memories in Therapy

The issue of false memories has a storied past for clinical and practicing psychologists. Over the past thirty years there has been widespread debate as to whether certain techniques in therapy may increase false memories. Referred to as the 'memory wars' (Patihis, Ho, Tingen, Lilienfeld, & Loftus, 2014), practitioners and cognitive scientists have established conflicting views about the reliability of repressed memories that surface during the course of therapy. On the one hand, practitioners argue that some forms of current psychological distress may be the result of repressed childhood trauma, particularly childhood abuse, and recovering these memories is necessary for the client to improve. On the other hand, cognitive and clinical researchers reason that traumatic memories are unlikely to be repressed because memory for such events is typically stronger than memory for everyday experiences (Loftus & Davis, 2006). As a consequence, researchers are increasingly concerned that suggestive techniques used in therapy to recover supposed repressed memories may facilitate development of false memories.

Empirical evidence tends to support the view of cognitive and clinical researchers, with numerous studies demonstrating the malleability of memory when implanting false details. A 'mega-analysis' of false memory implantation studies using the 'lost in the mall' technique established a false memory rate of 30.5% across 423 memory reports (Scoboria et al., 2017). Rubin and Boals (2010) deduce that if false memories are so easily manipulated, there is substantial reason to be concerned about the outcomes of memory recovery procedures in therapy.

Research investigating the effects of specific memory recovery procedures, including guided imagery, dream interpretation, hypnosis, reinterpretation of past events, and other suggestive techniques, has found such procedures increase the likelihood of false memories (Garry, Manning, Loftus, & Sherman, 1996; Loftus & Davis, 2006; Madill & Holch, 2004; Sharman, Garry, & Beuke, 2004; Sharman, Manning, & Garry, 2005). Moreover, since the 1990's there have been numerous reports of cases where people who underwent memory recovery in therapy for past childhood abuse have later realised their "recovered memories" were false or were disproven (Loftus & Davis, 2006).

Unfortunately, it is almost impossible to identify the full extent of the issue of false memories in therapy. Although some claims can be proven factually inaccurate or impossible, others lack evidence to either prove or disprove the recovered memory. As a consequence, the majority of our understanding of false recovered memories in therapy is based on laboratory studies. Such research has sparked conversations between clinicians and researchers regarding potential harmful practices and ways to minimise the problem of false memories in therapy (Loftus & Davis, 2006). However, it is likely that other therapeutic techniques which increase the likelihood of false memories have gone undetected.

Eye Movement Desensitisation and Reprocessing Therapy

One particular psychotherapy that has recently been linked to false memories is Eye Movement Desensitisation and Reprocessing therapy (EMDR; Shapiro, 1989). EMDR is an empirically-validated psychotherapy, most commonly used to treat symptoms of trauma. In particular, EMDR is regarded internationally as a frontline treatment for post-traumatic stress disorder (PTSD); a psychological condition characterised by flashbacks, avoidance, and negative alterations in affect and arousal for more than one month following a traumatic event (American Psychiatric Association, 2013). The primary aim of EMDR therapy is to alleviate distress associated with the traumatic memory.

EMDR therapy comprises eight treatment phases with specific focus on adverse experiences underlying the client's presenting symptoms, current perpetuating circumstances, and identifying the skills necessary for alleviating symptoms (Shapiro & Solomon, 2017). A unique component of EMDR therapy involves bilateral stimulation, usually through the client making horizontal eye movements, while thinking about the traumatic memory that is causing symptoms of distress (Shapiro & Laliotis, 2011). In a typical session, eye movements are completed in several sets lasting approximately 30 seconds each. At the end of each set, there is an interview stage where the therapist asks the client what aspects of the memory they were thinking about, and this information is used to guide the focus for the next set of eye movements (Shapiro & Solomon, 2017).

Effectiveness of EMDR Therapy

Since its development in the 1980's, a multitude of studies have investigated the effectiveness of EMDR for treating symptoms of trauma. Meta-analyses of the research tend to support the efficacy of EMDR in reducing symptoms of PTSD, anxiety, depression, and subjective distress when compared with placebo or waitlist control groups (Ana et al., 2017; Chen et al., 2014; Cusack et al., 2016). Some studies have even demonstrated comparable effectiveness with other treatments, including pharmacological treatment with fluoxetine (Cusack et al., 2016), and trauma-focused cognitive-behavioural therapy (Ana et al., 2017). Moreover, according to Lee and Cuijpers (2013), the incremental effect of the eye movement component of EMDR has been evidenced across several studies. However, a meta-analysis by Davidson and Parker (2001) revealed no difference in treatment effectiveness between EMDR and other exposure therapies, and no additive effect of the eye movement component. Such contrasting findings in the literature could be attributed to the lack of randomised control trials, small sample sizes, variations in outcome measures and differences in how EMDR techniques are applied.

Impact on memory vividness and emotionality. In EMDR, a key aim is to identify past experiences that are perpetuating current maladaptive responses and behaviours. It is theorised that eye movements enhance the processing of traumatic memories by decreasing the vividness and emotionality of traumatic memory images, thereby also reducing related distress and avoidance (Shapiro & Maxfield, 2002). Ultimately, this allows the individual to engage more effectively in desensitisation procedures and attend to more adaptive information regarding current life experiences.

Beneficial effects of eye movements on memory vividness and emotionality have been highlighted in a number of efficacy studies. Lee and Cuijpers (2013) conducted a meta-analysis of 10 laboratory studies investigating the effect of eye movements versus an eyes-stationary task on emotive autobiographical memories. In the studies included, ratings of memory emotionality and vividness were completed before and after performing either eye movements or an eyes-stationary control task during memory recall. The meta-analysis revealed a significant mean effect of eye movements on emotional memories, with eye movements resulting in larger reductions in both memory emotionality (d=0.66) and memory vividness (d=0.91) compared to eyes-stationary control tasks. Lee and Cuijpers (2013) concluded that eye movements in EMDR therapy alter the processing of emotive memories by reducing the intensity of image vividness and emotionality.

However, some inconsistencies in the effects of eye movements on memory have been observed. Andrade, Kavanagh, and Baddeley (1997) conducted one of the first studies specifically investigating the impact of eye movements on memory vividness and emotiveness. In their experiment, participants were shown emotive or neutral photographs. Participants rated the vividness and emotiveness of each image on a 10-point scale before and after performing either eye movements while recalling the images, or a recall-only control task. Results showed that eye movements resulted in the images becoming less vivid, however the effect was weaker and less consistent for image emotiveness. Andrade et al. (1997) reasoned that the effect of eye movements on emotiveness may have been less consistent because memory vividness is ultimately the mechanism of change. If this is the case, larger reductions in memory vividness may be required in order to observe a significant shift in emotiveness.

This argument was further investigated by Smeets, Dijs, Pervan, Engelhard, and Van den Hout (2012) in an experiment comparing the time-course of changes in memory vividness and emotionality. Participants recalled a negative autobiographical event during either an eye movement or eyes stationary task and rated the vividness and emotionality of their memory at pre-test, post-test, and at several intervals during the intervention. Results revealed that the time-course of reductions in memory vividness and emotionality differed; significant reductions in vividness were observed after only 2 seconds of commencing eye movements, with further reductions occurring between 2-10 seconds into the intervention. However, for memory emotionality, significant reductions were only observed after 74 seconds, demonstrating a more gradual reduction in memory emotionality compared to vividness. Smeets et al. (2012) concluded that the emotionality of a memory is likely dependent on memory vividness; less vivid images will, theoretically, result in the memory being less emotionally-intense.

Additional studies have sought to investigate whether the effects of eye movements are maintained at follow-up. Lilley, Andrade, Turpin, Sabin-Farrell, and Holmes (2009) established reductions in both memory vividness and memory emotionality during a concurrent eye movement task, however the effects on vividness and emotionality were not maintained at a one-week follow-up. In contrast, Leer, Engelhard, and van den Hout (2014) found that eye movements, but not recall-only, caused an immediate reduction in memory vividness, with further reductions after 24-hours. While there were no immediate reductions in memory emotionality, a decrease was observed for the eye movement group after 24-hours, again demonstrated more gradual effects on memory emotionality. Although eye movements appear to have an immediate impact on memory vividness, the effect on memory emotionality and the long-term effects of EMDR therapy are less clear.

In line with the three theories of false memory described earlier (AAT, SMF, FTT), it is reasonable to suggest that reductions in memory vividness may increase susceptibility to false memories. For instance, the source monitoring framework suggests that when memory for an event is weakened, less information can be retrieved about the original event to assist with making source judgements. In turn, this increases the likelihood of making a source monitoring error and producing a false memory. The connection between decreased memory vividness and false memories may also be explained by fuzzy-trace theory. When memory for an event becomes vague, there is a greater reliance on gist traces. Since false memories are supported by reliance on gist traces and absence of verbatim traces, the chance of falsely remembering an event will substantially increase when our recollection of the original event lacks vividness. Thus, if eye movements cause memories to become less vivid, a potential shortcoming of EMDR therapy may be increased susceptibility to false memories.

Theories Underpinning EMDR

Although EMDR is generally supported as an evidenced-based therapy, there has been widespread controversy regarding the underlying mechanisms involved. According to WHO (2013), theories proposed by researchers are still largely speculative and lack consensus. Moreover, it is important to identify the mechanisms involved in order to recognise any potential shortcomings of the therapy, such as the production of false memories. This section describes four of the major theoretical explanations that have been proposed; the adaptive information processing model, investigatory reflex/orienting response hypothesis, interhemispheric interaction account, and the working memory account.

Adaptive information processing model. The adaptive information processing model (AIP; Shapiro, 2001) is the founding theory of EMDR therapy. It posits that incoming information from our surroundings is processed to an adaptive state through an inherent information processing system (Shapiro & Maxfield, 2002). However, this system can be disrupted when faced with a particularly traumatic experience, preventing information from being stored adaptively. Instead, the experience is stored essentially as it was originally experienced, along with associated emotions, physical sensations, and beliefs (Shapiro & Laliotis, 2011). Consequently, similar experiences in the future can trigger the unprocessed memory and influence reactions to current situations that manifest as symptoms of psychopathology, such as flashbacks, intense fear, and hyperarousal.

From an AIP perspective, the eye movement component of EMDR therapy enhances adaptive processing of emotional information by reducing the vividness of the traumatic memory (Shapiro & Maxfield, 2002). In turn, this is thought to aid in desensitising the client to their traumatic memory; eventually resulting in decreased distress and related avoidance. As the memory becomes less distressing, clients are able to process the memory more adaptively to integrate information regarding positive experience and one's sense of identity (Shapiro & Laliotis, 2011; Shapiro & Maxfield, 2002). Adaptive processing of distressing memories alleviates the client from negative symptoms previously associated with the memory.

There is little empirical evidence specifically linking eye movements to adaptive processing of distressing memories (Gunter & Bodner, 2009). However, AIP is thought to be in line with neurobiological explanations of memory reconsolidation. These explanations posit that when accessed, memories become more malleable, allowing integration of new information into the original memory network to create an altered version of the memory (Solomon & Shapiro, 2008). Rogers and Silver (2002) argue that the effects of EMDR, particularly the integration and accommodation of new information, are consistent with theories of memory reconsolidation. However, evidence for this association is still largely anecdotal and requires further empirical research to precisely identify how eye movements may facilitate information processing.

Investigatory reflex/orienting response hypothesis. The investigatory reflex/orienting response hypothesis (Macculloch & Feldman, 1996) offers an alternative explanation for the benefits of EMDR therapy. The investigatory reflex is an evolutionary process that occurs in most animals, including humans, enabling us to visually scan and assess the environment for opportunities and threats. The orienting response is invoked when danger is perceived, and typically results in the fight, flight, or freeze responses. However, if no threat is detected, this response is inhibited, and arousal subsequently decreases (see Figure 2).

Macculloch and Feldman (1996) suggest that eye movements in EMDR therapy artificially induce the investigatory reflex. Since EMDR therapy is administered in a non-threatening, safe environment, the orienting response is inhibited when imagery of the traumatic memory is accompanied by eye movements. Thus, negative reactions associated with the traumatic memory (e.g., avoidance, fear, increased arousal, and negative affect) dissipate, while behaviours that are more consistent with the individual's current environment are supported.

Gunter and Bodner (2008) have cast some doubt on the investigatory reflex account of EMDR. They proposed that because the investigatory reflex induces a deep sense of relaxation lasting for up to ten minutes, reduced ratings of memory emotionality and vividness should be observed even when the traumatic memory is brought to mind soon after performing eye movements. However, they found that the effect of eye movements on memory diminished rapidly after the exercise. Eye movements were also associated with greater physiological arousal compared to no-eye movements, which contradicts the idea that eye movements induce a state of relaxation. These findings indicate that the investigatory reflex may not completely explain the benefits of eye movements in EMDR and suggests there may be another mechanism responsible.

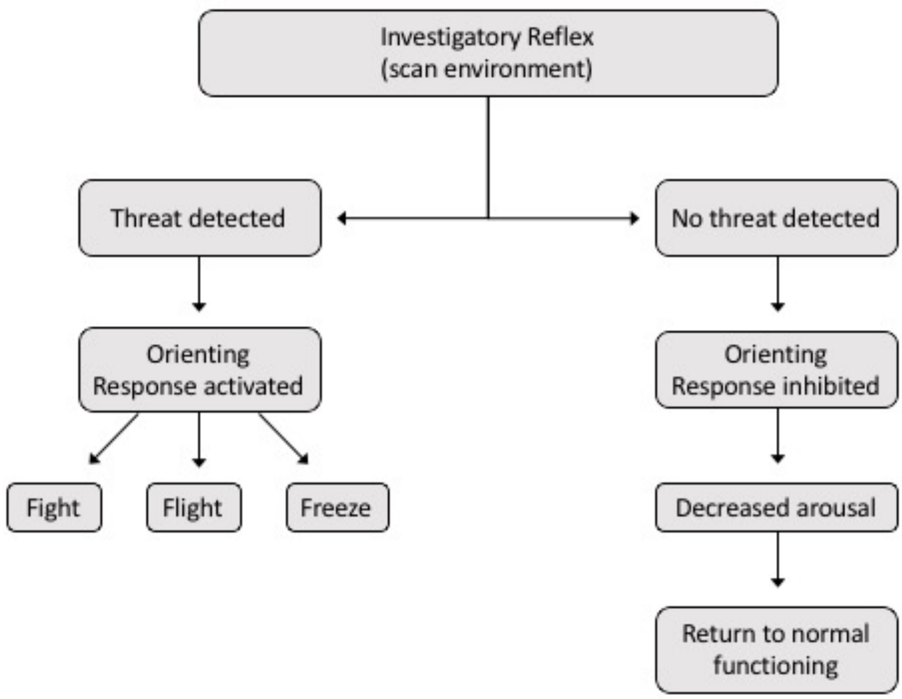

Figure 2. **Opposing processes involved in the investigatory reflex/orienting response hypothesis**

Interhemispheric interaction account. The interhemispheric interaction account (Christman, Garvey, Propper, & Phaneuf, 2003) offers a more neurobiological framework for explaining the mechanisms of change in EMDR therapy. This theory holds that bilateral stimulation, such as horizontal eye movements, in EMDR increases communication between the left and right brain hemispheres. In essence, this is thought to enhance retrieval of episodic memories and facilitate reprocessing of traumatic memories (Propper & Christman, 2008), while also inhibiting negative arousal (van den Hout & Engelhard, 2012).

Several empirical findings have challenged this view. For example, in a study using electroencephalography (EEG), Samara, Elzinga, Slagter, and Nieuwenhuis (2011) found no evidence that eye movements affected interaction between left and right brain hemispheres. Additionally, Gunter and Bodner (2008) demonstrated that similar effects on memory could be achieved using vertical eye movements. They argue that because vertical eye movements do not enhance interhemispheric interaction, it is unlikely that the effectiveness of EMDR therapy can be attributed to increased interhemispheric interaction.

Working memory account. More recently, some researchers have argued that the most likely explanation may be found in a working memory account of EMDR therapy (Andrade et al., 1997; Gunter & Bodner, 2008). According to Baddeley (2012), working memory has evolved from the earlier concept of short-term memory, which manages the temporary storage of information. Working memory comprises multiple components including two subsystems; the visuospatial sketchpad (VSSP) and the phonological loop, and the central executive. The VSSP is responsible for processing visuospatial information, the phonological loop processes auditory information, and the central executive operates as a general processor that directs attentional resources across the two subsystems. These systems each have a limited capacity; when two tasks are performed concurrently they compete for limited processing resources, leading to impaired performance on both tasks (Andrade et al., 1997; Engelhard, van Uijen, & van den Hout, 2010).

When traumatic memories are actively recalled, they are held in working memory. Since working memory has a limited capacity (Baddeley, 2012), performing eye movements and recalling a traumatic memory simultaneously draw upon the central executive and expend limited processing resources. As a result, less attentional resources are available for memory recall, leading to reductions in the vividness and emotional intensity of the memory. Therefore, eye movements in EMDR therapy function as a dual-task requiring divided attention.

Since this theory infers that divided attention is the crucial mechanism of change in EMDR, it would be reasonable to expect that any task that sufficiently taxes working memory should produce the same effects as eye movements. Moreover, the working memory account implies a dose-response-relationship, whereby the more a task taxes working memory, the stronger the effects on memory (van den Hout et al., 2010). Indeed, numerous studies have established support for these claims. For example, Maxfield, Melnyk, and Hayman (2008) compared the effect of no-eye movements, slow-eye movements, and fast-eye movements on ratings of memory vividness, emotionality, and thought clarity. In line with the dose-response-relationship, they observed greater reductions in memory vividness and thought clarity for the more complex fast-eye movements task compared to slow-eye movements and no-eye movements. Though reductions in memory emotionality failed to reach statistical significance in their first experiment, significant effects of fast eye movements on emotionality were observed in study two.

More recently, a meta-analysis by Houben, Otgaar, Roelofs, Merckelbach, and Muris (In Press) found comparable reductions in memory emotionality for eye movements and a range of alternative dual-tasks, such as drawing, finger-tapping, random number generation, and listening to relaxing music. However, it was noted that eye movements uniquely reduced memory vividness in comparison to the alternative tasks, providing some evidence that eye movements may encompass more than just working memory taxation.

Unlike other dual-tasks that have been compared to eye movements, van den Hout et al. (2011) investigated a task that is both used in therapy and taxes working memory to a comparable degree to eye movements. Across two experiments, the authors compared the effects of eye movements in EMDR to an attentional breathing task used in Mindfulness-Based Cognitive Therapy (MBCT; Segal, Williams, & Teasdale, 2002). They speculated that both tasks may derive their therapeutic effects by taxing working memory during recall of a distressing event. In both experiments, a reaction time task was used to test the degree to which eye movements and attentional breathing taxed working memory. Following this, participants recalled an autobiographical memory while simultaneously performing either eye movements, attentional breathing, or a recall-only control task. The attentional breathing task involved three basic steps: stepping out of automatic pilot, bringing attention to the breath, and expanding attention to include a sense of the breath and body as a whole. Ratings of memory emotionality and vividness were recorded both before and after performing the tasks.

In their first experiment, van den Hout et al. (2011) found that eye movements and attentional breathing taxed working memory to a comparable degree, with both tasks taxing working memory more than the single-task control. They also observed comparable reductions in memory emotionality and vividness for the attentional breathing and eye movements tasks, however only eye movements resulted in a significant effect on memory vividness relative to recall-only. In experiment two, they again found that eye movements and attentional breathing taxed working memory to a comparable degree, and both tasks resulted in significant and comparable reductions in memory vividness relative to recall-only. However, no significant reductions in memory emotionality were observed across any of the tasks. Differences in results between experiments one and two cannot be attributed to methodological changes between experiments, since changes were only made to the RTT component in session one. The authors suggested that inconsistency was more likely due to a lack of statistical power (van den Hout et al., 2011).

Taken together, these findings suggest that therapeutic benefits in EMDR may not be specific to the bilateral eye movement component. Instead, similar results may be obtained by using other cognitively-demanding tasks. Investigating this prediction is important from both a practical and theoretical standpoint; if therapeutic gains can be achieved using alternative dual-tasks, this will further support the working memory account of EMDR therapy and may validate the use of alternative tasks where eye movements may not be suitable.

EMDR and working memory capacity. If working memory taxation explains the effects of EMDR on the vividness and emotionality of traumatic memories, an important question to ask is whether individual differences in working memory capacity (WMC) influence the effectiveness of the therapy. According to Engle (2002), WMC refers to an individual's ability to control attention to maintain information in an active state that is easily accessible. Thus, greater WMC is indicative of a greater ability to control attention to achieve a specific goal and avoid distractions.

Consistent with this theory, van Schie, van Veen, Engelhard, van den Hout, and Klugkist (2016) proposed that individuals with higher WMC would be able to simultaneously perform memory recall and eye movements without much competition between tasks. As a result, they speculated that eye movements would have less impact on memory emotionality and vividness, thereby limiting the therapeutic benefits of eye movements. van Schie et al. (2016) tested this hypothesis by comparing the effects of a highly-taxing task (fast eye movements), a less-taxing task (slow eye movements), or recall-only for participants with either low or high WMC.

They found only very weak support that eye movements resulted in greater reductions in memory emotionality and vividness for low WMC participants than for high WMC participants. Moreover, there was also no evidence of an interaction between WMC and working memory taxation, suggesting that adjusting the speed of eye movements to individual differences in WMC does not improve therapeutic outcomes (van Schie et al., 2016). Failure to find an interaction between working memory taxation and memory ratings for the high WMC participants may reflect the possibility that neither task was taxing enough to produce significant reductions in memory ratings. Alternatively, this result may have been due to lack of variability in WMC within a sample of university students. Considering the implications for EMDR therapy, it is surprising that this interaction has not been further investigated with other dual-tasks and populations.

Divided Attention and False Memories

Though taxing working memory during recall of a traumatic memory may have therapeutic benefits, dividing attention between tasks may also have adverse implications in terms of false memories. Both empirical and theoretical understandings of memory suggest that memory processes will be disrupted when attention is divided at encoding or retrieval. As a consequence, people may become more vulnerable to producing false memories. This claim has been the centre of investigation in several false memory studies. For example, Hicks and Marsh (2000) explored the impact of dividing attention during the test phase of the DRM paradigm. They used a variety of divided attention tasks, including random number generation, random letter generation, serial addition, and a digit-load task. Results revealed that participants in the divided attention conditions performed worse on the recognition test and were more prone to producing false memories for items that were not presented at study.

Similar patterns have also emerged from research by Otgaar, Peters, and Howe (2012), and Skinner and Fernandes (2008) using other divided attention tasks. In the Otgaar et al. (2012) study, the divided attention task required participants to count the number of red smiley faces presented between words in the DRM word lists. Divided attention in the Skinner and Fernandes (2008) study involved either solving simple math problems or indicating whether a presented word corresponded to a man-made object. Both studies revealed significant disruptions in memory processes leading to decreased memory accuracy and increased false memories when attention was divided during encoding or retrieval.

Furthermore, Knott and Dewhurst (2007) found that false memories in the DRM paradigm decreased when attention was divided using a random number generation task during encoding, but increased when attention was divided at retrieval. The authors explained their findings through the associative activation theory; suggesting that divided attention at study may inhibit links being made between studied words and associated lures. As a result, processes involved in both correct and false memory responses are impaired. On the other hand, they suggested that increased false recognition when attention is divided at test may be due to the limited availability of attentional resources for making controlled source-monitoring decisions (Johnson et al., 1993; Knott & Dewhurst, 2007).

Together, these findings provide strong evidence of the detrimental effect of performing a secondary task during item encoding or retrieval. However, few studies have examined this effect using the misinformation paradigm. This is an important consideration because the misinformation paradigm largely reflects what is often experienced by eyewitnesses. Witnesses of traumatic events often encounter complex situations that may require them to divide their attention between different aspects of the situation at hand (Lane, 2006). For example, paying attention to identifying features of a perpetrator while also contacting emergency services.

The misinformation paradigm also theoretically corresponds to what is experienced in EMDR therapy. Recalling a traumatic memory while simultaneously making eye movements acts in a similar way to dividing attention when witnessing a traumatic event. In addition, misinformation may be inadvertently introduced by the therapist during the interview stage of EMDR therapy (Houben et al., 2018). Given the theoretical links, it is critical to understand how divided attention may impact memory for such events.

One of the few studies investigating divided attention in the misinformation paradigm was conducted by Zaragoza and Lane (1998). In their first experiment, participants answered misinformation questions under either full or divided attention. In experiment two, participants were given either limited or sufficient time to make source decisions at test. Across both experiments, results showed that dividing attention during the misinformation or retrieval phases decreased memory accuracy and increased acceptance of misinformation. Lane (2006) conducted a similar study and was also successful in demonstrating increased susceptibility to misinformation following divided attention at encoding. Such findings could be explained in terms of the discrepancy detection principle (Tousignant, Hall, & Loftus, 1986), in that dividing attention may impair the ability to detect discrepancies between misinformation and the original event.

Eye Movements and False Memory

Given the empirical and theoretical links between divided attention and false memory, it could be expected that eye movements used in EMDR therapy may increase false memories. Often after a set of eye movements, therapists will ask detailed follow-up questions to clarify certain aspects that emerged during the session (Shapiro, 1989). Houben et al. (2018) suggest that during these follow-up questions, therapists might inadvertently introduce suggestive misinformation that can influence the client's memory. Moreover, clients who engage in EMDR therapy may be especially susceptible to misinformation due to their memory for the original event becoming less vivid. It follows from associative activation, source monitoring, and fuzzy-trace theories that false memories are more likely to occur when memory for the original event has become vague. Thus, reductions in memory vividness resulting from eye movements may have the unintended effect of increasing susceptibility to false memories.

Recently, Houben et al. (2018) investigated this claim by testing whether horizontal eye movements increase false memories using the misinformation paradigm. In their experiment, 82 participants were shown a video of a violent car crash and asked to rate how vivid and emotional they found the video before and after performing either eye movements or an eyes-stationary task. The tasks were performed while simultaneously recalling the car crash event. Later, participants were presented with misinformation in the form of an eyewitness narrative before finally completing a recognition test.

Results revealed that ratings of memory vividness significantly decreased in both conditions, though the effect size was larger for the eye movement condition (d= 0.66) than for the control condition (d= 0.35). Similar findings were observed for reductions in memory emotionality. As hypothesized, eye movement participants tended to accept misinformation more frequently, and thus produced more false memories, than control participants. A Bayes factor of 35.26 was calculated, indicating strong support for the effect of eye movements on susceptibility to misinformation (Houben et al., 2018).

Although results from Houben et al.'s (2018) study provide strong evidence that eye movements may increase false memories, this contradicts previous research investigating eye movement effects. For instance, Christman et al. (2003) demonstrated that performing horizontal saccadic eye movements after being presented with a list of associated words improved discrimination between old and new word items at test in the DRM paradigm. In a second experiment, they also found that engaging in horizontal eye movements (without simultaneous memory recall) enhanced the retrieval of episodic memories, improved memory accuracy, and reduced false memories for everyday events recorded in a journal by participants. Christman et al. (2003) concluded that eye movements may be particularly effective in reducing instances of false memories.

Parker and Dagnall (2007) also found results that contrast with that of Houben et al (2018). In their study, participants were exposed to lists of associated words using the DRM paradigm. Participants then performed either horizontal, vertical, or no eye movements before completing a recognition test for their memory of presented words. Results revealed that participants who engaged in horizontal eye movements were more likely to correctly recognise words presented at study, and less likely to falsely recognise critical lures that were not presented at study. Parker and Dagnall (2007) speculated that eye movements might attenuate the false memory effect by enhancing activation of neural processes involved in source monitoring. They suggest their findings are consistent with the interhemispheric interaction account of eye movements, however, as previously discussed, the evidence supporting this theory is questionable.

Positive effects of eye movements on memory accuracy and false memories have been further demonstrated using the misinformation paradigm. In a study by Parker, Buckley, and Dagnall (2009), participants were shown a set of pictures with a verbal narration of the events portrayed in the pictures. Participants were asked either misleading or control questions about the events portrayed, and then engaged in 30 seconds of horizontal, vertical, or no eye movements, before completing a recognition test. They found that horizontal eye movements improved true memory for events, increased recollection, and reduced the strength of the misinformation effect. As such, the research by Parker and colleagues (2009; 2007) and by Christman et al. (2003) suggest that eye movements may actually improve memory accuracy and reduce the likelihood of producing false memories.

While these findings clearly stand in contrast to the research by Houben et al. (2018), there are several plausible explanations for this. Firstly, in the earlier studies eye movements were performed as a single-task. However, in Houben et al.'s (2018) study, eye movements were performed as a dual-task during memory recall, which corresponds to how eye movements are typically used in EMDR therapy. Given the tenets of the working memory account (i.e., that therapeutic effects of eye movements are due to the dual-task component) studies that involve only a single-task likely fail to evoke the same processes that are involved in EMDR therapy. Likewise, these studies have induced eye movements for particularly short time periods, usually only lasting 30 seconds, with little rationale for doing so. In contrast, participants in the Houben et al. (2018) study performed eye movements over four blocks lasting 24 seconds each—reflective of the eye movement procedures typically used in EMDR therapy (Shapiro &

Laliotis, 2011). Thus, less time performing eye movements may not be sufficient to produce the significant effects on memory that are often seen in therapy.

Lastly, both Christman et al. (2003) and Parker and Dagnall (2007) used the DRM paradigm, or a similar procedure, to produce the false memory effect. However, this paradigm does not address the effect of potential misinformation being introduced. Houben et al. (2018) suggest that EMDR therapy may increase false memories due to exposure to misleading information through suggestive questioning during the interview phase of therapy.

Though Parker et al. (2009) used the misinformation paradigm, in their study misinformation was introduced *before* participants performed the eye movement task. Again, this is not particularly reflective of the procedures in EMDR therapy. Theoretically, the potential for misleading suggestion would occur after an eye movement session during follow-up questioning (Houben et al., 2018). This order of events is more likely to cause false memories because memory for the original event, purportedly, becomes vague and is therefore more easily influenced by suggestion.

Methodology for the Current Study

In line with the study by Houben et al. (2018), false memories in the current study will be instilled using the misinformation paradigm. The misinformation paradigm is well-evidenced as a method for instilling false memories. Misinformation effects have been observed across a myriad of experimental domains, including neuroimaging, electrophysiology, ageing and developmental studies, individual differences, and even with several varieties of animals (see Loftus, 2005 for a review). Robustness of the misinformation effect is also demonstrated through the scope of events that have been used. While some studies have introduced misinformation for simulated events, such as a filmed robbery, others have implanted misinformation for true events. For example, in a study by Nourkova, Bernstein, and Loftus (2004), after being misinformed, participants reported seeing wounded animals (that were not actually present) during the Moscow terrorist attacks. Such evidence of the misinformation effect for real-life experiences is indicative of the generalizability of this effect outside of experimental settings.

The misinformation paradigm is most appropriate for replicating the type of false memories that may develop in EMDR therapy because this method involves post-event suggestion. Houben et al. (2018) propose that EMDR therapy may increase false memories due to exposure to misleading information through inadvertent suggestive questioning during the interview phase of therapy. Furthermore, they suggest that because eye movements act on traumatic memories by making them less vivid, misinformation is more likely to be accepted following eye movements.

Overview of the Current Research

Despite empirical evidence suggesting that eye movements may inhibit false memories, there is still strong theoretical reason to believe that this may not be the case. Alarmingly, there is a paucity of research investigating the potential drawbacks of EMDR therapy. Although Houben et al. (2018) have drawn attention to one particular drawback— namely, susceptibility to misinformation— Lilienfeld (2007) suggests such findings call for independent replication efforts. The current research aims to address this concern by conducting a partial replication of Houben et al.'s (2018) study. An initial pilot study will first explore whether eye movements tax working memory, as proposed by the working memory account. The pilot study also identifies an alternative dual-task that taxes working memory to a comparable degree as eye movements. This will partly inform the basis of the main experiment, where the effect of eye movements on false memories and ratings of memory vividness and emotionality will be compared to an alternative dual-task and a control task. In addition, the main experiment will explore whether working memory capacity might moderate the effect of performing a dual-task on false memories, and ratings of memory vividness and emotionality. The following chapters will outline the aims, hypotheses, methods, and results of this research.

CHAPTER 2

Pilot Study: A Preliminary Test of the Working Memory Account

The working memory account of EMDR therapy suggests that the therapeutic benefits of eye movements are the result of attention being divided across two simultaneous tasks; eye movements and memory recall. It is proposed that eye movements use up limited processing resources in working memory, which interferes with the processing of the traumatic memory. If this is the case, it is plausible that any task performed alongside memory recall that taxes working memory to a similar degree to eye movements will produce the same effects.

As discussed in the previous chapter, several studies have indeed demonstrated support for this claim. Of the various dual-tasks studied in these experiments, an attentional breathing task investigated by van den Hout et al. (2011), was the only task comparable to horizontal eye movements in terms of the degree of working memory taxation. Likewise, vertical eye movements during memory recall was one of the few dual-tasks that produced comparable reductions in *both* memory vividness and emotionality (Gunter & Bodner, 2008). Accordingly, the therapeutic benefits of horizontal eye movements on reductions in memory vividness and emotionality may also be achieved through other tasks, such as vertical eye movements and attentional breathing. However, to investigate this, it is important to know whether working memory is actually taxed by these tasks, and if so, by how much. This is the focus of the pilot study. The remainder of this chapter outlines the major aims and hypotheses, methods, and important findings from this preliminary research.

Aims

The aim of the pilot study was to test whether there are differences in how much working memory is taxed by three tasks: horizontal eye movements, vertical eye movements, and attentional breathing. Results from this study helped to determine which alternative dual-task would be used in the main experiment alongside horizontal eye movements. The task which taxed working memory most comparably to horizontal eye movements would be used.

Hypotheses

Hypothesis 1. Performing horizontal eye movements during the reaction time task will tax working memory more than performing the reaction time task alone.

Hypothesis 2. Performing attentional breathing will tax working memory to a comparable degree to horizontal eye movements.

Hypothesis 3. Performing vertical eye movements will tax working memory to a comparable degree to horizontal eye movements.

Method

Pre-registration

An online pre-registration was created to detail the method for the pilot study using AsPredicted (Simonsohn, Simmons, & Nelson, 2018). The pre-registration included an a priori power analysis using G*Power version 3.1.9.3 (Faul, Erdfelder, Lang, & Buchner, 2007) with n= 20 (α= .05; Power= .80) which gave a moderate effect size of Cohen's f= .27. Previous research on eye movements and working memory taxation have obtained sample sizes of n=17, with effect size η_p^2= .51 (Onderdonk & van den Hout, 2016), n=36, with effect size η^2= .45 (Gunter & Bodner, 2008), and n=36, with effect size η_p^2= .54 (van den Hout et al., 2011). The pre-registration document was made public on 17 December 2018 and can be accessed at https://aspredicted.org/pe3ch.pdf.

Design

The pilot study implemented an experimental within-subjects design to control for variability between participants. One independent variable with four levels was included: vertical eye movements, horizontal eye movements, attentional breathing, and a reaction time only control. These conditions were balanced using a 4(condition) × 4(group) Balanced Latin Squares design to control for order and fatigue effects. Participants were randomly assigned to one of four groups, with conditions presented in a unique order for each group. Balanced Latin Squares ensured each condition occurred only once in each order position, and each condition appeared before and after the other conditions an equal number of times across groups. This method produced four possible condition orders for the current study, as outlined in Figure 3. The dependent variable was reaction time, measured by the time (in milliseconds) participants took to press the spacebar whenever they heard an auditory beep.

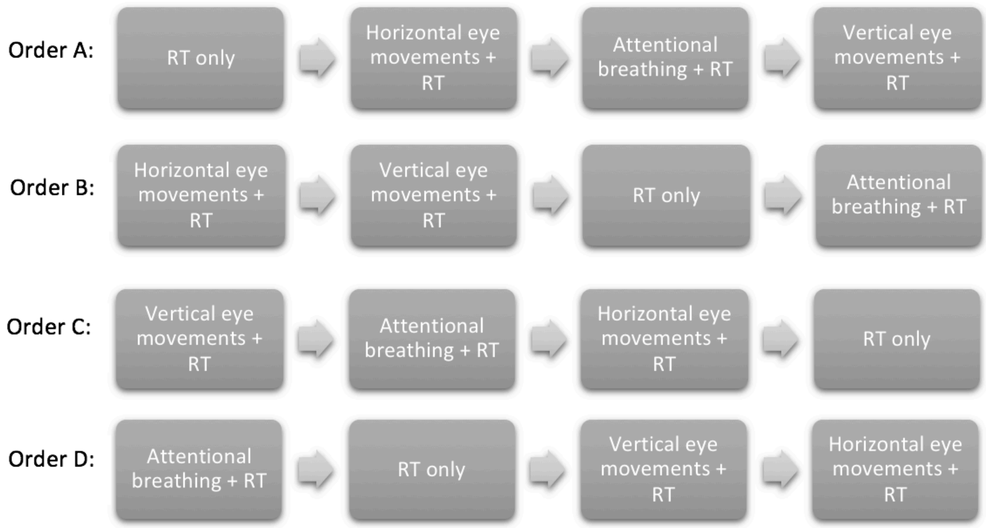

Figure 3. **Orders of conditions for each group using Balanced Latin Squares design.**

Participants

20 undergraduate and postgraduate students (12 females; 8 males) were recruited and participated in the pilot study. Participants ranged in age from 18-40

years, with a mean age of 23.95 (*SD*= 5.76). Data from all participants was included in the analysis.

Convenience sampling was used to recruit participants from the Manawatū campus of Massey University, New Zealand. Informed consent was obtained from all participants prior to commencement of the study. Participation in the study was voluntary, and all participants went in a draw for a $100 voucher. Recruitment ceased when 20 participants had agreed to participate.

Measures and Materials

All materials were presented via PsychoPy software version 1.90.1 (Pierce, 2007) on an HP desktop computer. Figure 4 illustrates each of the tasks.

Random interval repetition task. Since working memory has a limited capacity, performing one task can interfere with the resources required for concurrently carrying out a secondary task (Baddeley, 1992). A valid way to investigate the extent to which a task taxes working memory is to perform the task while simultaneously completing a reaction time task (van den Hout et al., 2011). In the main experiment, working memory taxation was tested using a modified version of the Random Interval Repetition (RIR) task, developed by Vandierendonck, De Vooght, and Van der Goten (1998).

The task required participants to wear headphones while they were presented with a series of audio beeps at 440Hz and constant volume (50%) for 100ms each. The beeps were presented at randomized inter-stimulus intervals (ISIs); half of the ISIs were 900ms long and the other half were 1500ms long. Participants pressed the spacebar on the keyboard as quickly as possible whenever they heard a beep. The RIR task was performed alone with eye gaze focused on a fixation cross (1cm × 1cm) presented in the middle of the screen, as well as in conjunction with the three dual-task conditions:

horizontal eye movements, vertical eye movements, and attentional breathing. The RT-only condition served as a control condition to be compared against the reaction times in each of the dual-task conditions.

The RIR task was repeated over four consecutive blocks for each condition. The first block in each condition was a short practice to familiarize participants with the tasks and consisted of 10 beeps, lasting 13 seconds. The remaining three blocks consisted of 22 beeps each, and each block lasted 28.6 seconds with a 10 second rest period between blocks. When 10 seconds elapsed, participants were able to initiate the start of the next block. A total of 76 reaction time measurements were recorded for each condition (RT-only, RT+ horizontal eye movements, RT+ vertical eye movements, and RT+ attentional breathing). The modified version described is in line with previous research exploring working memory taxation of eye movements (Onderdonk & van den Hout, 2016; van den Hout et al., 2011). Degree of working memory taxation was determined by calculating mean reaction times in each condition and comparing the dual-task reaction times to the RT-only control reaction times; higher reaction times indicated greater taxation of working memory.

Horizontal eye movement stimuli. To replicate the eye movement component of EMDR therapy, a computerized horizontal eye movement task was utilised, which has been described in previous research (Houben et al., 2018; van den Hout, Bartelski, & Engelhard, 2013). A grey dot (height and width= 1cm) was presented on a black background moving 26cm horizontally across the screen at one cycle per second (one cycle= from left to right, and back again). The stimulus was created in Microsoft PowerPoint using the ‘animations’ feature. This was then converted to a video format. Based on previous research using eye movements (Parker & Dagnall, 2007), the stimulus moved across a visual angle of 27 degrees with participants seated 54cm from the monitor.

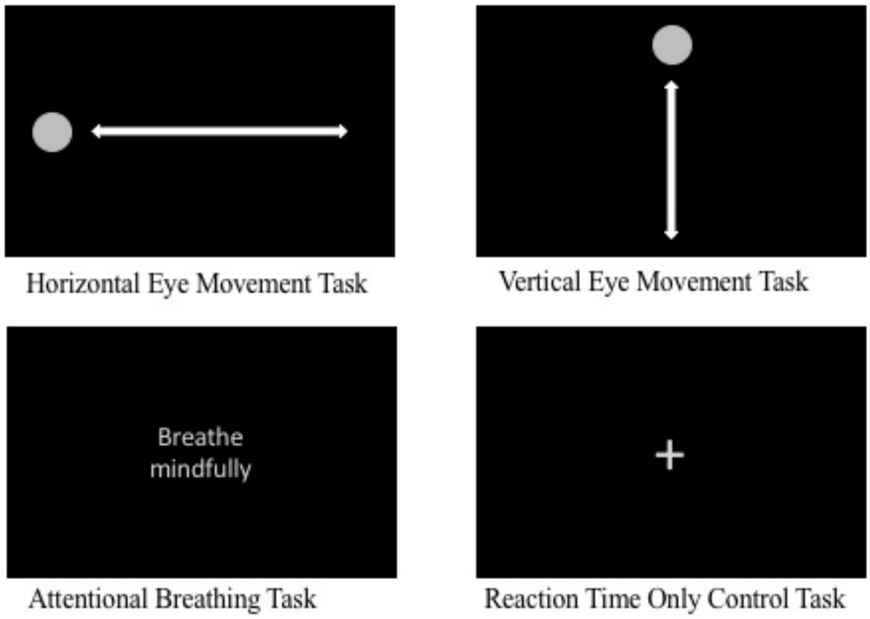

Figure 4. **Tasks used in the pilot study testing working memory taxation. Each task was performed during the RIR reaction time task. The white arrows signify movement and were not displayed during the experiment.**

Vertical eye movement stimuli. Vertical eye movements were included as a dual-task to test the working memory account of EMDR therapy. Vertical eye movements were induced using the same computerized eye movement task described for horizontal eye movements. A grey dot (height and width= 1cm) was presented on a black background moving 26cm vertically on the screen at one cycle per second (one cycle= from up to down, and back up again). The stimulus was created in Microsoft PowerPoint using the 'animations' feature. This was then converted to video format. Based on previous research using eye movements (Parker & Dagnall, 2007) the stimulus moved up and down a visual angle of 27 degrees with participants seated 54cm from the monitor.

Attentional breathing task. Attentional breathing was also included as a dual-task to test the working memory account of EMDR therapy. Attentional breathing was implemented using a breathing space exercise described by Segal et al. (2002) in their Mindfulness-Based Cognitive Therapy handbook. The exercise involved two basic steps: (1) stepping out of automatic pilot and becoming aware of thoughts and feelings, and (2) bringing attention to the breath and related sensations. Participants were asked to focus their eye gaze on the words 'breathe mindfully' which were presented in the middle of the screen (letter height= .50cm). This was to control eye movements.

Procedure

The pilot study consisted of a single session lasting 20 minutes. At the beginning of each session, participants were greeted by the researcher and shown to the computer lab. Participants sat approximately 54cm from a 1920×1080 LCD computer monitor with a refresh rate of 60Hz. Prior to commencing the study, participants were provided with an information sheet. If participants were willing to proceed with the study, they were asked to sign a written informed consent form outlining that they have understood the information provided and they agree to participate.

Training session. All participants completed the study individually. For the duration of the study, participants were asked to wear a set of headphones. Prior to beginning the main study, participants completed a training session to familiarize them with the RIR task, horizontal eye movements, vertical eye movements, and attentional breathing task. The researcher remained seated next to participants throughout the training session to allow participants to ask any questions and so the researcher could ensure participants were performing the tasks correctly.

Instructions for each task were presented on individual pages before each task began. Participants began each task when they were ready by pressing the spacebar. The first task that participants practiced was the RIR reaction time task. Participants were asked to press the spacebar as quickly as possible whenever they heard a beep while focusing their eye gaze on the fixation cross presented in the middle of the screen. Next, participants practiced the horizontal eye movement task. Participants were instructed to use their eyes to follow the grey dot moving horizontally across the screen while keeping their head as still as possible.

Participants then practiced the attentional breathing task. The researcher verbally explained this task to participants using an excerpt from 'Mindfulness-Based Cognitive Therapy for Depression' (See Appendix A; Segal et al., 2002, p. 174). Participants were instructed to focus on their breathing. Finally, participants practiced the vertical eye movement task, where they were instructed to use their eyes to follow the grey dot moving vertically on the screen while keeping their head as still as possible. During the training session, participants practiced each of these tasks once for 28.6 seconds each. After completing the training session, the researcher asked if participants had any questions about the tasks they had practiced before moving on to the main experiment.

Experiment process. Before beginning the main experiment, participants were told they would be combining some of the tasks they practiced in the training session and were asked to read the instructions carefully for each task. Participants were given the opportunity to ask questions before beginning the study. The researcher launched the appropriate version of the experiment on PsychoPy based on the condition order participants were assigned to (refer back to Figure 3). The researcher left the room for the duration of the main study. Prior to commencement, participants were asked to indicate their age and gender. Following this, the RIR reaction time task was administered under all four conditions: horizontal eye movements, vertical eye movements, attentional breathing, and control (RT only). The entire study took approximately 20 minutes to complete. At the end of the entire session, participants were debriefed as to the purpose of the study and thanked for their time.

Results

Data Preparation and Analyses

Raw data collected from the pilot study was stored in a Microsoft Excel spreadsheet. Prior to analysis, raw data was cleaned and reduced; reaction times greater than 900ms were excluded since the maximum inter-stimulus interval for half of the RT trials was 900ms. Reaction times less than 120ms were also excluded to ensure reaction times were genuine, and not anticipatory or accidental. According to Whelan (2008), at least 100ms are necessary for the required physiological processes to occur in a reaction time task (including perceiving the stimulus and motor movement). All RT measurements from the practice blocks and the first RT measurement from each block were also discarded to account for re-acclimation to each task following a break (Onderdonk & van den Hout, 2016). These criteria resulted in 8.6% of total RTs being excluded from analyses.

The mean RTs for each condition were then calculated. Following this, data was analysed using the software package JASP version 0.8.6 (JASP Team, 2018). Hypotheses were tested using a repeated-measures Analysis of Variance (ANOVA), which compared differences in mean RT's between each task condition. Statistical significance was observed at $p<.05$. Effect size was determined using partial eta squared (η_p^2) and effect sizes above .06 were considered to have practical significance, indicating the effect is large enough to be valuable in a practical setting. Cohen (1988) suggests that η_p^2 of .06 is equivalent to a medium effect size.

Follow up analyses were carried out using Bayes factors (BF) with a default Cauchy prior (0, 0.707). BFs quantify the relative evidence that the data provide for supporting the null hypothesis (where the effect is presumed to be zero) or alternative hypothesis (where the effect is presumed to be nonzero) (Williams, Baath, & Philipp, 2017). A hypothesis is considered more credible when the observed data is more likely under one hypothesis than the other. BFs less than 1 indicate evidence in favour of the null hypothesis and BFs greater than 1 indicate evidence in support of the alternative hypothesis. BFs further from 1 provide stronger evidence, while BFs closer to 1 indicate ambiguous evidence, meaning that there is less certainty that one hypothesis is supported more than another (Wagenmakers et al., 2015). In the current study, a BF <0.33 was considered moderate evidence in favour of the null hypothesis and a BF >3 was considered moderate evidence in favour of the alternative hypothesis.

BFs are an appropriate method of analysis for the pilot study because, unlike frequentist *p*-values, they allow us to investigate hypotheses of zero effect (Williams et al., 2017). In the pilot study, two hypotheses make predictions that there will be no difference in effects between the horizontal eye movement task, vertical eye movement task, and attentional breathing task. To test these hypotheses, we need to be able to quantify the extent to which the null hypothesis (of zero effect) is supported by the data.

Hypothesis Testing

Figure 5 shows the mean reaction times (in milliseconds), standard deviations, and 95% confidence intervals for each task. Mauchly's test indicated that the assumption of sphericity was violated (p=.045), therefore degrees of freedom was corrected using Greenhouse-Geisser estimates of sphericity (ε= .71). Results from a one-way repeated measures ANOVA (n=20) revealed a statistically significant difference in reaction times across tasks, $F(2.14, 40.62)= 15.38$, $p<.001$, $\eta^2_p = .45$. The large partial eta squared effect size indicates that 45% of the variance in reaction times can be explained by the type of task performed.

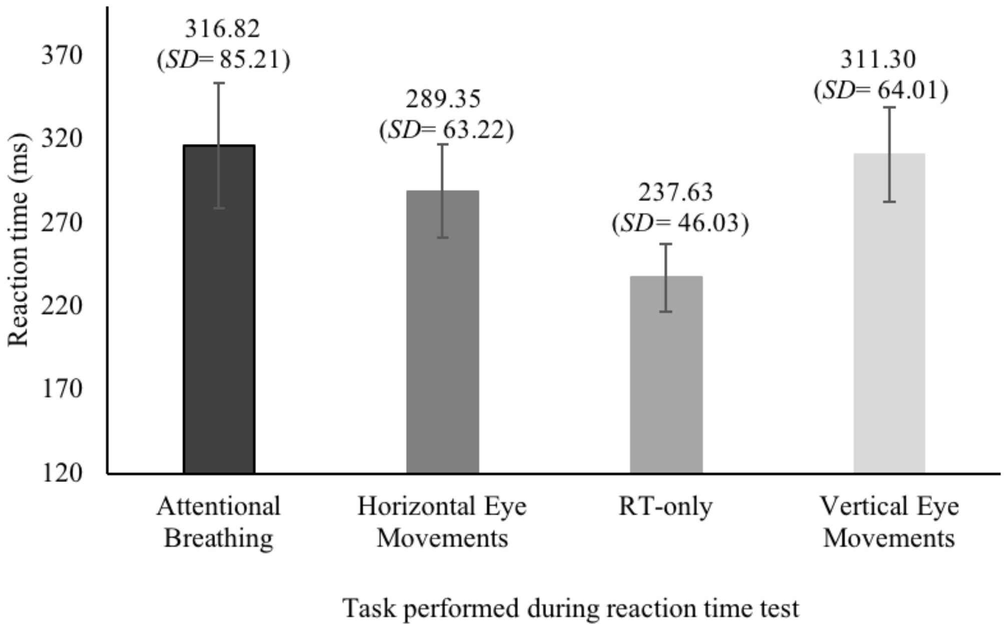

Figure 5. **Means and standard deviations (*SD*) of reaction times (ms) in the attentional breathing, horizontal eye movement, reaction-time only, and vertical eye movement tasks. Error bars show 95% confidence intervals.**

Post-hoc tests using the Bonferroni correction revealed that reaction times were faster when participants performed the RT-only task compared to the horizontal eye movement task, t=4.70, p<.001, vertical eye movement task, t=-6.93, p<.001, and attentional breathing task, t=5.34, p<.001. Therefore, all three dual-tasks were significantly more taxing than the single-task (RT-only) condition.

As shown in Figure 5, reaction times appeared to be faster during the horizontal eye movement task compared to both the attentional breathing task and the vertical eye movement task. However, the differences in reaction times in comparison to horizontal eye movements were non-significant for both attentional breathing, t=1.71, p=.63, and vertical eye movements, t=-2.75, p=.08, suggesting neither tasks were significantly more taxing than horizontal eye movements. There was also no statistically significant difference in reaction times between the attentional breathing task and the vertical eye movement task, t=0.36, p=1.00.

Bayes factors, with a default Cauchy prior (0, .707) were calculated to compare the relative evidence for supporting the null or alternative hypotheses. In BFs, the prior specifies which effect sizes are more or less likely if the true effect is non-zero, based on effect sizes from previous studies. A default Cauchy prior of (0, .707) means that if the true effect size is non-zero, there is a 50% chance that the effect size is greater than .707 in absolute value (Williams et al., 2017). The comparison of reaction times between the horizontal eye movement task and the reaction-time only tasks revealed a BF_{10}= 188.99, indicating very strong evidence in favour of the alternative hypothesis; that working memory is taxed more by performing horizontal eye movements than by performing the reaction-time task alone. This means the data is 188.99 times more likely under the alternative hypothesis than under the null hypothesis.

The comparison of reaction times between the attentional breathing task and the horizontal eye movement task found a BF_{10}= .79, suggesting anecdotal evidence in favour of the null hypothesis; that there is no difference in how much working memory is taxed by attentional breathing and horizontal eye movements. The data is only .79 times more likely under the null hypothesis than under the alternative hypothesis. Lastly, a BF_{10}= 4.21 was found for the comparison of reaction times between horizontal eye movements and vertical eye movements, indicating moderate evidence in favour of the alternative hypothesis; that there is a difference in how much working memory is taxed by horizontal eye movements and vertical eye movements. The data is 4.21 times more likely under the alternative hypothesis than under the null hypothesis, suggesting that vertical eye movements were more taxing than horizontal eye movements.

Summary of Pilot Results

The pilot study aimed to investigate the extent to which working memory was taxed by three dual-tasks: horizontal eye movements, vertical eye movements, and attentional breathing. In line with Hypothesis 1, performing horizontal eye movements during a RT task resulted in slower reaction times compared to performing the RT task alone. This suggests that horizontal eye movements tax working memory to a greater degree than RT-only. Findings from the pilot study also offered support for the second hypothesis; there was no significant difference in reaction times between the attentional breathing task and horizontal eye movement task, indicating that attentional breathing and horizontal eye movements taxed working memory to a comparable degree. However, support for the third hypothesis was less clear. Although a post-hoc *t*-test found no difference in reaction times for the vertical eye movement task and the horizontal eye movement task, analysis using Bayes factors suggested that vertical eye movements were more taxing than horizontal eye movements.

Results from this pilot study are consistent with a growing body of research that support the working memory account of eye movements in EMDR therapy. In particular, findings replicated an earlier study by van den Hout et al. (2011), which found that eye movements and attentional breathing taxed working memory to a similar degree, with both tasks resulting in slower RTs relative to a RT-only control task. This suggests that, like other dual-tasks, eye movements interfere with resources in working memory that are required for carrying out secondary tasks, and this may explain the effect of eye movements on traumatic memories in therapy.

Despite replication of the reaction time results in van den Hout et al.'s (2011) study, reaction times were slightly faster across all tasks in the current study. While this could indicate that the tasks were slightly less taxing for the current sample, the difference is more likely due to the variation in exclusion criteria for the lower-bound cut-off of reaction times. In the current study, reaction times less than 120ms were excluded, whereas in van den Hout et al.'s (2011) study a lower bound cut-off of 130ms was used. As a result, the current study allowed for faster reaction times to be analysed, which likely reduced the mean reaction times for each condition.

The pilot study also provides some evidence in line with predictions made by Gunter and Bodner (2008). In their study, Gunter and Bodner (2008) found that horizontal eye movements and vertical eye movements resulted in similar reductions in memory vividness and emotionality immediately post-intervention. The authors speculated that the comparable effects of these tasks may be explained by both tasks taxing working memory. Indeed, the current study found that vertical and horizontal eye movements taxed working memory to a similar degree, though BF analysis suggested that vertical eye movements were slightly more taxing. This finding may indicate a dose-response relationship of working memory. Assuming that vertical eye movements are more taxing, it could be expected that they result in greater reductions in memory vividness and emotionality compared to horizontal eye movements. Gunter and Bodner's (2008) findings do provide some evidence of a dose-response relationship; although not statistically significant, vertical eye movements did result in slightly greater reductions in memory vividness, emotionality, and completeness compared to horizontal eye movements.

This pilot study was a preliminary step in evaluating whether working memory taxation may explain the therapeutic benefits of eye movements in EMDR therapy. The pilot study provides clear evidence that horizontal eye movements are significantly more taxing than a single-task control and working memory taxation was comparable for an attentional breathing task. Contrary to predictions, vertical eye movements were found to be more taxing than horizontal eye movements. The working memory account suggests that the RIR task used in the pilot study engages the same process that is responsible for reductions in memory vividness and emotionality in EMDR therapy. It follows from this theory that the effects of attentional breathing on memory should be comparable to the effects of eye movements. This theory is investigated in the main experiment, described in the following chapters.

CHAPTER 3

Main Experiment

Overview of the Literature

Recently, research by Houben et al. (2018) revealed that eye movements used in EMDR therapy may significantly increase an individual's susceptibility to false memories in the misinformation paradigm. They reasoned that this may be due to the effect of eye movements on memory vividness. According to several prominent theories of false memory, including associative activation, source monitoring framework, and fuzzy-trace theory, false memories are most likely to occur when memory for the original event has become vague. Therefore, the reduced memory vividness that results from eye movements in EMDR therapy may actually increase one's vulnerability to producing false memories.

Eye movements may not be the only task used in therapy that increases susceptibility to developing a false memory. Given the evidence demonstrating the effect of divided attention on false memories, alternative dual-tasks that divide attention during memory recall may also increase one's susceptibility to false memories. Results from the pilot study revealed that attentional breathing and horizontal eye movements tax working memory to a similar degree. Moreover, previous research has found that attentional breathing and horizontal eye movements lead to similar reductions in memory vividness and emotionality (van den Hout et al., 2011). If working memory taxation is the causal mechanism of these effects, then false memories may also be produced through performing attentional breathing during memory recall. Accordingly, the major objective of the current research is to replicate Houben et al.'s (2018) study and extend these findings by comparing the effects of eye movements and attentional breathing to a recall-only control condition.

Due to the established link between working memory capacity and false memory, it will also be important to investigate whether the dual-tasks (eye movements and attentional breathing) might differentially affect memory depending on an individual's working memory capacity. Lower working memory capacity has been consistently associated with increased susceptibility to developing false memories (Brydges et al., 2018; Calvillo, 2014; Gerrie & Garry, 2007; Jaschinski & Wentura, 2002; Leding, 2012; Watson et al., 2005). There is also theoretical reason to expect that working memory capacity might affect the benefits of eye movements in EMDR therapy. Eye movements might result in smaller reductions in the emotionality and vividness of a traumatic memory for individuals with higher working memory capacity compared to those with lower working memory capacity, though this effect has not yet been observed (van Schie et al., 2016).

Aims of the Study

The current study primarily addresses the question "do eye movements uniquely increase an individual's susceptibility to misinformation?" This will be answered by implementing the misinformation paradigm across three experimental conditions: horizontal eye movements, attentional breathing, and a recall-only control. In particular, this study is concerned with (1) the effects of horizontal eye movements and attentional breathing on the emotionality and vividness of a memory; (2) the effects of horizontal eye movements and attentional breathing on false memory; and (3) whether these effects might be explained by the working memory account of EMDR therapy. The study also examines the relationships between working memory capacity and (a) change in memory vividness from pre- to post- test, (b) change in memory emotionality from pre- to post- test, and (c) false memories.

Hypotheses

The hypotheses for the current research are divided into four main areas of interest; memory vividness ratings, memory emotionality ratings, overall performance on the recognition test, and endorsement of misinformation. Within each area, several main hypotheses are generated to predict the effects of each condition on the dependent variables described.

Hypothesis 1: Memory vividness ratings. The study will explore the effect of each condition on participant ratings of memory vividness. Memory vividness will be measured using a pre-test/post-test design to test whether there is a difference in vividness from pre- to post- intervention for each condition. In addition, the research will explore whether working memory capacity attenuates the effects of the conditions on changes in memory vividness. Consistent with previous research demonstrating the effect of eye movements on reductions in memory vividness (Andrade et al., 1997; Lee & Cuijpers, 2013; Smeets et al., 2012), I predict that:

a) There will be greater decreases (from pre- to post- intervention) in ratings of memory vividness for participants in the eye movement condition than for participants in the recall-only control group.

Research by van den Hout et al. (2011) demonstrated significant and comparable reductions in memory vividness for eye movements and an attentional breathing task. In line with these findings and the working memory account of EMDR therapy, I predict that:

b) There will be greater decreases (from pre- to post- intervention) in ratings of memory vividness for participants in the attentional breathing condition than for participants in the recall-only control group.

c) There will be no difference in how much memory vividness decreases (from pre- to post- intervention) for participants in the eye movement condition and participants in the attentional breathing condition.

Theoretically, if eye movements and attentional breathing reduce memory vividness by taxing working memory, individual differences in working memory capacity may attenuate the effects of eye movements and attentional breathing (van Schie et al., 2016). Therefore, I also predict that:

d) There will be a negative correlation between working memory capacity and change in ratings of memory vividness (from pre- to post- intervention), and this relationship will be stronger for the eye movement and attentional breathing groups. Figure 6 illustrates the hypothesis for the moderating effect of working memory capacity on memory vividness ratings.

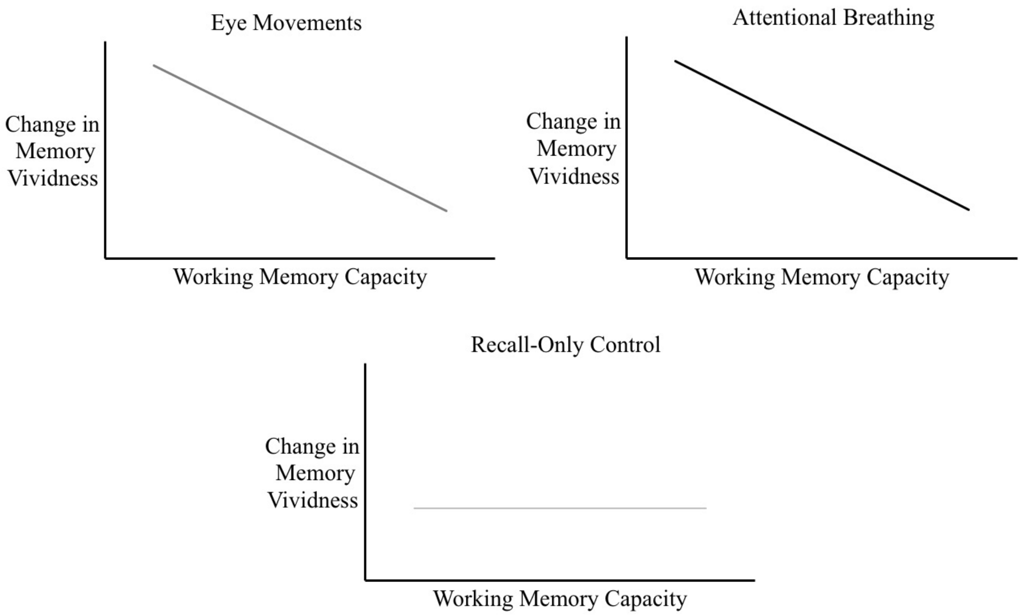

Figure 6. **The hypothesised moderating effect of working memory capacity on memory vividness ratings across experimental conditions.**

Hypothesis 2: Memory emotionality ratings. The effect of each condition on participant ratings of memory emotionality will also be explored. Memory emotionality will be measured using a pre-test/post-test design to test whether there is a difference in emotionality from pre- to post- intervention for each condition. In addition, the study will investigate whether working memory capacity attenuates the effects of the conditions in changes in memory emotionality. Consistent with previous research demonstrating the effect of eye movements on reductions in memory emotionality (Lee & Cuijpers, 2013; Smeets et al., 2012), I hypothesise that:

a) There will be greater decreases (from pre- to post- intervention) in ratings of memory emotionality for participants in the eye movement condition than for participants in the recall-only control group.

Research by van den Hout et al. (2011) demonstrated comparable reductions in memory emotionality for eye movements and an attentional breathing task. In line with these findings and the working memory account of EMDR therapy, I predict that:

b) There will be greater decreases (from pre- to post- intervention) in ratings of memory emotionality for participants in the attentional breathing condition than for participants in the recall-only control group.
c) There will be no difference in how much memory emotionality decreases (from pre- to post- intervention) for participants in the eye movement condition and participants in the attentional breathing condition.

Theoretically, if eye movements and attentional breathing reduce memory emotionality by taxing working memory, individual differences in working memory capacity may attenuate the effects of eye movements and attentional breathing (van Schie et al., 2016). Therefore, I also predict that:

d) There will be a negative correlation between working memory capacity and change in ratings of memory emotionality (from pre- to post- intervention), and this relationship will be stronger for the eye movement and attentional breathing groups. Figure 7 illustrates the hypothesis for the moderating effect of working memory capacity on memory emotionality ratings.

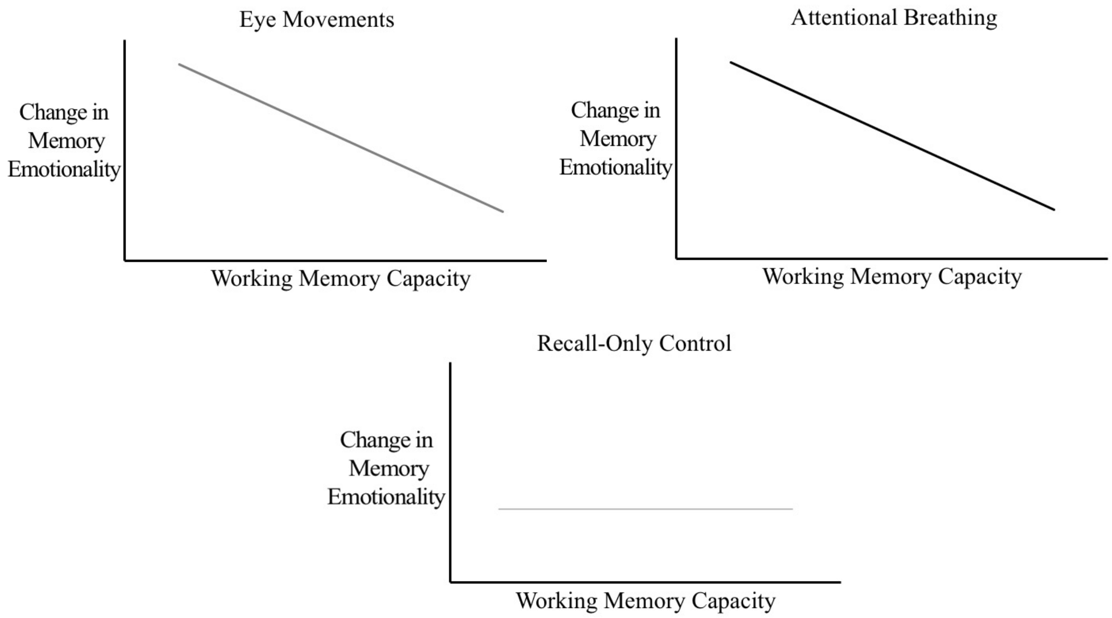

Figure 7. **The hypothesised moderating effect of working memory capacity on memory emotionality ratings across experimental conditions.**

Hypothesis 3: Recognition test scores. The current study will also explore whether performance on the recognition test differs between groups. Performance on the recognition test indicates overall memory accuracy, with low scores on the recognition test suggesting poor overall memory for the car crash video. Consistent with results from the original study by Houben et al. (2018), which demonstrated poorer recognition test performance following eye movements compared to recall-only, I predict that:

a) Participants in the eye movement condition will have lower scores on the recognition test than participants in the recall-only control group.

Previous research has demonstrated the detrimental effects of divided attention on memory accuracy at test (Knott & Dewhurst, 2007; Lane, 2006; Skinner & Fernandes, 2008; Zaragoza & Lane, 1998). Given that eye movements and attentional breathing are dual-tasks requiring divided attention during memory recall, I predict that:

b) Participants in the attentional breathing condition will have lower scores on the recognition test than participants in the recall-only control group.

c) There will be no difference in recognition test scores for participants in the eye movement condition and participants in the attentional breathing condition.

Hypothesis 4: Endorsement of misinformation. Finally, the main purpose of this study is to investigate the effects of each condition on false memory. This will be tested by comparing how much misinformation is endorsed by participants on the recognition test. In addition, the research will explore whether working memory capacity attenuates the effects of the conditions on false memory. Prominent false memory theories, including associative activation, source monitoring, and fuzzy-trace theory, suggest that false memories are more likely to occur when memory for the original event has become vague. Thus, reductions in memory vividness resulting from eye movements may have the unintended effect of increasing susceptibility to misinformation. Consistent with this idea, and recent findings demonstrating an increase in susceptibility to misinformation following eye movements (Houben et al., 2018), I hypothesise that:

a) Participants in the eye movement condition will endorse more misinformation items than participants in the recall-only control group.

A number of studies have demonstrated that people are more susceptible to misinformation when their attention has been divided (Lane, 2006; Zaragoza & Lane, 1998). Given that eye movements and attentional breathing are dual-tasks requiring divided attention during memory recall, I predict that:

b) Participants in the attentional breathing condition will endorse more misinformation items than participants in the recall-only control group.

c) There will be no difference in endorsement of misinformation items for participants in the eye movement condition and participants in the attentional breathing condition

Studies have consistently found that working memory capacity is negatively correlated with endorsement of misinformation (Brydges et al., 2018; Calvillo, 2014; Jaschinski & Wentura, 2002). Theoretically, if eye movements and attentional breathing are thought to affect memory by taxing working memory, then eye movements and attentional breathing might differentially increase endorsement of misinformation based on individual differences in working memory capacity. In line with this idea, I also predict that:

d) There will be a negative correlation between working memory capacity and endorsement of misinformation, and this relationship will be stronger for the eye movement and attentional breathing groups. Figure 8 illustrates the hypothesised moderating effect of working memory capacity on endorsement of misinformation.

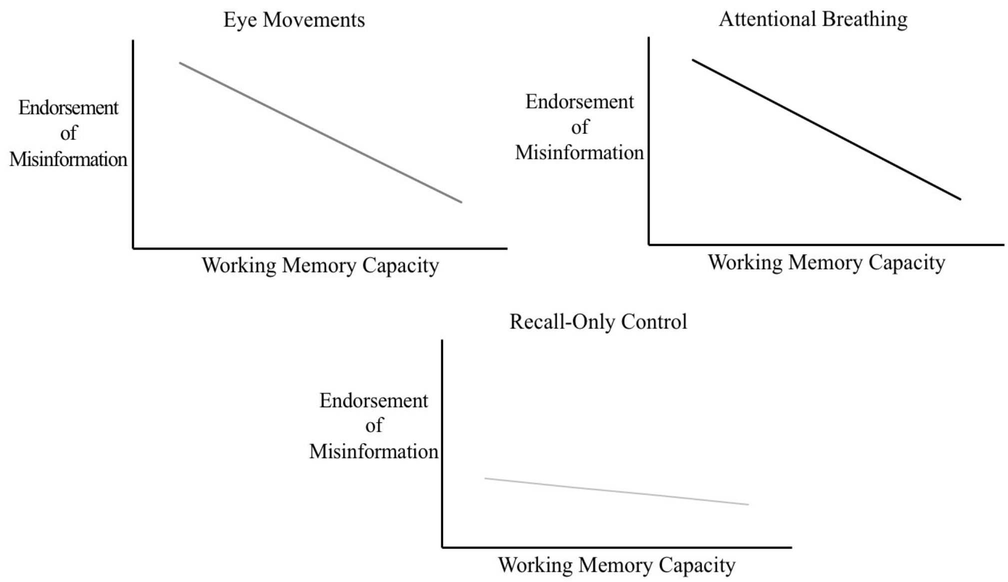

Figure 8. **The hypothesised moderating effect of working memory capacity on endorsement of misinformation across experimental conditions.**

CHAPTER 4

Experiment Method

The method for testing the research hypotheses outlined in Chapter 3 was largely informed by the methods involved in the research by Houben et al. (2018). Methodological decisions were also made based upon current theoretical understandings of EMDR therapy and false memories reviewed in Chapter 1. This chapter describes the methods used to address the research questions for the current study, including details of the pre-registration, research design, and participant recruitment. The measures/materials section provides a description of the resources used to manipulate the independent variable and measure the dependent variables in the current research. Lastly, the processes involved in the experiment are described in the procedure section, including an outline of the participant introduction, main experiment processes, and the debriefing procedure.

Pre-registration

An online pre-registration was created prior to commencement of data collection to outline the methodology of the current study using Open Science Framework (OSF; https://osf.io). The pre-registration included an a priori power analysis using G*Power version 3.1.9.3 (Faul et al., 2007) with a medium effect size (Cohen's f= .25) and a power of .80 (α= .05), which indicated a sample size of 159. This was based on a post-hoc power analysis by Houben et al. (2018), with n= 82, moderate to large effect sizes for eye movements ranging d= .30 to .88, and a power of .93. In line with this, the aim in the current study was to achieve a sample size of 150 participants. Due to time restrictions, a cut-off point for data collection was decided upon for 5:00PM on the 31st of August 2018. The pre-registration also described the research questions, hypotheses, data collection methods, and data analysis decisions for the current study. The pre-registration document was made public on 2 June 2018 and can be accessed at https://osf.io/ny7qj/.

Design

An experimental between-subjects design was used, with participants randomly assigned to one of three conditions; eye movements, attentional breathing, or recall-only control. Participants were randomly assigned to experimental conditions through an online random number generation tool (Urbaniak & Plous, 2013). Dependent variables included working memory capacity (measured by OSPAN absolute scores, described in the measures and materials section), ratings of memory vividness, memory emotionality, accuracy on the recognition test, and number of misinformation items endorsed on the recognition test. Working memory capacity, recognition test accuracy, and endorsement of misinformation were all post-test only design, and ratings of memory vividness and emotionality were pre-test/post-test design.

Participants

A convenience sample of 94 participants (64 females; 30 males), with a mean age of 25.74 (*SD*= 9.68) were recruited from the Manawatū campus of Massey University, New Zealand. Participants were randomly assigned to one of three conditions: eye movements, attentional breathing, or recall-only control. Table 1 displays the participant demographics for each condition. One participant from the eye movement group withdrew from the experiment. Eight participants (four from the eye movement group, three from the attentional breathing group, and one from the recall-only control group) had math accuracy below 85% on the OSPAN and were therefore excluded from working memory capacity analyses. This was to ensure participants were not compromising on math accuracy in order to remember the letters, and is consistent with the recommended exclusion criteria (Unsworth, Heitz, Schrock, & Engle, 2005).

Table 1

Gender and Mean Age of Participants in the Attentional Breathing Group, Eye Movement Group, and Recall-Only Control Group

		Condition		
Demographics		Attentional breathing	Eye movements	Recall-only control
Gender	Male *n*	12	9	9
	Female *n*	19	21	23
Age *M*(*SD*)		24.87(8.34)	25.97(10.42)	26.38(10.40)

Participants gave informed consent prior to commencement of the study. Participation in the study was voluntary, and all participants received a $10 New World grocery voucher in thanks for their participation. Recruitment ceased when 150 participants had agreed to participate, or at 6:00PM on 31st August 2018, whichever came first. Recruitment involved poster advertisement on campus noticeboards and word-of-mouth. Following an expression of interest, the researcher emailed participants with details about the nature of the study and a link to an appointment booking page.

Measures and Materials

The experiment was conducted via computer using E-Prime 2.0 (Schneider, Eschman, & Zuccolotto, 2002), PsychoPy (Pierce, 2007), and a custom-made online app. Materials from the Houben et al. (2018) study, including the trauma video, misinformation narrative, and recognition test were accessed via their article's OSF page (https://osf.io/j479p/).

Operation Span task. Working memory capacity was measured using an automated version of the Operation Span task (OSPAN; Unsworth et al., 2005). The OSPAN programme was downloaded from the Georgia Institute of Technology

Attention & Working Memory Lab website (http://englelab.gatech.edu/tasks.html), and administered using E-Prime 2.0 (Schneider et al., 2002). The OSPAN included 75 trials where participants solved simple math problems while remembering a string of letters. Figure 9 illustrates the sequence of events involved in the OSPAN task. Participants saw a math problem, (e.g., (2 × 4) – 3=?) and clicked the mouse when they had calculated the answer to the problem.

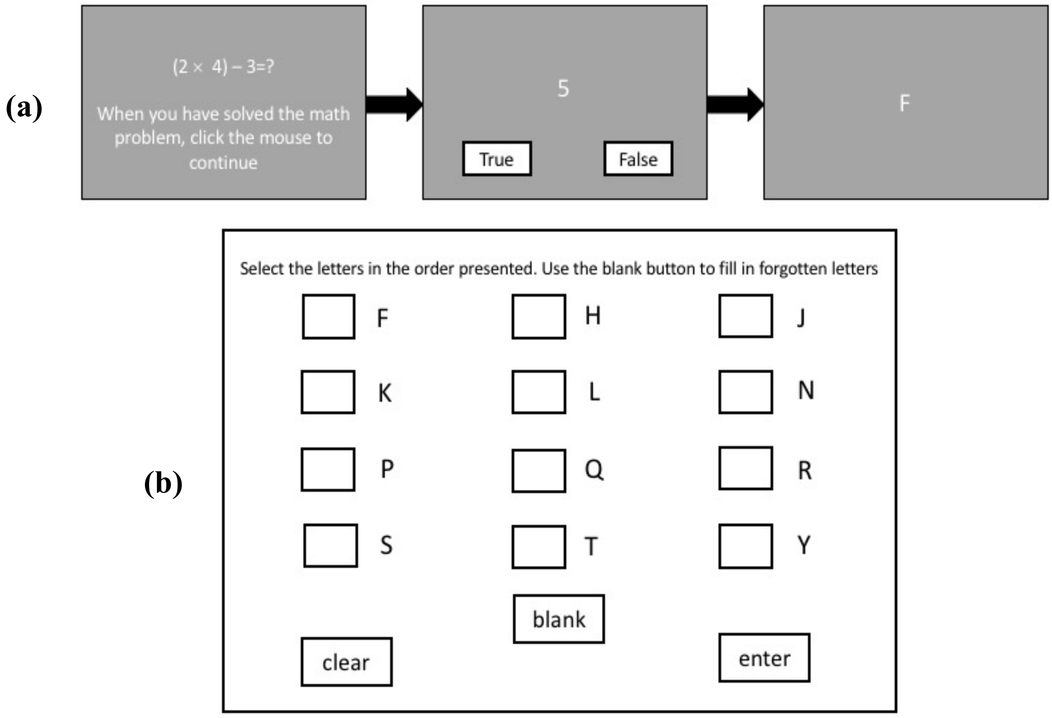

Figure 9. **Illustration of the sequence of tasks in the OSPAN. (a) shows the sequence of events during the study phase, (b) shows the test phase, where participants recalled the letters they saw during the study phase.**

The next screen displayed a number (e.g., 5) and participants indicated whether the number was the correct answer to the previous math problem by clicking either on a button marked 'True' or 'False'. After making the math decision, a letter (e.g., F) was displayed, which participants were told to remember. This pattern was repeated with different math problems and letters until the end of the trial. Participants were asked to remember 3-7 letters in each trial. At the end of each trial, participants indicated the letters they remembered from the trial and the order they were presented in from a four-by-three grid of possible letters. OSPAN absolute scores were calculated by the sum of all perfectly recalled sets (where all presented letters were recalled accurately and in the correct order). Following letter recall, a feedback screen was displayed showing the number of correct letters identified, the number of math errors made during the trial, and the percentage of correct math answers for the whole experiment.

The OSPAN programme also included a practise session prior to the main trials. The practise session was comprised of three blocks. In the first block, participants practised the letter memorisation task alone, which involved memorising a string of letters that appeared on the screen one at a time. At the end of a trial, participants recalled the letters and the order they were presented in by selecting the appropriate letters on the recall screen. In the second block, participants practised the math task alone; participants were shown a math problem and were asked to click the mouse when they had calculated the answer. The next screen displayed a number and participants indicated whether this was the correct answer to the previous math question by selecting "True" or "False". At the end of the math practise trials, participants were made aware that the computer had calculated their average time to compute the answer to the math problems. This was used to calculate the display times for math problems in the main trials.

In the final practise block, participants practised combining the letter and math tasks. Participants completed a math problem, were shown a letter to memorise, and then completed another math problem, and so on until the end of the trial. At the end of each trial the recall screen was displayed, and participants recalled the letters that were presented and the order in which they saw them. In all three practise blocks participants received feedback regarding their accuracy in the math and letter tasks.

Trauma video. The trauma video used in the experiment was previously used in the trauma film paradigm to induce an intrusive emotional memory (Holmes, Bourne, Elzinga, & van den Hout, 2008; Strange & Takarangi, 2012). The video was played in a customized online app and depicted a serious car accident involving several vehicles. It began by showing three teenage women in a car arguing about a text message the driver was attempting to send. Failing to attend to the road, the driver crossed the centre line and crashed into another vehicle. When the car stopped, another car crashed into the two vehicles. The video showed the aftermath of the accident, including the distressed driver and at least five other people who were injured. Emergency services arrived, and the video ended with a close-up of the driver's face as she was taken to hospital.

Eye movement stimulus. Similar to the pilot study, the current study used a computerised eye movement task to replicate the eye movement component of EMDR therapy. A grey dot (height and width= 1cm) was presented on a black background moving 26cm horizontally across the screen at one cycle per second (one cycle from left to right, and back again). The stimulus was created in a customised online app. Based on previous research using eye movements (Parker & Dagnall, 2007), the stimulus moved across a visual angle of 27 degrees with participants seated 54cm from the monitor. Prior to the main experiment, participants practised the eye movement task for 24 seconds.

Attentional breathing task. The attentional breathing task described in the pilot study was also used in the current experiment as an alternative dual-task to test the working memory account of EMDR therapy. This task was derived from a Mindfulness-Based Cognitive-Therapy handbook by Segal et al. (2002) and closely followed the attentional breathing task used by van den Hout et al. (2011). The exercise involved two basic steps: (1) stepping out of automatic pilot and becoming aware of thoughts and feelings, and (2) bringing attention to the breath and related sensations. Eye movements were controlled by having participants focus their eye gaze on the words ‘breathe mindfully’ which were presented in the middle of the screen (letter height= 5mm). Prior to the main experiment, participants practised the attentional breathing task for 24 seconds. In the practise task, the researcher instructed participants to focus on their breathing and the sensations they felt during each breath (refer to Appendix A for the specific instructions).

Recall-only task. A recall-only task was used as a single-task to control for the effects of performing a dual-task during memory recall. In the recall-only task, participants focused their eye gaze on a grey dot (height and width= 1cm) fixed in the middle of a black screen while recalling the trauma video.

The eye movement task, attentional breathing task, and recall-only task described above were each performed over four blocks lasting 24 seconds with a 10 second rest period between blocks. A countdown timer was displayed to indicate to participants when the next block would begin. This timing follows that used by Houben et al. (2018), and largely adheres to EMDR practices. Each of the tasks were programmed via a customised online app.

Maze filler-task. An open-source maze game accessed online (https://wwwtyro.github.io/Astray/) was used as a filler-task before and after misinformation was introduced. This was programmed via a customised online app. The game required participants to navigate their way through a maze using the arrow keys on the computer keyboard. Once reaching the end of the maze, participants moved on to the next level. Participants played the maze game for five minutes before misinformation was introduced, and for another five minutes after misinformation was introduced. The maze game was also used as a control practise task for the recall-only control group prior to beginning the main experiment. Participants in the recall-only control group practised the maze game (in place of the attentional breathing or eye movement practise) until they had completed three levels.

Vividness rating scale. Memory vividness was measured using a Visual Analogue Scale (VAS) presented on the computer via a customised online app, as shown in Appendix B. Participants were asked to indicate how vivid they found the event portrayed in the video on a scale from 0 (not vivid at all) to 10 (extremely vivid). Participants selected their response by clicking on the appropriate radio button.

Emotionality rating scale. Memory emotionality was also measured using a VAS presented on the computer, also shown in Appendix B. Participants were asked to indicate how they feel about the event portrayed in the video on a scale from 0 (extremely negative) to 10 (extremely positive). Participants selected their response by clicking on the appropriate radio button. VAS have been used to measure the emotional intensity and vividness of a memory in a multitude of previous studies demonstrating the effect of eye movements on traumatic memories (e.g., Houben et al., 2018; Leer et al., 2014; Onderdonk & van den Hout, 2016).

Misinformation narrative. Misinformation was introduced through a computerised version of the eyewitness narrative used by Houben et al. (2018), and was presented via a customised online app. The narrative was written from the perspective of another witness of the car crash shown in the trauma film and is shown in Appendix C. The narrative included ten true statements about the video (e.g., ‘the girls were driving a small car’) and five false statements (e.g., ‘the driver was texting *John’* instead of *James*; ‘I saw the injured *mother*’ instead of *father*). Participants had unlimited time to read the eyewitness narrative. After reading the narrative, participants clicked on the 'continue' button to move on to the next task.

Recognition test. Memory accuracy and susceptibility to misinformation was measured using a two-alternative forced-choice recognition task used by Houben et al. (2018). The recognition test contained 15 questions about the trauma video, with two possible response options for each question, as shown in Appendix D. Ten questions included a true and foil response option (e.g., 'What vehicle were the girls driving?' True answer: 'a small car', Foil answer: 'a van'). The remaining five questions include the misinformation that was presented in the eye-witness narrative (e.g., 'To whom were the girls writing a text message?' True answer: 'James', Misinformation answer: 'John'). Correct answers were recorded as "1" and incorrect answers were recorded as "0". Memory accuracy was indicated by the sum of correct answers on the recognition test. An incorrect answer for a misinformation question indicated susceptibility to misinformation. Susceptibility to misinformation was measured by the total number of incorrect misinformation answers. Although Houben et al. (2018) administered the recognition test verbally to participants, the current research presented the recognition test via computer to minimise experimenter effects.

Procedure

The current research involved three main procedural stages; participant greeting and introduction upon arrival, administering the experimental tasks, and a post-experiment debrief. The following sections describe the processes involved at each stage of the experiment.

Greeting and introduction. The current study consisted of sessions lasting one hour each. At the beginning of each session, participants were greeted by the researcher and shown to the computer lab. Sessions were held in a computer lab containing a desktop computer and two chairs (one for the participant and one for the researcher). Only one participant was allocated to each session. Participants sat approximately 54cm from a 1920 × 1080 22-inch wide LED computer monitor, with a refresh rate of 60Hz. Prior to commencing the study, the researcher described the tasks involved in the study and made participants aware that they would be shown a video of a traumatic car accident. The researcher asked participants if they were willing to view the video, and informed participants that they may withdraw from the study at any time, without penalty. The researcher also demonstrated how to turn off the computer monitor and sound if the car crash video became too distressing for participants during the experiment.

Participants were then provided with an information sheet and given time to read through this carefully. The information sheet invited participants to take part in a study on memory and attention and outlined relevant details regarding their participation including: a brief description of the research, task requirements, participant rights, confidentiality and privacy information, contact details of the researcher, and ethical integrity of the research. Participants were given the opportunity to ask any questions about the study and their participation. If participants were willing to proceed with the study, they were asked to sign a written informed consent form outlining they have understood the information provided and they agree to participate.

Experiment process. Figure 10 displays the sequence of events during the main experiment. After agreeing to participate, the researcher introduced the first task which was the OSPAN. Participants were told this task involved remembering letters that were presented on the screen while also solving some simple math problems. The researcher gave participants time to read through the instructions which were provided by the computer program.

The first part of the OSPAN involved a series of practice trials to familiarize participants with the different tasks. During the practice trials, the researcher sat next to the participant to ensure tasks were understood. Participants then proceeded to the real trials. The researcher left the room while participants completed the real trials. This took approximately 10 minutes to complete. Participants let the researcher know when they had completed the OSPAN task.

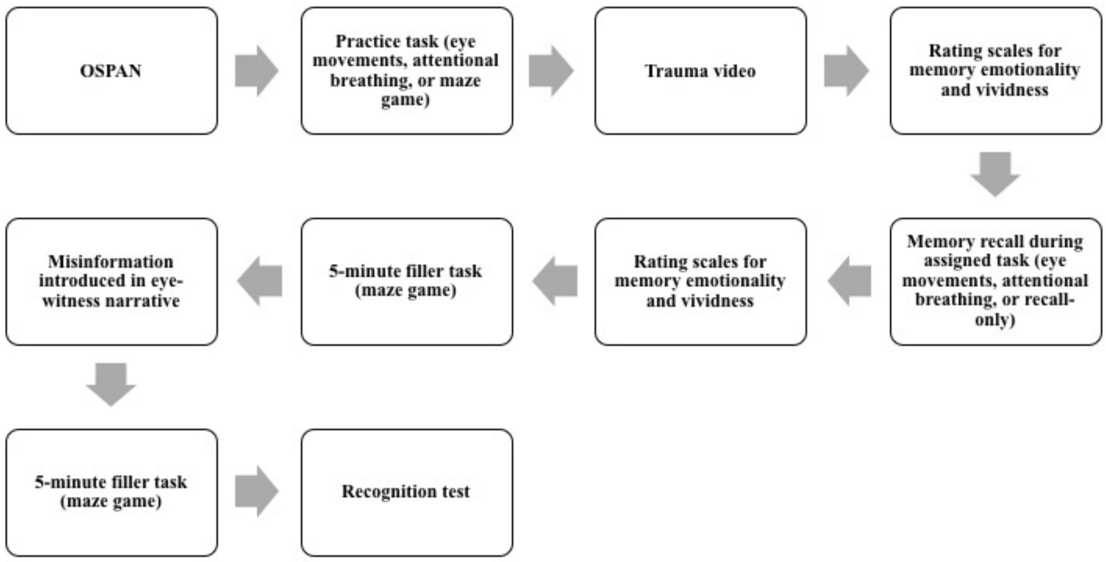

Figure 10. **Sequence of tasks that participants completed in the main experiment for the current study.**

Next, the researcher launched the appropriate practice task based on the condition the participant was randomly assigned to. During the practice tasks, the researcher sat next to participants. Participants in the eye movement condition practiced the eye movement task, participants in the attentional breathing condition practiced the attentional breathing task, and participants in the recall-only control condition practiced the maze game.

Afterward, the researcher opened a web browser and launched the main experiment. Participants were made aware of the sequence of tasks they were to complete in the main part of the experiment and were reminded of their right to withdraw from the study if they were not comfortable viewing the trauma video. The researcher explained that instructions for all of the tasks would be provided by the computer. The researcher left the room while the participant completed the remainder of the study. Before beginning, participants were first asked to indicate their age and gender. Following this, an instruction screen appeared for the trauma video, asking participants to watch the video as though they were a witness to the car accident. The video began playing when participants clicked on the ‘watch video’ button. Volume for the video was set at 50% on the computer sound settings.

The video played for approximately 5 minutes, after which the computer displayed two rating scales; one for memory vividness and the other for memory emotionality. Participants were asked to rate their memory of the trauma video in terms of the emotional intensity and vividness. Participants selected a value from 0 to 10 for each of the scales and then clicked the ‘next’ button to continue to the next task.

At this point, participants completed the task for the condition they had been randomly assigned to. In the eye movement condition, participants were instructed to use their eyes to track a grey dot moving horizontally across the screen. In the attentional breathing condition, participants were instructed to focus their eye gaze on the words ‘Breathe mindfully’ which were presented in the middle of the screen and focus on their breathing. In the recall-only control condition, participants were instructed to focus their eye gaze on a grey dot fixed in the middle of the screen. In all three conditions, participants were instructed to complete the task while simultaneously thinking about the trauma video and the emotions they felt during the video.

Again, participants were asked to rate the emotionality and vividness of their memory for the trauma video. Participants were then moved on to the maze filler-task. After five minutes, the computer automatically moved on to the instruction screen for the eyewitness narrative. Here, participants were instructed to carefully read a statement from another eyewitness of the car crash they had observed earlier. There was no time limit for reading the narrative, and participants were able to initiate the next task by clicking the ‘next’ button when they had finished reading.

Participants completed the maze game for another five minutes before moving on to the recognition test. Instructions for the recognition test stated that they would be asked a series of questions about what they remember from the trauma video. The computer displayed the questions and the two response options for each question. Participants responded by selecting the answer they believed to be correct for each question. After completing all 15 recognition questions, participants notified the researcher that they had completed the experiment.

Post-experiment debrief. Upon completion of the experiment, the researcher re-entered the computer lab to give a debrief, thank participants for their time, and provide them with their voucher. A funnel debrief was used to explore the participant’s awareness of the research hypothesis. The researcher began by asking participants open-ended questions about the purpose of the experiment. Questions became increasingly focused to explore whether participants were aware of the link between the experimental task and the outcome measures (e.g., “what do you think the purpose of the eye movement task was in the experiment?”). Following this, the researcher explained the purpose of the study and participants were given the opportunity to ask questions. Finally, the researcher thanked participants for their time and gave them their $10 grocery voucher.

CHAPTER 5

Experiment Results

This chapter describes the results of the main experiment described in Chapter 4. The first two sections explain the processes used to prepare the data for analysis and check assumptions of the parametric tests outlined in the pre-registration. The third section outlines the criteria used for making decisions about statistical and practical significance of results from the inferential tests. In the fourth section, patterns that emerged from the data are described, along with the results of confirmatory tests used to investigate the hypotheses outlined in Chapter 3. The chapter ends with an outline of exploratory analyses which compared findings from the current study to the findings from the original study by Houben et al. (2018).

Data Preparation

Raw data collected during the experiment was stored in a Microsoft Excel spreadsheet. Data from one participant was excluded due to failure to complete the experiment. The gender variable was transformed into a dummy variable so that female= 1 and male= 0. Endorsement of misinformation was reverse-coded so that the value represented the number of misinformation answers. Emotionality ratings for pre- and post- intervention were also reverse coded for easier comparison to vividness ratings, so that higher scores represented more negative emotionality. Two new variables were created to show change in ratings of memory vividness and emotionality from pre- to post- intervention by subtracting pre-intervention emotionality/vividness ratings from post-intervention emotionality/vividness ratings.

OSPAN absolute scores, math errors, speed errors, and total math errors were found for each participant. Eight participants (four from the eye movement group, three from the attentional breathing group, and one from the recall-only control group) were excluded from OSPAN analyses due to math accuracy below 85% (Unsworth et al., 2005). The independent variable's (IV) three conditions were transformed into two dummy variables for the linear regression: One eye movements variable (coded 1 for eye movements and 0 for the control condition), and one attentional breathing variable (coded 1 for attentional breathing and 0 for the control condition).

Means, standard deviations, and confidence intervals were calculated for total recognition test scores, total endorsement of misinformation, pre/post vividness and emotionality ratings, and OSPAN absolute scores for each experimental group.

Assumption Checks

Assumption checks were carried out prior to confirmatory analyses to determine the appropriate parametric tests for analyzing the data. The parametric tests used to address the research hypotheses included: (1) a one-way Analysis of Variance (ANOVA) to test the effect of the conditions on recognition test performance and false memories, (2) mixed-design ANOVA to test change in ratings of memory vividness and emotionality from pre- to post- intervention (within-subjects) for each group (between-subjects), and (3) multiple linear regression to test whether working memory capacity moderates the effect of the conditions on false memories and on ratings of memory vividness and emotionality.

The assumption of normality was assessed by visual inspection of boxplots for each of the dependent variables (DVs), as shown in Figures E1-E5, Appendix E. The assumption of normality was violated across all DVs, as demonstrated by skewness, and kurtosis well below 3. Since the one-way ANOVA is a robust test against the assumption of normality (Blanca, Alarcón, Arnau, Bono, & Bendayan, 2017), no corrections were made to account for non-normality of the dependent variables.

Homogeneity of variances was assessed using Levene's test for equality of variances. Table 2 shows that the assumption of homogeneity of variances was met for recognition test scores, endorsement of misinformation, memory emotionality ratings, and memory vividness ratings. The assumption of sphericity was met because the repeated-measures ANOVA has only two levels (pre-test/post-test).

Table 2

Results from Levene's Test of Equality of Variances for the Dependent Variables

Variable	F	p
Recognition test scores	1.27	.29
Endorsement of misinformation	0.63	.53
Memory emotionality ratings		
Pre-intervention	0.50	.61
Post-intervention	0.40	.67
Memory vividness ratings		
Pre-intervention	0.94	.40
Post-intervention	0.82	.44
OSPAN absolute scores	2.65	.08

Note. Homogeneity of variances satisfied if $p>.05$; df= (2,90) for recognition test scores, endorsement of misinformation, memory emotionality, and memory vividness; df= (2,83) for OSPAN absolute scores.

Inference Criteria

Null hypothesis testing was used to compare the effects of the three levels of the IV (eye movements, attentional breathing, and recall-only control) on the DVs (accuracy on the recognition test, endorsement of misinformation, memory emotionality ratings, and memory vividness ratings). Null hypotheses (H_0) stated no effect of the IV on the DV, and alternative hypotheses (H_1) stated an effect of the IV on the DV. As outlined in the pre-registration, statistical significance was observed at $p<.05$, thus H_0 was rejected when $p<.05$, however H_0 cannot be rejected when $p>.05$ because this indicates insufficient evidence that there is an effect present. Partial-eta squared effect sizes were calculated for each of the ANOVAs.

Bayes factors (BF) were used to compare the relative evidence for the null and alternative hypotheses. BFs quantify the likelihood of the data under the null hypothesis (where the effect is presumed to be zero) or the alternative hypothesis (where the effect is presumed to be nonzero) (Williams et al., 2017). A hypothesis is considered more credible when the observed data is more likely under one hypothesis than the other. BF_{01} quantifies the likelihood of the data under H_0 relative to H_1, whereas BF_{10} quantifies the likelihood of the data under H_1 relative to H_0. In effect, BF_{01} is the inverse of BF_{10} ($BF_{01}= 1/BF_{10}$). BF_{01} greater than 1 indicates evidence in favour of the null hypothesis. BFs further from 1 provide stronger evidence, while BFs closer to 1 indicate ambiguous evidence, meaning that there is less certainty that one hypothesis is supported more than another (Wagenmakers et al., 2015). In the current study, $BF_{01} >3$ was considered moderate evidence in favour of H_0.

Importantly, BFs can take into account prior information about the effect being investigated. This requires the researcher to make decisions about which effect sizes are more or less likely if the true effect is non-zero, referred to as the ‘prior’ (Williams et al., 2017). In the current study, a default Cauchy prior (0, 0.707) has been used, which means that if we assume the true effect is non-zero, there is a 50% chance that the effect is larger than $d= 0.707$ in absolute value.

A major advantage of the Bayesian approach is that, unlike frequentist null hypothesis testing, BFs allow us to calculate the likelihood that either the null or alternative hypothesis is correct given the observed data (Williams et al., 2017). The ability to quantify evidence in favour of the null hypothesis is particularly important in replication research, such as the current study, because it allows us to determine the *extent* to which an effect has, or has not, been replicated (Verhagen & Wagenmakers, 2014). BFs are also advantageous in replication research because, unlike *p*-values, they are independent of the researcher's intentions of data collection (Wagenmakers, 2007). Moreover, BFs do not reject the null hypothesis as readily as *p*-values because the alternative hypothesis may provide a fit that is just as poor, or worse, than the null (Verhagen & Wagenmakers, 2014; Wagenmakers, 2007).

A Bayesian approach is also appropriate for the current study because BFs allow us to investigate hypotheses of zero effect (Williams et al., 2017). In the current study, there are several hypotheses that make predictions of no difference in effects between eye movements and attentional breathing. To test such hypotheses, we need to be able to quantify the extent to which the null hypothesis is supported by the data. However, this cannot be achieved using a frequentist null hypothesis testing approach, because *p*-values can only provide evidence against the null hypothesis, not in support of it (Wagenmakers, 2007).

Region of Practical Equivalence (ROPE) analyses quantified the size and direction of effects. The ROPE defines a small range of values that are considered to be practically equivalent to zero (Kruschke & Liddell, 2018; Rouder, Haaf, & Vandekerckhove, 2018). In the current study, effect sizes (δ) in the range -0.2 to 0.2 were considered to be practically equivalent to no effect. The ROPE was compared against a 95% Highest Density Interval (HDI), which contains the effect size values for the 95% most credible values. Effect size values that fall inside the 95% HDI are considered to have higher credibility than effect size values that fall outside of the 95% HDI (Kruschke & Liddell, 2018). The 95% HDI provides an indication of how certain we can be about a particular effect size estimate; a higher degree of certainty is attained when the 95% HDI is spread over a narrow range of effect size values (Kruschke & Liddell, 2018).

The decision regarding the size and direction of an effect was determined by the amount of overlap between the ROPE and 95% HDI. The null hypothesis was supported if the entire 95% HDI fell within the defined ROPE, meaning that all of the 95% most credible values are practically equivalent to no effect. The alternative hypothesis was supported if the entire 95% HDI fell outside of the defined ROPE, meaning that none of the 95% most credible values are practically equivalent to no effect (Kruschke & Liddell, 2018). Where only some of the 95% HDI fell inside the defined ROPE, Kruschke and Liddell (2018) recommend remaining undecided about the size and direction of the effect.

Hypothesis Testing

This section describes the results of confirmatory data analyses used to test the hypotheses outlined in Chapter 3. The analyses described in this section were pre-registered prior to data collection. The confirmatory results for the current study are divided into four sections according to the main hypotheses; memory vividness ratings, memory emotionality ratings, recognition test performance, and endorsement of misinformation.

Memory vividness ratings. The first hypothesis predicted that performing eye movements, attentional breathing, or the recall-only control task would differentially affect pre/post intervention ratings of memory vividness. Specifically, I hypothesised that the eye movement task and the attentional breathing task would result in greater decreases in ratings of memory vividness from pre- to post- intervention compared to the recall-only control task (H_1: the distribution of the change in memory vividness ratings from pre- to post- intervention between conditions is unequal). I also predicted that there would be no difference between the eye movement and attentional breathing groups in how much memory vividness decreases from pre- to post- intervention (H_0: the distribution of the change in memory vividness from pre- to post- intervention between the eye movement and attentional breathing groups is equal).

Across all conditions, there was only a small decrease in participants' ratings of memory vividness from pre-intervention (*M*= 6.59, *SD*= 2.19) to post-intervention (*M*= 6.26, *SD*= 1.87). Change in memory vividness from pre- to post- intervention for each group is displayed in Figure 11, which shows a small decrease in vividness for the eye movement and attentional breathing groups, and no change for the control group.

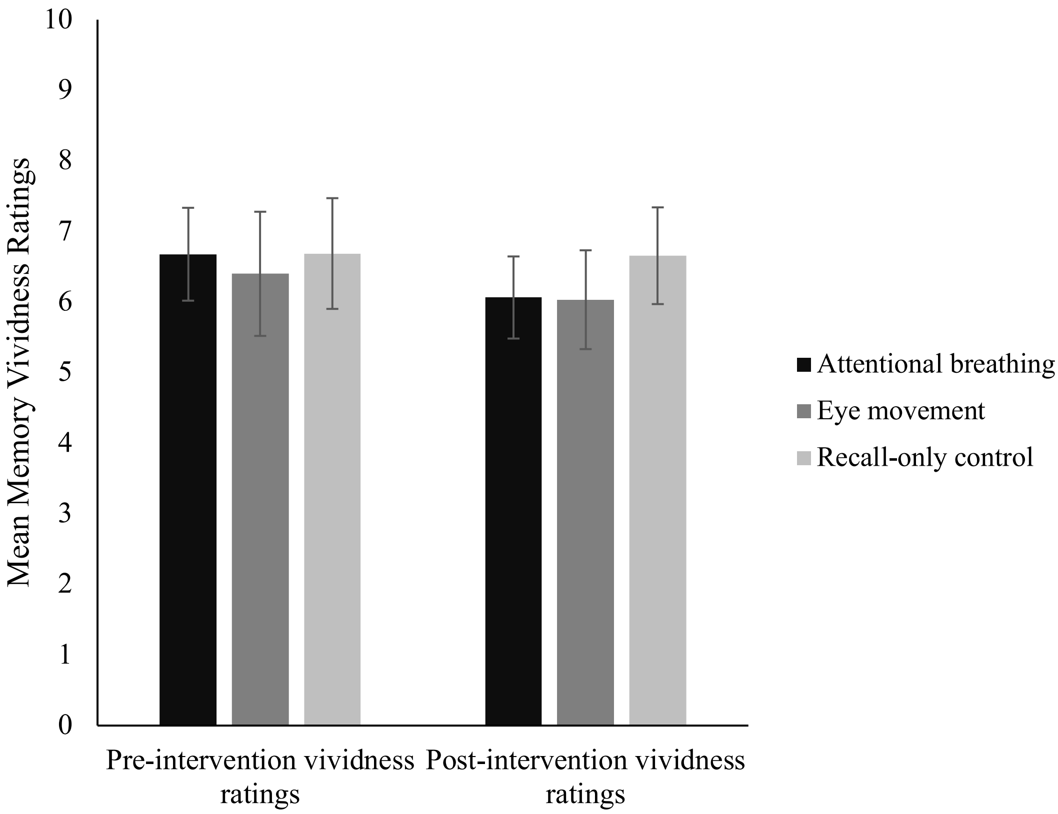

***Figure 11.* Group means for memory vividness ratings at pre- and post-intervention. Error bars show 95% confidence intervals.**

A mixed-model ANOVA revealed a significant main effect of time, $F(1,90)=4.07$, $p=.047$, $\eta^2_p=.04$, suggesting memory vividness ratings decreased from pre- to post- intervention across all three groups. The main effect of condition on the change in memory vividness was non-significant, $F(2,90)=0.47$, $p=.63$, $\eta^2_p=.01$. There was also no interaction between time and condition, $F(2,90)=1.04$, $p=.36$, $\eta^2_p=.02$, indicating that neither eye movements nor attentional breathing led to significantly greater reductions in memory vividness compared to recall-only. A modified Brinley plot (displayed in Figure E6, Appendix E) further demonstrates no effect of the conditions on memory vividness ratings.

Post-hoc BFs (with a default Cauchy prior of .707 on effect size on the alternative hypothesis) compared the relative evidence in favour of the null or alternative hypotheses. The between-group comparison for eye movements and recall-only resulted in a $BF_{01}= 2.80$. Contrary to the expected effect, this BF indicates that the observed data are 2.80 times more likely under the null hypothesis which predicts the absence of an effect of eye movements on memory vividness than under the alternative hypothesis that predicts the presence of an effect. According to Jeffreys (1961), this is anecdotal evidence in favour of H_0: that there is no difference in how much memory vividness ratings changed from pre- to post- intervention for participants who performed eye movements and participants who performed recall-only. This was further confirmed by a ROPE analysis with a 95% HDI (-0.11, 0.55), which found that only some of the 95% most credible effect sizes were practically equivalent to zero effect, therefore there is insufficient evidence to accept or reject H_0.

The between-group comparison for attentional breathing and recall-only established a $BF_{01}= 3.75$, which was not in line with the predicted effect. The BF indicates that the observed data are only 3.75 times more likely under the null hypothesis which predicts the absence of an effect of attentional breathing on memory vividness than under the alternative hypothesis. This can be interpreted as moderate evidence in favour of H_0: that there is no difference in how much memory vividness ratings changed from pre- to post- intervention for participants who performed attentional breathing and participants who performed recall-only. However, a ROPE analysis with a 95% HDI (-0.07, 0.59) found that some of the 95% most credible effect sizes were practically equivalent to zero effect, therefore there is insufficient evidence to accept or reject H_0.

Lastly, the between-group comparison for eye movements and attentional breathing found a BF_{01}= 4.77 in the expected direction. The BF indicates that the observed data are 4.77 times more likely under the null hypothesis which predicts no difference between groups in their effects on memory vividness than under the alternative hypothesis. This is interpreted by Jeffreys (1961) as moderate evidence in favour of H_0: that there is no difference in how much memory vividness ratings changed from pre- to post-intervention for participants who performed eye movements and participants who performed attentional breathing. However, a ROPE analysis with a 95% HDI (-0.25, 0.35) found that only some of the 95% most credible effect sizes were practically equivalent to zero effect, therefore there is insufficient evidence to accept or reject H_0.

Overall, findings indicated that performing eye movements, attentional breathing, or the recall-only control task did not differentially affect change in memory vividness from pre- to post- intervention, thus there was insufficient evidence to support the first hypothesis.

Moderating effect of working memory capacity. Under the first hypothesis, I also predicted that working memory capacity would moderate the effect of the conditions on change in memory vividness. Specifically, I hypothesised that there would be a negative correlation between working memory capacity and change in memory vividness, and this relationship would be stronger for the eye movement and attentional breathing groups than for the recall-only control group (H_1). H_0 predicted that working memory capacity would not moderate the effect of eye movements and attentional breathing on memory vividness ratings.

Working memory capacity was measured using OSPAN absolute scores, which quantified the sum of perfectly remembered letters for each participant. Across all three conditions, participants tended to have relatively high absolute scores on the OSPAN (M= 45.40, SD= 14.66), suggesting that participants' working memory capacity, was overall, reasonably high. Figure 12 displays the mean working memory capacity scores and mean math errors on the OSPAN for each group.

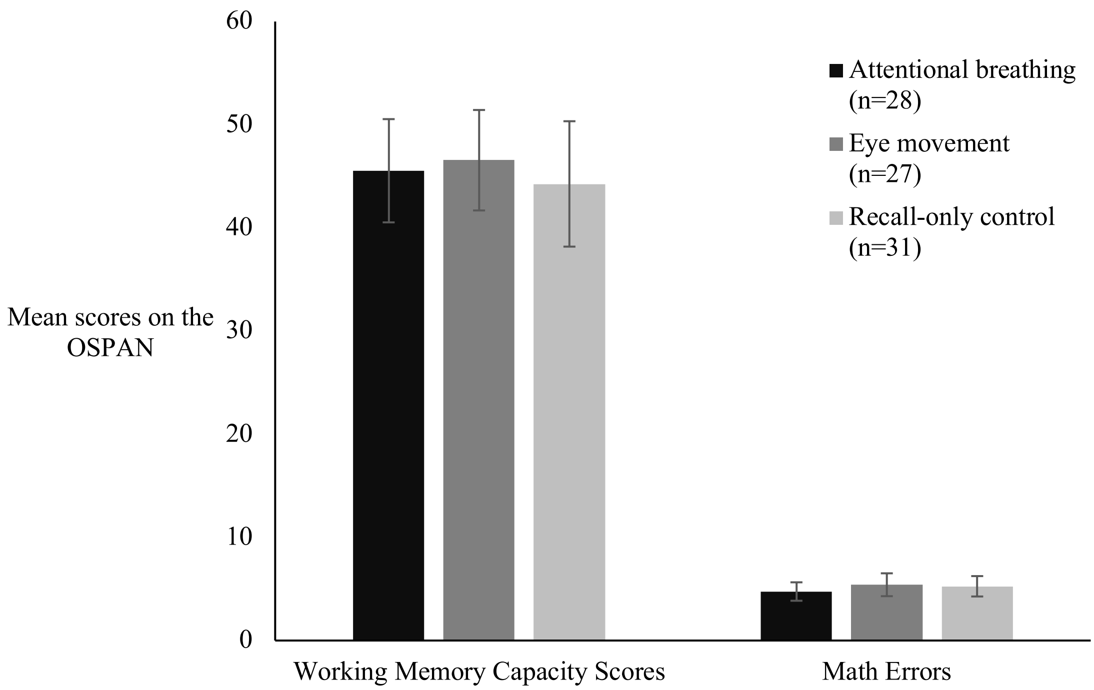

Figure 12. **Mean working memory capacity scores and mean math errors on the OSPAN for each group. OSPAN scores are based on absolute scores. Error bars show 95% confidence intervals.**

Working memory capacity scores were similar across groups; the eye movement group had slightly higher working memory capacity (M= 46.56, SD= 12.91), closely followed by the attentional breathing group (*M*= 45.54, *SD*= 13.51), and the recall-only control group (*M*= 44.26, *SD*= 17.27). A one-way ANOVA revealed that there was no statistically significant difference between groups in working memory capacity scores, $F(2,83)= 0.18$, $p=.84$, $\eta^2_p= 0.004$.

The number of math errors on the OSPAN task were also similar across groups; the eye movement group made the most math errors (*M*= 5.54, *SD*= 2.92), closely followed by the recall-only control group (*M*= 5.26, *SD*= 2.80), and the attentional breathing group (*M*= 4.65, *SD*= 2.41). A one-way ANOVA revealed that there was no statistically significant difference between groups in the number of math errors made on the OSPAN task, $F(2,82)= 0.59$, $p= .56$, $\eta^2_p=0.01$.

Multiple linear regression examined the moderating effect of working memory capacity on the relationship between condition and change in memory vividness from pre- to post- intervention. Table 3 displays the main effects and interaction effects on change in memory vividness for working memory capacity, attentional breathing, and eye movements. Pre-intervention memory vividness ratings were included in the model to control for any effect the initial ratings had on the change in vividness from pre- to post- intervention. The main effect for pre-intervention memory vividness shows there was no significant relationship between baseline vividness ratings and the change in vividness over time when condition and working memory capacity were held constant. The main effect of working memory capacity shows that, when condition and pre-intervention vividness ratings were held constant, working memory capacity did not significantly predict how much memory vividness changed from pre- to post-intervention.

The interaction effect between working memory capacity and attentional breathing (also displayed in Table 3) found that working memory capacity did not significantly attentuate the effect of attentional breathing on change in memory vividness from pre- to post- intervention.

Table 3

Unstandardized (B) and Standardized (β) Coefficients for the Moderating Effect of Working Memory Capacity on the Relationship Between Condition and Change in Memory Vividness

Model		*B*	SE *B*	β	*t*	*p*	95% CI for *B* [LL, UL]
1	(Intercept)	-0.48	1.04		-0.47	.64	[-2.55, 1.58]
	Pre-test vividness	0.04	0.08	0.06	0.49	0.63	[-0.12, 0.20]
	Working memory capacity	0.00	0.02	0.04	0.26	.80	[-0.03, 0.04]
	Attentional breathing	0.08	1.35	0.02	0.06	.96	[-2.61, 2.76]
	Eye movements	1.24	1.47	0.37	0.84	.40	[-1.69, 4.16]
	Working memory capacity * Attentional breathing	-0.01	0.03	-0.19	-0.45	.65	[-0.07, 0.04]
	Working memory capacity * Eye movements	-0.04	0.03	-0.52	-1.18	.24	[-0.10, 0.03]

Note. Attentional breathing dummy coded: 0=control, 1=attentional breathing. Eye movements dummy coded: 0=control, 1=eye movements.
B= unstandardized regression coefficient; SE *B*= Standard error of unstandardized coefficient; β= standardized regression coefficient; LL= lower limit; UL= upper limit.

Results were similar for the interaction between working memory capacity and eye movements, which found that working memory capacity did not attenuate the effect of eye movements on change in memory vividness from pre- to post- intervention. Therefore, neither the attentional breathing task nor the eye movement task differentially affected memory vividness based on individual working memory capacity.

The model found an Adjusted R^2=-.03, indicating that the model explains only 3% of the variance in the decrease in memory vividness in the population. An omnibus F-test revealed that the model's overall fit was non-significant, $F(6,79)=0.61$, $p=.72$. Contrary to the hypothesised effect, findings indicated that working memory capacity did not moderate the effect of eye movements or attentional breathing on reductions in memory vividness from pre- to post- intervention, therefore there was insufficient evidence to reject H_0.

Memory emotionality ratings. The second hypothesis predicted that performing eye movements, attentional breathing, or the recall-only control task would differentially affect pre/post intervention ratings of memory emotionality. Specifically, I hypothesised that the eye movement task and the attentional breathing task would result in greater decreases in ratings of memory emotionality from pre- to post- intervention compared to the recall-only control task (H_1: the distribution of the change in memory emotionality ratings from pre- to post- intervention between conditions is unequal). I also predicted that there would be no difference between the eye movement and attentional breathing groups in how much memory emotionality decreases from pre- to post- intervention (H_0: the distribution of the change in memory emotionality from pre- to post- intervention between the eye movement and attentional breathing groups is equal).

Across all conditions, there was a small decrease in participants' ratings of memory emotionality from pre-intervention (M= 7.06, SD= 2.36) to post-intervention (M= 6.90, SD= 2.25). Change in memory emotionality from pre- to post- intervention for each group is displayed in Figure 13, which shows a small decrease in emotionality for the eye movement and attentional breathing groups, and a small increase in emotionality for the control group.

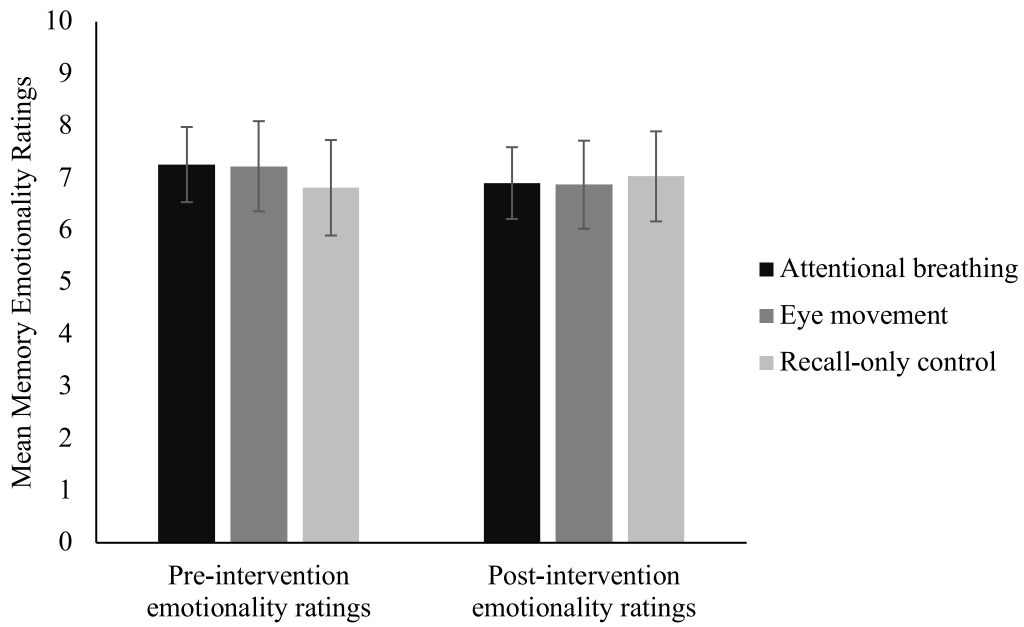

Figure 13. **Group means for memory emotionality at pre- and post-intervention. Error bars show 95% confidence intervals.**

A mixed-model ANOVA revealed a non-significant main effect of time, $F(1,91)=1.85$, $p<.18$, $\eta^2_p= 0.02$. The main effect of condition on the change in memory emotionality was also non-significant, $F(2,91)=0.04$, $p=.96$, $\eta^2_p=0.001$, and there was no interaction effect between time and condition, $F(2,91)=2.56$, $p=.08$, $\eta^2_p =0.05$. The results suggest there was no change in memory emotionality ratings from pre- to post-intervention across any of the groups, and there was no effect of eye movements or attentional breathing on memory emotionality. A modified Brinley plot (displayed in Figure E7, Appendix E) further demonstrates no effect of the tasks on memory emotionality.

Post-hoc Bayes factor analyses (with a default Cauchy prior of .707 on effect size on the alternative hypothesis) compared the relative evidence in favour of the null or alternative hypotheses. The between-group comparison for eye movements and recall-only resulted in a BF_{01}= 5.06, which was not in line with the predicted effect. The BF revealed that the observed data are 5.06 times more likely under the null hypothesis which predicts the absence of an effect of eye movements on memory emotionality than under the alternative hypothesis that predicts the presence of an effect. According to Jeffreys (1961), this is moderate evidence in favour of H_0. However, a ROPE analysis with a 95% HDI (0.00, 1.03) found that only some of the 95% most credible effect sizes were practically equivalent to zero effect, therefore there is insufficient evidence to accept or reject H_0.

The between-group comparison for attentional breathing and recall-only obtained a BF_{01}= 4.91, which was also not in the expected direction. The BF indicates that the observed data are 4.91 times more likely under the null hypothesis which predicts the absence of an effect of attentional breathing on memory emotionality than under the alternative hypothesis. This is interpreted as moderate evidence in favour of H_0. However, a ROPE analysis with a 95% HDI (-0.03, 0.74) found that only some of the 95% most credible effect sizes were practically equivalent to zero effect, therefore there is insufficient evidence to accept or reject H_0.

Lastly, the between-group comparison for eye movements and attentional breathing obtained a BF_{01}= 5.21, revealing that the observed data are 5.21 times more likely under the null hypothesis which predicts no difference between groups in their effects on memory emotionality than under the alternative hypothesis. This is in the expected direction and can be interpreted as moderate evidence in favour of H_0. However, a ROPE analysis with a 95% HDI (-0.28, 0.27) found that only some of the 95% most credible effect sizes were practically equivalent to zero effect, therefore there is insufficient evidence to accept or reject H_0.

Findings indicated that performing eye movements, attentional breathing, or the recall-only control task did not differentially affect change in memory emotionality from pre- to post- intervention, thus there was insufficient evidence to support the second hypothesis.

Moderating effect of working memory capacity. Under the second hypothesis, I also predicted that working memory capacity would moderate the effect of the conditions on change in memory emotionality from pre- to post- intervention. Specifically, I hypothesised that there would be a negative correlation between working memory capacity and change in ratings of memory emotionality, and this relationship would be stronger for the eye movement and attentional breathing groups than for the recall-only control group (H_1). H_0 predicted that working memory capacity would not moderate the effect of eye movements and attentional breathing on memory emotionality ratings.

Multiple linear regression examined the moderating effect of working memory capacity on the relationship between condition and change in memory emotionality from pre- to post- intervention. Table 4 presents the main effects and interaction effects on change in memory emotionality for working memory capacity, attentional breathing, and eye movements. Pre-intervention memory emotionality ratings were included in the model to control for any effect the initial ratings had on the change in memory emotionality from pre- to post- intervention.

The main effect for pre-intervention memory emotionality shows that, when controlling for condition and working memory capacity, pre-intervention memory emotionality ratings significantly predicted a very small increase in how much memory emotionality changed from pre- to post- intervention. This means that higher pre-intervention emotionality ratings predicted a greater reduction in memory emotionality over time than lower pre-intervention emotionality ratings.

Table 4

Unstandardized (B) and Standardized (β) Coefficients for the Moderating Effect of Working Memory Capacity on the Relationship Between Condition and Change in Memory Emotionality

Model		*B*	SE *B*	β	t	*p*	95% CI for *B* [LL, UL]
1	(Intercept)	-0.83	0.70		-1.17	.24	[-2.23, 0.58]
	Pre-test emotionality	0.12	0.06	0.22	2.06	0.04	[0.00, 0.23]
	Working memory capacity	0.01	0.01	0.07	0.46	.65	[-0.02, 0.03]
	Attentional breathing	0.56	0.98	0.22	0.57	.57	[-1.39, 2.51]
	Eye movements	-0.06	1.03	-0.02	-0.06	.95	[-2.12, 1.99]
	Working memory capacity * Attentional breathing	-0.03	0.02	-0.50	-1.25	.22	[-0.07, 0.02]
	Working memory capacity * Eye movements	-0.01	0.02	-0.25	-0.60	.55	[-0.06, 0.03]

Note. Attentional breathing dummy coded: 0=control, 1=attentional breathing. Eye movements dummy coded: 0=control, 1=eye movements.
B= unstandardized regression coefficient; SE *B*= Standard error of unstandardized coefficient; β= standardized regression coefficient; LL= lower limit; UL= upper limit.

The main effect of working memory capacity shows that, when condition and pre-intervention emotionality ratings were held constant, working memory capacity did not significantly predict how much memory emotionality changed from pre- to post-intervention. No significant interaction was found between working memory capacity and attentional breathing, indicating that working memory capacity did not attenuate the effect of attentional breathing on memory emotionality. Results were similar for the interaction between working memory capacity and eye movements, which found that working memory capacity did not attenuate the effect of eye movements on memory emotionality. Therefore, neither the attentional breathing task nor the eye movement task differentially affected memory emotionality based on individual working memory capacity.

The model found an Adjusted R^2=.05, indicating that the model explains only 5% of the variance in the decrease in memory emotionality in the population. An omnibus *F*-test revealed that the model's overall fit was non-significant, $F(6,79)=1.72$, $p=.13$. Overall, findings indicated that working memory capacity did not moderate the effect of eye movements or attentional breathing on reductions in memory emotionality from pre- to post- intervention, therefore there was insufficient evidence to reject H_0.

Recognition test performance. The third hypothesis predicted that recognition test scores would differ between the three experimental groups. Specifically, I predicted that participants in the eye movement group and the attentional breathing group would have lower scores on the recognition test than participants in the recall-only control group (H_1: the distribution of recognition test scores between the three groups is unequal). I also predicted that there would be no difference in recognition test scores for participants in the eye movement group and participants in the attentional breathing group (H_0: the distribution of recognition test scores between the eye movement and attentional breathing groups is equal).

Across all three conditions, accuracy on the recognition test was relatively high, with participants achieving a mean of 85% (*SD*= 10.27%) correct answers. Figure 14 displays the mean correct answers on the recognition test for each group (eye movements, attentional breathing, and recall-only control). The eye movement group (*M*= 12.93, *SD*= 1.44) had slightly more correct answers on the recognition test compared to the attentional breathing group (*M*= 12.74*, SD*= 1.24) and recall-only control group (*M*= 12.47, *SD*= 1.88).

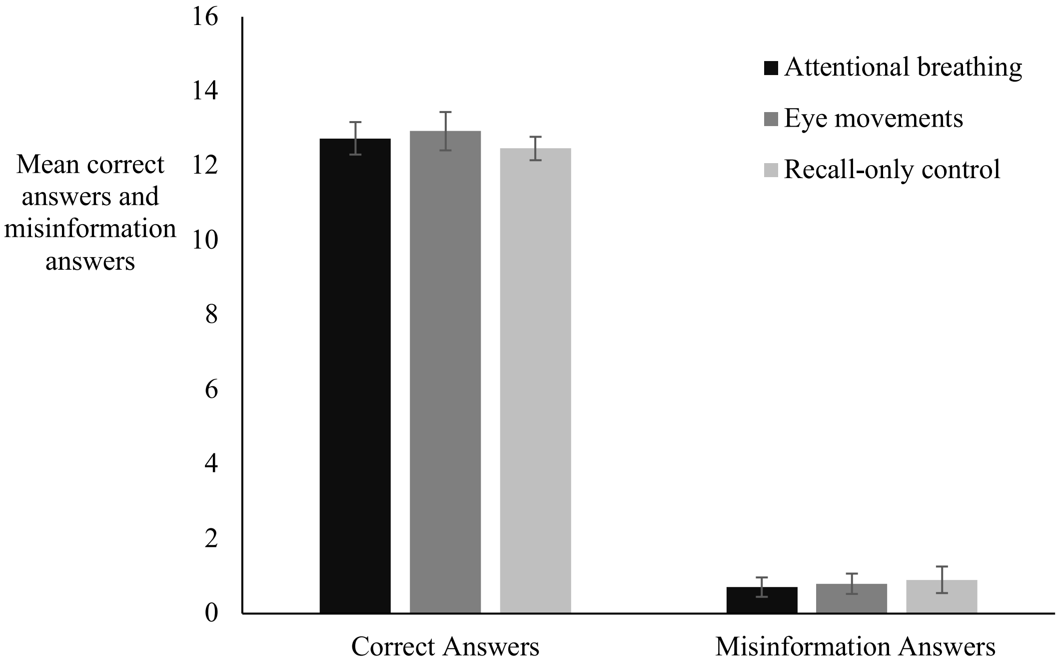

Figure 14. **Means of correct answers and misinformation answers for the attentional breathing group, eye movement group, and control group. Error bars show 95% confidence intervals.**

A one-way ANOVA revealed no statistically significant effect of the conditions on recognition test scores, $F(2,90)= 0.71$, $p=.50$, $\eta^2_p = .02$, indicating that eye movements and attentional breathing did not hinder participants' accuracy on the recognition test in comparison to recall-only.

Post-hoc Bayes factors (with a default Cauchy prior of .707 on effect size) were used to quantify the relative evidence in support of the null or alternative hypotheses. The comparison for eye movements and recall-only revealed a $BF_{01}= 2.35$, which was not in line with the predicted effect. The BF indicates that the observed data are 2.35 times more likely under the null hypothesis which predicts the absence of an effect of eye movements on recognition test scores than under the alternative hypothesis that predicts the presence of an effect. Consistent with Jeffreys (1961) classification system, this is anecdotal evidence in favour of H_0. This was further confirmed by a ROPE analysis with a 95% HDI (-0.40, 0.19), which found that only some of the 95% most credible effect sizes were practically equivalent to zero effect, therefore there is insufficient evidence to accept or reject H_0.

The comparison between attentional breathing and recall-only obtained a BF_{01}= 3.20, which was also not in line with predictions. The BF suggests that the observed data are 3.20 times more likely under the null hypothesis which predicts the absence of an effect of attentional breathing on recognition test scores than under the alternative hypothesis. This is classified as moderate evidence in favour of H_0. However, a ROPE analysis with a 95% HDI (-0.48, 0.18) revealed that only some of the 95% most credible effect sizes were practically equivalent to zero effect, therefore there is insufficient evidence to accept or reject H_0.

Lastly, the comparison between attentional breathing and eye movements found a BF_{01}= 3.37, indicating that the observed data are 3.37 times more likely under the null hypothesis which predicts no difference between groups in effects on recognition test scores than under the alternative hypothesis. This effect is in the expected direction and can be interpreted as moderate evidence in support of H_0. Despite this, a ROPE analysis with a 95% HDI (-0.35, 0.25) suggested that only some of the 95% most credible effect sizes were practically equivalent to zero effect, therefore there is not enough evidence to accept or reject H_0.

Findings indicated that performing eye movements, attentional breathing, or the recall-only control task did not differentially affect participants' scores on the recognition test, thus there was insufficient evidence to support the third hypothesis.

Endorsement of misinformation. The final hypothesis predicted that performing eye movements, attentional breathing, or the recall-only control task would differentially affect endorsement of misinformation. Specifically, I hypothesised that eye movement participants and attentional breathing participants would endorse more misinformation items than control participants (H_1: the distribution of misinformation answers between the three groups is unequal). I also predicted that there would be no difference in the number of misinformation items endorsed by participants in the eye movement and attentional breathing groups (H_0: the distribution of misinformation answers between the eye movement and attentional breathing groups is equal).

Across all three conditions, participants endorsed very few misinformation items (*M*=0.81, *SD*=0.85), suggesting that, overall, participants had low susceptibility to misinformation. Figure 14 (above) also illustrates that there was little difference between the three groups in the number of misinformation answers. While the recall-only control group endorsed the most misinformation items (*M*= 0.91, *SD*= 1.03), this was closely followed by the eye movement group (*M*= 0.80, *SD*= 0.76), and the attentional breathing group (*M*= 0.71, *SD*= 0.74). A one-way ANOVA revealed no statistically significant effect of the conditions on endorsement of misinformation, $F(2,90)= 0.42$, $p=.66$, $\eta^2_p= .01$.

Post-hoc BFs for the comparison between eye movements and recall-only found a $BF_{01}= 3.53$ which was not in the expected direction. The BF indicates that the observed data are 3.53 times more likely under the null hypothesis which predicts the absence of an effect of eye movements on endorsement of misinformation than under the alternative hypothesis. In line with Jeffreys (1961), this is moderate evidence in favour of H_0. However, a ROPE analysis with a 95% HDI (-0.19, 0.39) revealed that only some of the 95% most credible effect sizes were practically equivalent to zero effect, therefore there is insufficient evidence to accept or reject H_0.

The comparison between attentional breathing and recall-only obtained a BF_{01}= 2.83, which was also not in the expected direction. The BF suggests that the observed data are 2.83 times more likely under the null hypothesis which predicts the absence of an effect of attentional breathing on endorsement of misinformation than under the alternative hypothesis. This is interpreted as anecdotal evidence in favour of H_0. This was further confirmed by a ROPE analysis with a 95% HDI (-0.15, 0.46), which indicated that only some of the 95% most credible effect sizes were practically equivalent to zero effect, therefore there is insufficient evidence to accept or reject H_0.

Lastly, the comparison between eye movements and attentional breathing found a BF_{01}= 3.50, indicating that the observed data are 3.50 times more likely under the null hypothesis which predicts no difference between groups in their effects on endorsement of misinformation than under the alternative hypothesis. This effect is in the expected direction and can be interpreted as moderate evidence in favour of H_0. However, a ROPE analysis with a 95% HDI (-0.23, 0.35) revealed that only 95% of the most credible effect sizes were practically equivalent to zero effect, therefore there is insufficient evidence to accept or reject H_0.

Findings indicated that performing eye movements, attentional breathing, or the recall-only control task did not differentially affect endorsement of misinformation, thus there was insufficient evidence to support the fourth hypothesis.

Moderating effect of working memory capacity. Under the fourth hypothesis, I also predicted that working memory capacity would moderate the effect of the conditions on endorsement of misinformation. Specifically, I hypothesised that there would be a negative correlation between working memory capacity and endorsement of misinformation, and this relationship would be stronger for the eye movement and attentional breathing groups than for the recall-only control group (H_1). H_0 predicted that working memory capacity would not moderate the effect of eye movements and attentional breathing on endorsement of misinformation.

Multiple linear regression examined the moderating effect of working memory capacity on the relationship between condition and endorsement of misinformation. Table 5 presents the main effects and interaction effects on endorsement of misinformation for working memory capacity, eye movements, and attentional breathing. The main effect of working memory capacity shows that, when condition was held constant, working memory capacity did not significantly predict the number of misinformation items endorsed. This suggests there is no relationship between working memory capacity and false memories.

Figure 15 illustrates a small negative relationship between working memory capacity and endorsement of misinformation for participants in the attentional breathing group. However, the interaction effect (displayed in Table 5) found that working memory capacity did not significantly attenuate the effect of attentional breathing on endorsement of misinformation. Figure 15 also illustrates that there was no relationship between working memory capacity and endorsement of misinformation for participants in the eye movement group. In line with this, no significant interaction was established between working memory capacity and eye movements. Therefore, neither attentional breathing nor eye movements differentially affected susceptibility to misinformation based on individual working memory capacity.

Table 5

Unstandardized (B) and Standardized (β) Coefficients for the Moderating Effect of Working Memory Capacity on the Relationship Between Condition and Endorsement of Misinformation

Model		*B*	SE *B*	β	t	*p*	95% CI for *B* [LL, UL]
1	(Intercept)	1.03	0.48		2.15	.04	[0.07, 1.98]
	Working memory capacity	-0.00	0.10	-0.04	0.28	.78	[-0.02, 0.02]
	Attentional breathing	0.49	0.80	0.25	0.61	.54	[-1.11, 2.09]
	Eye movements	-0.42	0.85	-0.21	-0.49	.63	[-2.10, 1.27]
	Working memory capacity * Attentional breathing	-0.01	0.02	-0.34	-0.83	.41	[-0.05, 0.02]
	Working memory capacity * Eye movements	0.01	0.02	0.16	0.36	.72	[-0.03, 0.04]

Note. Attentional breathing dummy coded: 0=control, 1=attentional breathing. Eye movements dummy coded: 0=control, 1=eye movements.
B= unstandardized regression coefficient; SE *B*= Standard error of unstandardized coefficient; β= standardized regression coefficient; LL= lower limit; UL= upper limit.

The model found an Adjusted R^2=-.04, suggesting that the model explains only 4% of the variance in endorsement of misinformation in the population. An omnibus *F*-test revealed that the model's overall fit was non-significant, $F(5,80)=0.42$, $p=.83$. Overall, findings indicated that working memory capacity did not moderate the effect of eye movements or attentional breathing on endorsement of misinformation, therefore there was insufficient evidence to reject H_0.

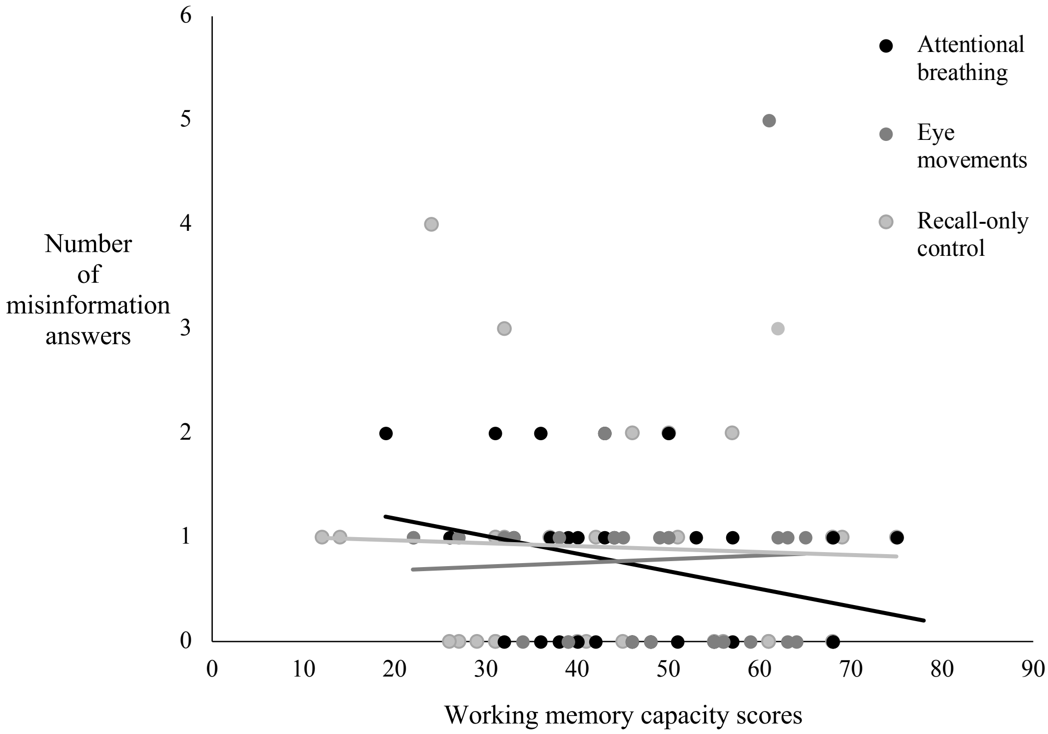

Figure 15. **Scatterplot of the relationship between working memory capacity (OSPAN absolute scores) and the number of misinformation answers for each experimental group.**

Exploratory Data Analyses

Confirmatory analyses failed to find evidence of the effects of eye movements reported by Houben et al. (2018), indicating that eye movements did not have the same effects on memory accuracy and false memories within this sample. In view of these findings, the researcher explored whether there were any differences between samples in terms of performance on the recognition test and misinformation answers by comparing raw data from the Houben et al. (2018) study with data from the current study. These analyses were not outlined in this study's pre-registration and are therefore exploratory rather than confirmatory.

Assumption checks. Visual inspection of boxplots presented in Figure F1 and Figure F2, Appendix F showed that the one-way ANOVA assumption of normality was violated across recognition test scores and misinformation answers, as demonstrated by skewness, and kurtosis below 3. Since the one-way ANOVA is a robust test against the assumption of normality (Blanca et al., 2017), no corrections were made to account for non-normality of the dependent variables in the exploratory analyses.

Levene's test for equality of variances demonstrates that the assumption of homogeneity of variances was met for recognition test scores, $F(3,140)= 1.51$, $p= .21$, and endorsement of misinformation, $F(3,140)= 1.04$, $p= .38$.

Recognition test performance. Confirmatory analyses suggested that eye movements did not impair recognition accuracy. This did not support the finding by Houben et al. (2018); that eye movement participants were less accurate than control participants on the recognition test. The researcher explored whether this may be due to differences between samples in performance on the recognition test.

Means of correct answers are depicted in Figure 16, which shows that accuracy on the recognition test was similar for both studies across the eye movement and control groups. The eye movement group in the Houben et al. (2018) study scored almost equally as high as the eye movement group in the current study, however the control group in the Houben et al. (2018) study were slightly more accurate on the recognition test than any of the groups in the current study. A one-way ANOVA comparing recognition test scores for the eye movement and control groups from the current study and Houben et al.'s (2018) study revealed that there was a significant difference between the studies, $F(3,140)= 4.79$, $p= .003$, $\eta_p^2= .09$.

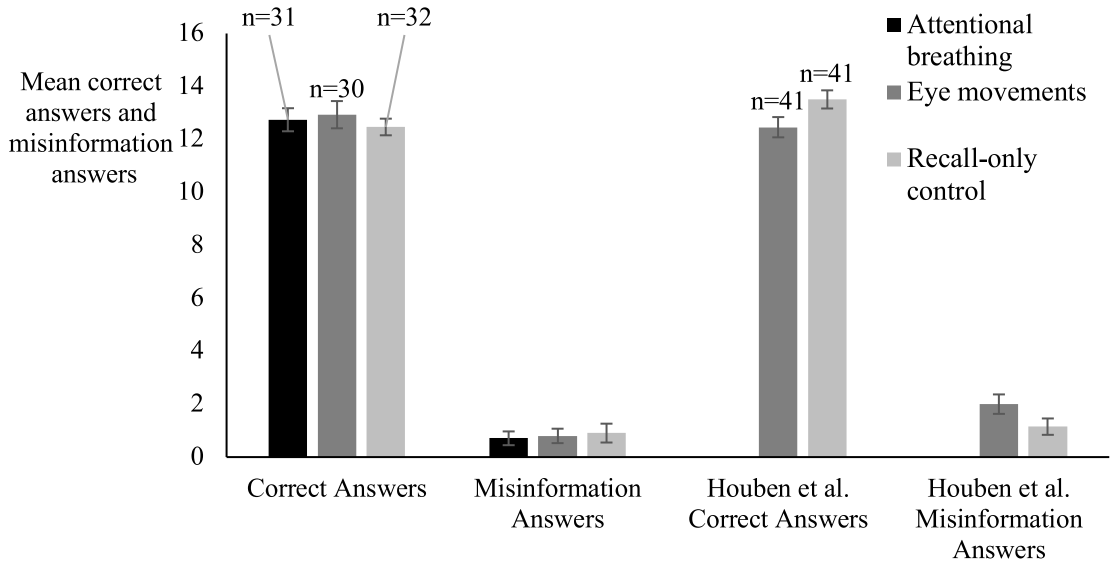

Figure 16. **Comparisons of mean correct answers and mean misinformation answers between the current study and Houben et al. (2018) study. Error bars show 95% confidence intervals.**

Post-hoc analyses using the Tukey post-hoc criterion for significance found that the control group in Houben et al.'s (2018) study (*M*= 13.51, *SD*= 1.12) answered more questions correctly on the recognition test compared to the control group in the present study (*M*= 12.47, *SD*= 1.88, *p*=.01), however Houben et al.'s control group did not significantly differ from the current study's eye movement group (*M*=12.93, *SD*= 1.44, *p*=.33). Accuracy on the recognition test also did not significantly differ between Houben et al.'s (2018) eye movement group (*M*= 12.46, *SD*= 1.25) and the current study's eye movement group (*p*=.52), or control group (*p*=1.00). These findings indicate that the effects on recognition test performance were replicable for the eye movement group, but not for the control group.

Endorsement of misinformation. Confirmatory analyses also revealed that eye movements did not increase endorsement of misinformation. This did not support the finding by Houben et al. (2018); that eye movement participants endorsed more misinformation items than control participants. The researcher explored whether differences in findings may be due to differences between samples in misinformation effects.

Means of misinformation answers are also depicted in Figure 16, which shows that endorsement of misinformation was similar across both studies, with the control group and eye movement groups in Houben et al.'s (2018) study achieving only marginally more misinformation answers than in the present study. A one-way ANOVA comparing misinformation answers for the eye movement and control groups from the current study and Houben et al.'s (2018) study found that there was a significant difference between the studies, $F(3,140)= 10.47$, $p<.001$, $\eta_p^2=.18$.

Post-hoc analyses using the Tukey post-hoc criterion for significance revealed no significant difference in misinformation answers between Houben et al.'s (2018) control group ($M= 1.15$, $SD= 1.01$) and the current study's control group ($M= 0.91$, $SD= 1.03$, $p=.76$), or eye movement group ($M= 0.80$, $SD= 0.76$, $p=.50$). However, participants in Houben et al.'s (2018) eye movement group ($M= 2.00$, $SD= 1.20$) endorsed significantly more misinformation items than participants in the current study's eye movement group ($p<.001$), and control group ($p<.001$). These findings suggest that the effects on endorsement of misinformation were replicable for the control group, but not replicable for the eye movement group. This implies that while the misinformation manipulation triggered false memories for Houben et al. (2018), the misinformation effect was unsuccessful in the current study.

Brief Summary of Results

Confirmatory data analyses revealed no significant effect of eye movements on recognition test performance, endorsement of misinformation, memory vividness, or memory emotionality. As a result, I was unable to replicate the effect reported by Houben et al. (2018). Similarly, no significant effects were found for attentional breathing. Working memory capacity did not moderate the effect of eye movements or attentional breathing on endorsement of misinformation, change in memory vividness, or change in memory emotionality. Thus, hypotheses for the current study were unsupported. Exploratory analyses suggest that non-significant results for memory accuracy and endorsement of misinformation may be the result of a failure to instill the misinformation effect. Implications of these findings are discussed in Chapter 6.

CHAPTER 6

Discussion

This chapter begins by summarising the main findings from this study in relation to the hypotheses outlined in Chapter 3. The theoretical and practical significance of these findings for both EMDR therapy and false memory research are discussed, with particular consideration of results in relation to the existing body of research. Limitations of the current study are acknowledged, along with practical suggestions to resolve the identified issues in future research. Finally, this chapter concludes with reflection on the contributions of the present research to the extant literature.

Summary of Key Findings

Recently, a study by Houben et al. (2018) found that eye movements may increase susceptibility to false memories, highlighting a potential drawback of EMDR as an evidenced-based psychotherapy. Given the implications for therapeutic practices, surprisingly little research has been conducted investigating this issue. The primary purpose of the current study was to investigate the robustness of the effect of eye movements on false memories by conducting a partial replication of the original study by Houben et al. (2018). As part of this replication, the study also aimed to confirm whether eye movements used in EMDR therapy reduce the vividness and emotional intensity of traumatic memories. A secondary aim of the current study was to investigate whether similar effects could be found for an alternative dual-task (i.e., attentional breathing), thereby providing support for the working memory account of eye movements.

Contrary to what was expected, results from this experiment indicated that participants who performed eye movements were no more likely to endorse misinformation than participants who performed attentional breathing or recall-only.

Importantly, results showed that there were very few misinformation answers in each group. This may suggest a failure to instil the misinformation effect, as discussed later in this chapter. As a likely result of failing to instil the misinformation effect, the study found that working memory capacity did not moderate the effect of eye movements or attentional breathing on endorsement of misinformation. Findings also did not support the hypothesised effect for recognition test accuracy, with eye movement participants being no less accurate on the recognition test than attentional breathing participants or recall-only participants.

Also counter to hypotheses, results from this experiment found no effect of eye movements or attentional breathing on ratings of memory vividness and memory emotionality. Furthermore, moderation analyses suggested that working memory capacity did not attenuate the effect of eye movements or attentional breathing on the vividness or emotionality of the traumatic memory.

Taken together, findings from the current study raise important questions regarding the effectiveness of eye movements in EMDR therapy, as well as the appropriateness of the materials used to study false memories in the laboratory. The following sections will discuss the implications of this research for EMDR therapy, WM theory, and the false memory literature.

Implications for EMDR Therapy

The inconclusive findings for each hypothesis dispute the effectiveness of eye movements in EMDR therapy for treating symptoms of post-traumatic stress. Results also cast doubt on the claim made by Houben et al. (2018) that eye movements increase susceptibility to misinformation. This section considers the evidence for and against the effectiveness of EMDR, the Working Memory (WM) account, and the misinformation potential of eye movements, with reflection on possible explanations for the lack of effects observed in this study.

Effects of eye movements on traumatic memories. Following the trauma video, participants' first task in the misinformation experiment was to rate the vividness and emotionality of the video before and after performing the task they were randomly assigned to (i.e., recall-only, eye movements, and attentional breathing). As previously stated, the current study found no evidence that the eye movements and attentional breathing manipulations were effective in reducing memory vividness or emotionality. This contrasts with the vast body of literature that establishes the effectiveness of eye movements in experimental settings (Lee & Cuijpers, 2013; Leer et al., 2014; Onderdonk & van den Hout, 2016).

However, the current study's failure to find significant effects of eye movements on memory emotionality and vividness is somewhat consistent with research by Houben et al. (2018). Similar to the current study, Houben et al. (2018) reported significant reductions in memory vividness for both groups, but no specific effects of eye movements. They also found significant reductions in memory emotionality for both groups, with no additional effects of eye movements. Despite non-significance of effects, Houben et al. (2018) did find larger effect sizes for the eye movement group compared to the control group, indicating potential effectiveness of eye movements that was not replicated in the current study. Taken together, these findings raise an important question about whether eye movements are a necessary component in EMDR therapy for ameliorating symptoms of PTSD.

Null findings from this study may be in line with earlier doubt that has been cast regarding the efficacy of EMDR therapy. Some sceptics argue that EMDR is supported only by pseudoscience; suggesting that the extraordinary claims of EMDR advocates are empirically unsubstantiated (Herbert et al., 2000; Meichenbaum & Lilienfeld, 2018). Such researchers contend that EMDR advocates tend to inflate confirming findings and diminish the validity of disconfirming findings by using multiple ad-hoc hypotheses to explain null results (Herbert et al., 2000). They also accuse EMDR advocates of invoking the *Dodo Bird* conjecture (Rosenzweig, 1936) –the reasoning that all psychotherapies are equally effective– to legitimise the effectiveness of EMDR. These assertions highlight the necessity to remain sceptical when investigating the effectiveness of psychotherapies, as naïve acceptance of therapies can create risks for both clients and the psychotherapy profession (Herbert et al., 2000; Meichenbaum & Lilienfeld, 2018). In consideration of these issues, results from the current study may simply reflect the poor effectiveness of eye movements to reduce memory vividness or emotionality.

Another possible explanation for the failure to find an effect of eye movements on memory vividness and emotionality may be due to divergence in the methods used to elicit eye movements and induce traumatic memories. In the current study, participants engaged in eye movements by visually-tracking a grey dot moving horizontally across a computer monitor over four blocks, each lasting 24 seconds. Previous studies finding an effect on memory emotionality and vividness have implemented a variety of techniques to engage participants in eye movements. Techniques include asking participants to attend to a letter or shape that flashed on alternating sides of a computer monitor (e.g., Andrade et al., 1997; Kemps & Tiggemann, 2007; Lilley et al., 2009), and visually-tracking the experimenter's finger as it moves rapidly across the participants' visual field (e.g., van den Hout, Muris, Salemink, & Kindt, 2001). Studies also differ in the amount of exposure to eye movements; for instance, in their meta-analysis Lee and Cuijpers (2013) noted that eye movements lasted anywhere from 8 to 96 seconds during a single session. Thus, inconsistent results may be a reflection of the varying methods used to instil eye movements in lab-based experiments.

Equally, the current study may have failed to find an effect of eye movements on memory vividness and emotionality due to the technique used to evoke a traumatic memory. In this study, traumatic memories were produced using the trauma film paradigm, where participants viewed a video depicting a violent car accident. Yet, the vast majority of EMDR studies trigger emotional memories by asking participants to recall a distressing event they have personally experienced (e.g., Barrowcliff, Gray, Freeman, & MacCulloch, 2004; Kemps & Tiggemann, 2007; Lilley et al., 2009; Smeets et al., 2012; van den Hout et al., 2011; van den Hout et al., 2001; van Veen, Engelhard, & van den Hout, 2016). There is an important distinction to be made here; while participants in the current study were *indirectly* exposed to a distressing event (trauma film), participants in previous studies recalled memories where they were *directly* exposed to a distressing event (e.g., death of a family member, being seriously injured).

Though the trauma film paradigm has been well-evidenced as a valid tool for inducing PTSD-like symptoms (e.g., fear, distress, avoidance, and negative mood; Holmes et al., 2008; James et al., 2016), it is possible that symptoms induced by viewing a trauma video are subtly, yet qualitatively distinct to symptoms induced by directly experiencing a traumatic event (James et al., 2016). This claim is consistent with Pezdek's (2003) conceptualisation of autobiographical and event memory. According to Pezdek (2003), autobiographical memory is memory for one's personal experience of an event, whereas event memory is memory for the specific events that occurred. Pezdek (2003) proposes that event memories and autobiographical memories are perceived and processed separately, and are therefore distinct entities. In line with this, the type of memory produced through viewing a video may be more consistent with event memory, while memory for direct experiences may be more in line with autobiographical memory. Consequently, the effect of eye movements may only be seen for memories that are inherently autobiographical; akin to the types of memories that are typically of focus in EMDR therapy.

The current study failed to provide evidence of the effectiveness of eye movements for reducing the vividness and emotional intensity of distressing memories. Thus, eye movements did not work in the way expected. Reasons for the failure to replicate the effects reported in the EMDR literature were explained in terms of the methods and materials used. Insignificant results from the present study and evidence from the literature suggest that the use of autobiographical memories for experienced events would be more appropriate for future research on the effectiveness of eye movements.

Working memory theory of EMDR. Inconclusive findings from confirmatory analyses failed to support the WM account of EMDR therapy. According to this account, eye movements affect memory by interrupting processes in working memory that are required for an event to be actively recalled (Andrade et al., 1997; Baddeley, 2012). In line with this, WM theory makes the prediction that any dual-task that sufficiently taxes working memory should reduce the vividness and emotionality of memories. Though evidence from the pilot study determined that both horizontal eye movements and attentional breathing were significantly more taxing than a single-task control, neither task led to significant reductions in memory vividness or emotionality. Since neither task had an effect on memory ratings, it was not possible to determine whether the effects of eye movements and attentional breathing were comparable. These findings failed to replicate the effects of eye movements and attentional breathing reported by van den Hout et al. (2011). Results also diverge from the considerable body of literature establishing support for the WM account (e.g., Andrade et al., 1997; Gunter & Bodner, 2008; Maxfield et al., 2008; van den Hout & Engelhard, 2012; van den Hout et al., 2011).

Is it possible that the lack of effects on memory may be explained by the tasks being too taxing for this sample? Engelhard, van den Hout, and Smeets (2011) and Gunter and Bodner (2008) suggest that a task that is overly taxing might inhibit the ability to simulataneously hold a memory in mind. If the image cannot be maintained in working memory, vividness and emotionality cannot be reduced. This is unlikely because results from the pilot study indicate that the eye movement and attentional breathing tasks were not as taxing as in previous studies (e.g., Onderdonk & van den Hout, 2016; van den Hout et al., 2011), as indicated by slightly faster reaction times. Moreover, participants' average working memory capacity scores in the current study were slightly higher than in previous studies using the OSPAN task (e.g., Leding, 2012; Unsworth et al., 2005). This suggests participants had a high enough working memory capacity to successfully carry out the dual-tasks during memory recall.

Alternatively, it may be that the tasks were not taxing enough to produce effects on memory vividness and emotionality in this sample. Previous investigations have demonstrated that high working memory taxation (using fast eye movements) is superior to lower working memory taxation (using slow eye movements) for reducing memory vividness and emotionality (Maxfield et al., 2008; van Veen et al., 2015). However, results from the pilot study showed that eye movements and attentional breathing both taxed working memory significantly more than a single-task control. These results, in conjunction with the many laboratory studies that have found memory effects with similar eye movement or attentional breathing tasks, refute the possibility that the tasks were insufficiently taxing.

A more likely explanation for the failure to find an effect of working memory taxation is because the present study had an inadequate sample size. It is important to note that while confirmatory analyses failed to find significant effects on memory vividness and emotionality, descriptive data showed a small difference between conditions for memory vividness; where eye movements and attentional breathing more often resulted in reductions in memory vividness than recall-only. Failure to find BFs large enough to support this effect is likely the result of a small sample size. Small samples lack sufficient information to discriminate between the null hypothesis (zero effect) and small-to-moderate effects (Verhagen & Wagenmakers, 2014). As a result, the typical outcome in small samples is an inconclusive result, such as that found in this study. In this way, BFs encounter a similar problem as p-values, as only particularly strong effects can be detected when small samples are used.

Moreover, small sample sizes are unable to provide strong evidence in favour of the null hypothesis, even when the null hypothesis is true (Verhagen & Wagenmakers, 2014). This may mean that, even if the effects of eye movements and attentional breathing were comparable (thereby supporting the WM account), the current study lacked sufficient power to provide strong evidence of this. Therefore, future studies would benefit from using a larger sample size with sufficient power to detect small effects.

In sum, the findings reported in this study were inconclusive as to whether the WM account can explain the effects of eye movements used in EMDR therapy on memory vividness and emotionality. Reasons for the failure to replicate the effects reported in the WM literature were explained in terms of the success of the working memory taxation manipulation and sample size adequacy. Results suggest that further research with larger samples is required to determine whether WM taxation is the mechanim responsible for the therapeutic benefits of eye movements.

Do eye movements increase susceptibility to misinformation? In this study, participants were exposed to misinformation related to the car crash video that they had viewed earlier. As previously stated, the key aim of this research was to examine susceptibility to this misinformation after performing eye movements. Confirmatory analyses found no evidence that eye movements increased susceptibility to misinformation. That is, participants who engaged in eye movements were no more likely to endorse misinformation than participants who engaged in attentional breathing or recall-only.

Despite implementing the same materials and procedures, the present study did not replicate the effects reported by Houben et al. (2018). Exploratory data analyses highlighted the similarities and differences in recognition accuracy and misinformation answers between the present study and Houben et al.'s (2018) study. Although the eye movement groups across both studies were comparable in terms of accuracy on the recognition test, Houben et al.'s (2018) control group were more accurate than the control group in the current study. Moreover, Houben et al.'s (2018) eye movement group endorsed significantly more misinformation items than any of the groups in the current study. While Houben et al. (2018) found evidence of false memories, exploratory results suggest that the misinformation manipulation in the current study was unsuccessful. As a result, the current study cannot make any formal conclusions about whether eye movements or attentional breathing had any impact on susceptibility to misinformation, because the misinformation effect was not present in the first place.

A number of factors may explain the failure to produce misinformation effects in the present study. One possibility is that memory for the car crash video did not become vague enough for the misinformation effect to occur. This is consistent with the tenets of three prominent theories of false memories: associative activation, source monitoring gramework, and fuzzy trace theory. Each of these theories makes the assumption that false memories are more likely to occur when memory for the original event is no longer vivid enough to correctly distinguish between original details and related details (Brainerd & Reyna, 2002; Howe et al., 2009; Johnson et al., 1993). Since reductions in memory vividness were minimal, it is likely that verbatim memory and source monitoring abilities were still intact. Consequently, participants were able to correctly discriminate between original details of the car crash video and misinformation presented in the eyewitness narrative, thereby inhibiting the misinformation effect.

This explanation is also compatible with experiences reported by participants during the post-experiment debrief. Many participants stated that they were aware some information presented in the eyewitness narrative was incorrect, with several participants providing examples of incorrect details (e.g., the man was wearing a blue shirt, not a black jacket). Awareness of misinformation has been found to inhibit the misinformation effect; a meta-analysis by Blank and Launay (2014) suggests that warning participants about misinformation can reduce its effects on memory. Although participants in the present study were not warned about potential misinformation, studies included in the meta-analysis demonstrate that being aware of incorrect details can minimise the misinformation effect.

Two other possible reasons for the failure to instil the misinformation effect and replicate the findings of Houben et al. (2018) are due to inadequate sample size and chance. Limited time and resources restricted the sample size for the current study, meaning that the sample for each experimental group was smaller than in Houben et al.'s (2018) study. Moreover, the difference in susceptibility to misinformation between the eye movement group and control group in Houben et al.'s (2018) study was relatively small, with a difference of approximately one misinformation answer. As mentioned previously, the current study's sample size was likely inadequate for detecting such small differences between groups.

Correspondingly, the failure to replicate could simply be due to chance. According to Matzke et al. (2015), even if the effect exists, a certain number of replication attempts will inevitably be unsuccessful. This is particularly salient to the present research given that this is only the second study (that the researcher is aware of) investigating the effects of eye movements on susceptibility to misinformation. Thus, further research with larger samples is required to eliminate these possibilities and to substantiate the claims made by Houben et al. (2018).

In contrast to the findings of Houben et al. (2018), previous research has suggested that eye movements may *improve* memory accuracy and *inhibit* misinformation/false memory effects (Christman et al., 2003; Parker et al., 2009; Parker & Dagnall, 2007; Parker, Relph, & Dagnall, 2008). These researchers reasoned that bilateral eye movements enhance memory retrieval processes through increasing interhemispheric interaction. In turn, this is thought to augment source monitoring strategies for distinguishing between true details and post-event misinformation (Parker et al., 2009). However, the current study found no evidence to support this claim. This is unsurprising given the difference in research designs. In Parker and colleagues' (2007, 2008, 2009) studies misinformation was introduce *before* performing eye movements, whereas in the current study misinformation was introduced *after* performing eye movements in order to mimic what might occur in EMDR therapy (Houben et al., 2018). Thus, the current study was more concerned with *susceptibility* to misinformation following eye movements, rather than the effects of eye movements after misinformation is introduced.

In light of the present study, it is unclear whether a drawback of EMDR therapy might be increased susceptibility to false memories. No evidence of the misinformation effect was found across any of the experimental groups, indicating possible methodological shortcomings. Null findings for the misinformation effect may also be attributed to insufficient reductions in memory vividness. The following section considers the implications of the materials and procedures used in the current study for producing false memories in the laboratory.

Implications for False Memory Research

The inconclusive findings also bring to the fore the possible impact of materials and procedures used in the misinformation paradigm to produce false memories. Thus, the present study's null findings have significant implications for how false memories are investigated in laboratory experiments. This section reflects on the role of the retention interval in the misinformation paradigm and the appropriateness of the recognition test used in the current study. Results are also considered in terms of the literature investigating the effects of divided attention on false memories.

Retention interval for misinformation. In misinformation studies, the retention interval between original event presentation and exposure to misinformation plays a crucial role in producing false memories. Typically, in studies producing false memory effects, misinformation is delayed until at least a day after the event in question is presented (Loftus, 2005; Monds, Paterson, Kemp, & Bryant, 2013; Paz-Alonso & Goodman, 2008). However, in the current study participants were exposed to the misinformation narrative only minutes after viewing the trauma video. Such a short retention interval may have been a factor in the failure to instil the misinformation effect.

Several studies have investigated the impact of retention intervals on misinformation effects. In particular, research comparing misinformation effects following short (immediately after event presentation) and long retention intervals (one to two weeks after event presentation) has demonstrated increased susceptibility to misinformation after a delay (Frost, Ingraham, & Wilson, 2002; Paz-Alonso & Goodman, 2008). These findings are in line with predictions made by the discrepancy detection principle (Tousignant et al., 1986). This theory predicates that as event memory weakens over time, the ability to detect discrepancies between misinformation and memory for the original event becomes increasingly impaired (Loftus, 2005; Tousignant et al., 1986). According to Frost et al. (2002), this is also consistent with the source monitoring framework; information regarding a memory's source is more likely to be intact soon after encoding, thus the potential for source monitoring errors is minimal following a short retention interval.

It is important to note that, unlike most misinformation studies, the present research aimed to mimic how false memories might be produced in EMDR therapy. As a result, the study attempted to mirror the timeline of an eye movement session in EMDR therapy by replicating the procedures outlined by Houben et al. (2018). However, a longer retention interval may be more ecologically valid (i.e., consistent with real-world applications) in the context of EMDR therapy and post-traumatic stress. This is because, following a traumatic event, it is particularly unlikely that a person will immediately access mental health services. Rather, it is more likely that an individual will undergo EMDR therapy for trauma that occurred at some point in their past—which may be a matter of weeks, months, or even years later. Therefore, increasing the retention interval between event exposure and misinformation may provide a more accurate representation of the time-course involved in EMDR therapy. If misinformation effects are more likely to occur over time, then the potential for false memories in EMDR therapy may be greater than originally anticipated.

Recognition test. The current study also highlights potential flaws in the recognition test used to assess memory accuracy and identify misinformation effects. In the study, memory was tested using a two-alternative forced-choice (2AFC) recognition test, where participants were asked to select one of two possible response options. For five of the recognition questions, the two alternatives were the original and misinformation items, and for the remaining ten questions the two alternatives were the original and foil items.

Although 2AFC tests are commonly used in false memory studies (for example, Loftus et al., 1978; Wyler & Oswald, 2016), this type of memory test is not without criticism. Specifically, 2AFC recognition tests are problematic in that “don’t know” responses are usually unavailable (Paz-Alonso & Goodman, 2008). In the case that a participant does not know the answer to a question, they are instead forced to choose one of two response options based on a guess. McCloskey and Zaragoza (1985) argue that this may produce over-estimation of the extent of misinformation effects in the literature by inflating the rate in which misinformation items are selected. Moreover, in both a forensic and therapeutic context, individuals can respond “don’t know”, which avoids the potential for misinformation effects. To remedy this, Paz-Alonso and Goodman (2008) suggest providing participants with four response options, including the correct item, misinformation item, foil item, and “don’t know”. Future research using these four response options will provide a clearer distinction between misinformation effects and mere guessing.

The mode in which the recognition test is presented may also influence the materialisation of misinformation effects. Previous studies examining the effect of eye movements on false memories have presented the recognition test orally to participants (Houben et al., 2018; Parker et al., 2009). The argument here is that in both forensic and therapeutic contexts, questions regarding one's memory for events are typically asked in-person by an interviewer or therapist. Therefore, oral presentation of recognition questions (by an experimenter or confederate) is thought to increase the ecological validity of such studies.

However, studies using oral recognition tests are exposed to the effects of experimenter bias and participant compliance (McCloskey & Zaragoza, 1985; Paz-Alonso & Goodman, 2008). The influence of experimenter expectations on participant behaviour has been well-documented in psychological research (Doyen, Klein, Pichon, & Cleeremans, 2012). It is suggested that subtle inadvertent cues provided by the experimenter (or confederates of the experimenter) can cause participants to behave in accordance with the experimenter's expectations. Relatedly, McCloskey and Zaragoza (1985) argue that reporting of misinformation may be inflated by social-demand characteristics, whereby participants comply with misleading suggestions provided by the experimenter. To control for such effects in the current study, the recognition test was presented via computer without the presence of the experimenter. As a result, participants were not subjected to the same biases that might have contributed to false memory reporting in the original study (Houben et al., 2018), thus increasing the current study's methodological rigour.

Divided attention and false memories. Lastly, findings from the current study also have implications for the literature investigating the effects of divided attention on memory. As outlined in Chapter 1, numerous studies have established that dividing attention during encoding or retrieval can result in memory impairment and increased incidence of false memories (Hicks & Marsh, 2000; Knott & Dewhurst, 2007; Otgaar et al., 2012; Skinner & Fernandes, 2008), including increased misinformation effects (Lane, 2006; Zaragoza & Lane, 1998). On the contrary, the current study found that dividing attention during memory recall with an eye movement or attentional breathing task did not increase endorsement of misinformation.

In hindsight, it is not surprising that findings diverged from previous research. Typically, in these studies, attention is divided during encoding of the event memory or during memory retrieval at test. However, in the current study attention was divided *between* the encoding and test phases— during a separate recall phase. The lack of effects of dual-tasks on endorsement of misinformation and recognition accuracy in the present study may indicate that memory is only affected when attention is divided at encoding or retrieval. Given that this is the first study (that the researcher is currently aware of) to investigate divided attention outside of the encoding and test phases, further research is necessary to substantiate this claim.

In sum, though findings from the present research cannot draw any substantive conclusions about the effects of eye movements on false memories, the present research draws attention to the shortcomings of methods and materials that are used to study false memories in the literature. As such, this study highlights areas for improvements for future misinformation studies, including consideration of longer retention intervals and appropriate response options for the recognition test. Further limitations of this study are discussed in the following section.

Limitations of the Current Study and Future Directions

There is a paucity of research investigating the potential drawbacks of EMDR therapy (Houben et al., 2018; Lilienfeld, 2007). Recently, Houben et al. (2018)

produced the first work showing that eye movements in EMDR therapy can have adverse effects; namely, that eye movements can increase susceptibility to misinformation. However, Lilienfeld (2007) suggests such findings should be interpreted with caution and call for independent replication efforts. The present study addresses this concern. Findings from the present research are of particular importance due to the failure to replicate effects reported by Houben et al. (2018). Moreover, the inability to instil the misinformation effect using the same materials and procedures as Houben et al. (2018) casts doubt upon the validity of this method for investigating false memories. This research is also important due to the failure to find effects of eye movements on memory vividness and emotionality. Such findings contribute to the body of literature that remains sceptical about the efficacy of EMDR therapy and its underlying mechanism of action (e.g., Herbert et al., 2000; Meichenbaum & Lilienfeld, 2018).

Beyond the limitations already described in this chapter (e.g., inadequate retention interval, limited response options on the recognition test, and insufficient sample size to detect small effects), there are several other factors that may impede the generalisability of this study's findings. In particular, caution must be taken in extrapolating the findings of this study to practical applications of EMDR therapy in clinical settings. The present study investigated the effects of eye movements on memory during a single session. Although eye movements are a key component of EMDR therapy, there is more to EMDR than eye movements alone (Shapiro, 2001). Furthermore, EMDR therapy typically involves more than one treatment session, with the number of sessions contingent on the complexity and severity of psychological distress (Shapiro & Solomon, 2017). Despite these arguments, experimental research on eye movements contributes significantly to our understanding of the *additional* value of eye movements in EMDR procedures (Lee & Cuijpers, 2013).

Relatedly, this study relied on a sample of university students rather than a clinical sample of trauma patients. Therefore, it is unclear whether results can be generalised beyond this sample to people with symptoms of post-traumatic stress. According to Onderdonk and van den Hout (2016), there is no *a priori* reason to suspect that the effects of eye movements on memory vividness and emotionality would be any different for PTSD patients and healthy individuals. However, the same cannot be said about the potential for false memories. This is a particularly salient issue in light of recent findings by Otgaar, Muris, Howe, and Merckelbach (2017), showing that individuals with PTSD are at increased risk of reporting false memories. Similarly, McNally (2017) suggests the prevalence of false memories in therapy is likely greater than estimated by laboratory experiments due to additional risk factors that are present in many psychotherapy clients, but absent in most research participants. Hence, future research using clinical samples may shed further light on the outcomes of EMDR therapy and the extent of potential misinformation effects in therapeutic contexts.

Also concerning the generalisability of findings is the impact of memory stimuli used to reproduce false memories in lab-based experiments. Some researchers argue that false memories produced in experimental settings may not be analogous to false memories in the real-world (Andrews & Brewin, 2017; Patihis, Frenda, & Loftus, 2018). This idea builds on the argument put forth by Roediger and McDermott (2013), that "memory for laboratory events may be fundamentally different from memory for events of one's life" (p. 20856). Though the issue of whether lab-based experiments should be generalised to real-world settings is a valid concern, the ability to investigate false memory effects across a variety of settings provides crucial evidence of the robustness of those effects (Wade et al., 2007).

Another limitation of the current study regards the use of self-report measures for memory vividness and emotionality. Self-report measures are susceptible to demand characteristics, whereby participants may respond in accordance with how they presume the experimenter wants them to respond. In the context of this study, demand effects seem unlikely, especially given that no significant effects were observed. Additionally, eye movement effects have been demonstrated with measures that are less prone to demand effects, such as eyeblink startle responses (Engelhard et al., 2010), and reaction times (van den Hout et al., 2013). However, self-report measures also have the drawback of relying on participants' understanding and interpretation of measurement items. This issue was apparent in the current study, with a number of participants commenting during the post-experiment debrief that they did not understand what 'vividness' referred to on the memory vividness rating scale. Providing clear definitions of concepts (e.g., for emotionality and vividness) would be useful in future studies to minimise ambiguity and improve the reliability of these measures.

Results from the current study also call for further research investigating the effects of attentional breathing on false memories. Although the current study found no evidence of misinformation effects following an attentional breathing task, this was most likely due to methodological issues related to the study's design (as discussed previously). Given the current popularity of mindfulness-based therapies and recent contention in the false memory literature regarding the effects of mindfulness meditation (e.g., Baranski & Was, 2017; Wilson, Mickes, Stolarz-Fantino, Evrard, & Fantino, 2015), additional research with larger samples and improved methods would make a valuable contribution to the understanding of false memories in therapy.

This study's findings, and the above discussion, suggest that further research is required to elucidate the effects of eye movements on susceptibility to misinformation. Future research should replicate this study with larger samples, clinical populations, and more rigorous experimental methods (i.e., longer retention intervals in the misinformation paradigm and appropriate response options on the recognition test). Other studies investigating the mechanism underlying eye movements in EMDR therapy should continue comparing eye movements with other therapeutic techniques, using Bayesian estimation to quantify the extent to which effects are similar. Such research will contribute to understanding the strengths and weaknesses of EMDR as an evidenced-based therapy and draw further attention to the issue of false memories in therapeutic settings.

Concluding Comments

The current study was not successful in replicating the effects reported by Houben et al. (2018) that suggest eye movements in EMDR therapy increase susceptibility to misinformation. Likewise, the study found no evidence to support that eye movements reduce the vividness and emotional intensity of a traumatic memory, which meant the working memory account of EMDR was also unsupported. Lastly, no moderating effects of working memory capacity were found for any of the dependent variables. The failure to instil misinformation effects— despite using the same materials and procedures as Houben et al. (2018)— raises concerns about the validity of this particular method for producing false memories in the misinformation paradigm. Furthermore, evidence from the study questions the added benefits of eye movements to EMDR therapy. The present study ultimately highlights the need for further research with larger samples and improved methodological rigour to advance our understanding of the possible drawbacks of EMDR therapy.

This study provides an important contribution to the EMDR literature, as it is only the second study investigating the potential harmful effects of EMDR therapy. The present research, alongside the work of Houben et al. (2018), develops the foundations for future follow-up studies. As noted by Houben et al. (2018), given recent links between PTSD and false memories (Otgaar et al., 2017) and research demonstrating poor understanding of memory processes by many therapists (Patihis et al., 2014), additional research considering the effects of therapeutic techniques on false memories is imperative. The limitations of the current study highlight areas for improvement in future work— both within EMDR studies and false memory research. This includes the need for research with longer retention intervals in the misinformation paradigm to better reflect the time-course of EMDR therapy and misinformation effects in forensic eyewitness settings.

Findings from this research have demonstrated the importance of conducting replication studies in psychology. Pre-registered replications, such as the current study, support open-science practices that help to combat the file-drawer effect (Rosenthal, 1979); the tendency to only publish findings that support the researcher's hypotheses. Null results from the current study cast some doubt on the findings of Houben et al. (2018), however it is clear that further work needs to be conducted to resolve the methodological shortcomings in the extant research.

The consequences of false memories are pervasive; from false accusations to the psychological distress that ensues for the rememberer. In light of these implications, it is surprising that such little research has been carried out in this particular area. Understanding the factors that may (or may not) contribute to the occurrence of false memories in therapy assists in developing the necessary procedures to minimise this risk in future practice.

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Appendices

Appendix A

Instructions for the Attentional Breathing Practice Task

In this task, it is important you take a relaxed posture with your back straight, but not stiff, letting your body express a sense of being present and awake.

You will need to focus your eyes on the words "breathe mindfully" that will be presented in the middle of the screen. The first step is to be aware of what is going on with you right now. Become aware of what is going through your mind- what thoughts are around? As best as you can, just note the thoughts as mental events. Also note the feelings that are around at the moment. In particular, turn toward any sense of discomfort or unpleasant feelings. Rather than try to push them away or shut them out, just acknowledge them.

The next step is to collect your awareness by focusing on the movements of the breath. Now you will focus attention on the movements of your abdomen with the rise and fall of each breath. Just bring your awareness to the pattern of movement as you breathe in and out.

Appendix B

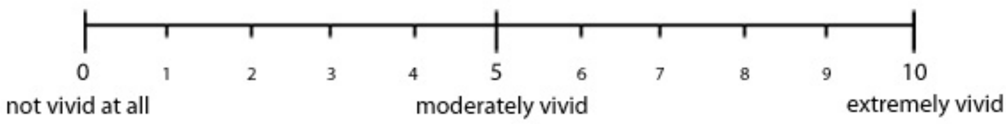
Rating Scales for Memory Emotionality and Vividness

Next, you will be asked to indicate how you feel about the video you just watched and how vivid the event is for you.

Your response will be indicated on a 10-point scale.

Please indicate how you feel about the observed event.

Please indicate the vividness of the observed event.



Appendix C

Misinformation Manipulation

Next, you will be shown a statement from another eyewitness of the car crash you witnessed earlier. Please read the statement carefully.

When the video started, I saw a small car driving with three girls sitting in it. The girl who was driving was texting with a boy called John. The other girls were chatting with each other.

As the driver did not pay attention to the road, she got into the oncoming traffic and then I saw them crash. The girls screamed and it was shown how they got hurt during the crash. Other cars were involved in the accident and, completely damaged, they ended up at the side of the road. A close up showed the situation in the car, with the girl in the driver's seat being injured, but still alive. She started sobbing when she saw her two friends not responding. The injured girl started screaming. A passing car stopped and a man with a black jacket ran to the wreck while instructing other witnesses to call the police.

The man tried to open the car of the girls but he didn't succeed. Next, a car with sirens arrived and a policeman talked to the girl in the driver's seat. Paramedics arrived and opened the door of another car that was involved in the accident. In this car, I saw a young man who appeared unconscious.

A fire truck arrived and the occupants of the third car involved in the accident were shown. I saw a child calling for her parents to wake up, then I saw the mother who was injured and not responding. There was also a baby in this car that seemed in shock. Subsequently, the fire department opened the door of the car of the three girls by cutting it, while the girl in the driver's seat was still sobbing. Paramedics helped the girl and she received an oxygen mask. Then they salvaged her from the car. Next she was put on a stretcher and I saw a helicopter arriving. The girl was put into the ambulance. The video ended by showing the girl pinching her eyes.

Appendix D

Recognition Test

Next you will be asked a series of questions about what you remember from the video you watched earlier. There will be two possible response options for each question. Please select the answer you think is correct.

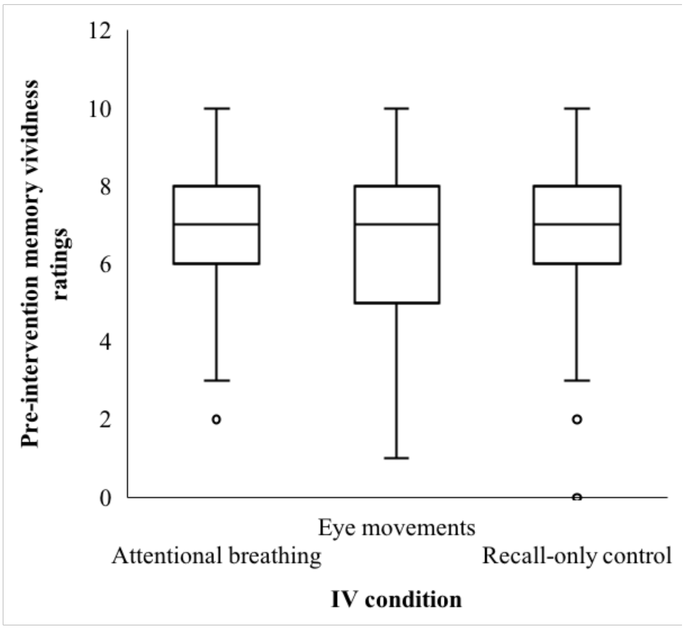
1. What vehicle were the girls driving?
    - o A van
    - o A small car
2. To whom were the girls writing a text message?
    - o John
    - o James
3. What are the girls doing?
    - o Chatting
    - o Drinking alcohol
4. Where does the car end up?
    - o At the side of the road
    - o On the field
5. What was the man who approached the girls' car wearing?
    - o A blue shirt
    - o A black jacket
6. This man reaches the girls' car and asks people to call…
    - o The police
    - o An ambulance
7. Does the man succeed to open the door of the car?
    - o Yes

- No

8. Who talks to the girl in the driver's seat of the car?
    - The police
    - A female witness
9. Who drove the car the paramedics open first?
    - A young man
    - An old man
10. Who is shown injured in the car of the family?
    - The mother
    - The father
11. How is the baby reacting?
    - It is in shock
    - It is crying
12. How does the fire department access the car?
    - Break the glass of the window
    - Cut open the door
13. What does the injured girl sitting in the driver's seat receive?
    - A neck brace
    - An oxygen mask
14. Where do they carry the girl?
    - To the helicopter
    - To the ambulance
15. How does the video end?
    - With the girl pinching her eyes
    - With the girls screaming

Appendix E

Confirmatory Analysis Data



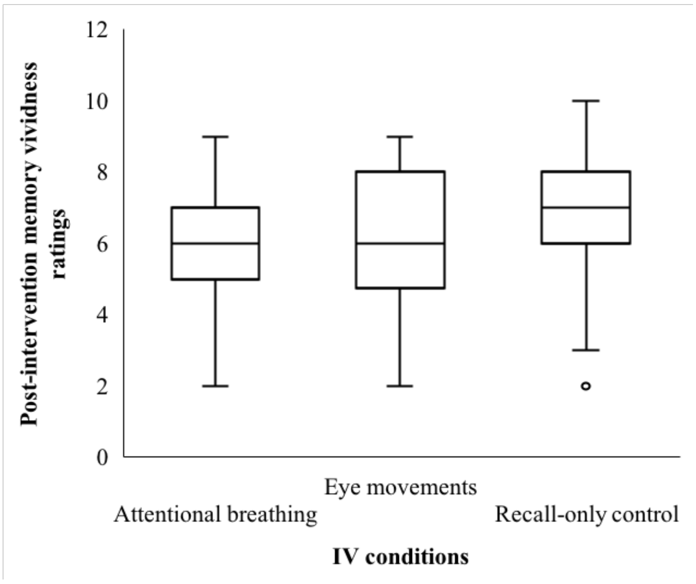
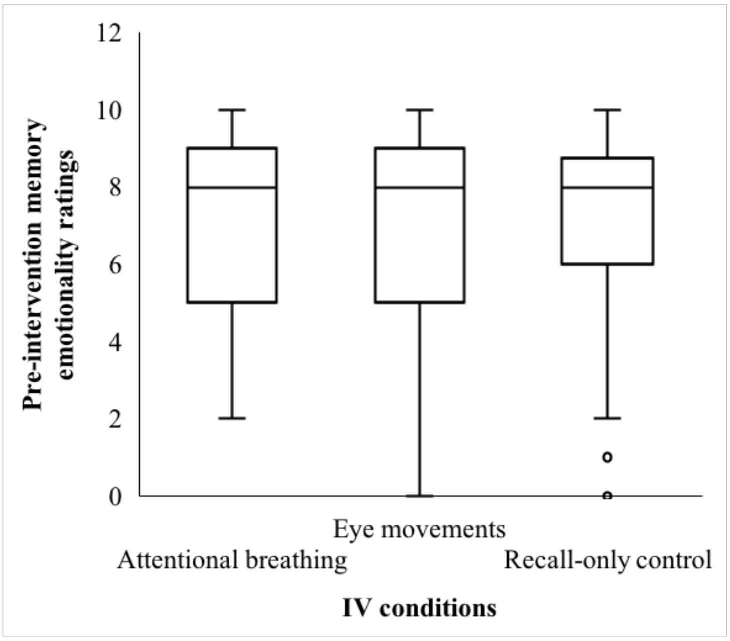


Figure E1. **Boxplots for the pre- (top) and post- (bottom) intervention memory vividness rating scales in each condition.**



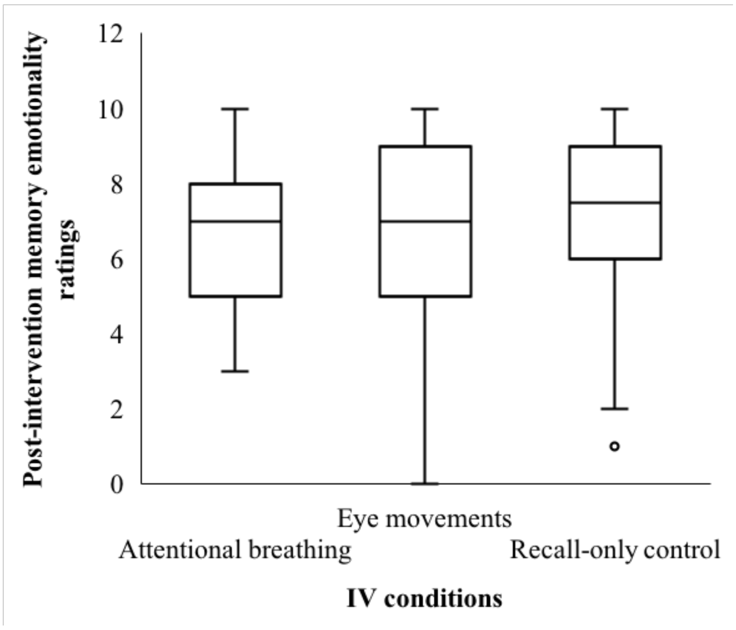


***Figure E2*. Boxplots for the pre- (top) and post- (bottom) intervention memory emotionality rating scales in each condition.**

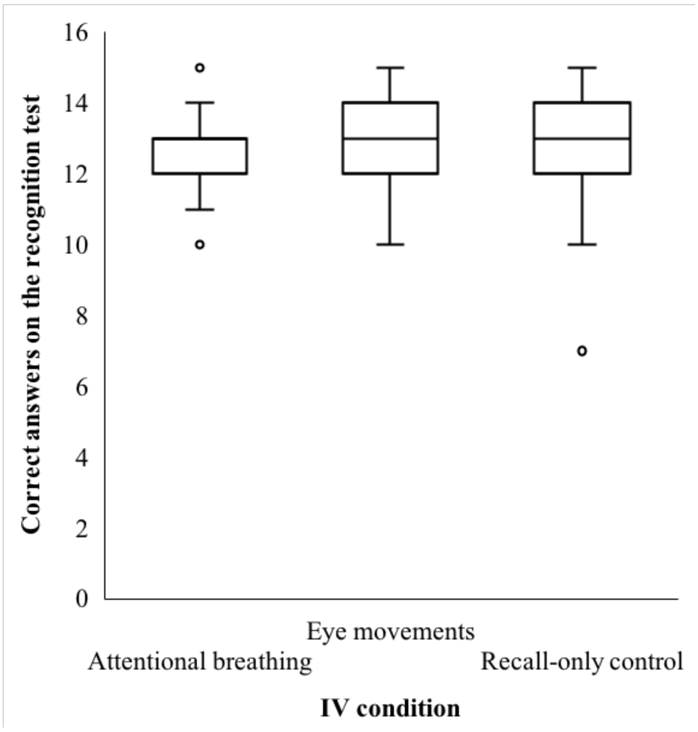


***Figure E3*. Boxplots for recognition test accuracy in each condition.**

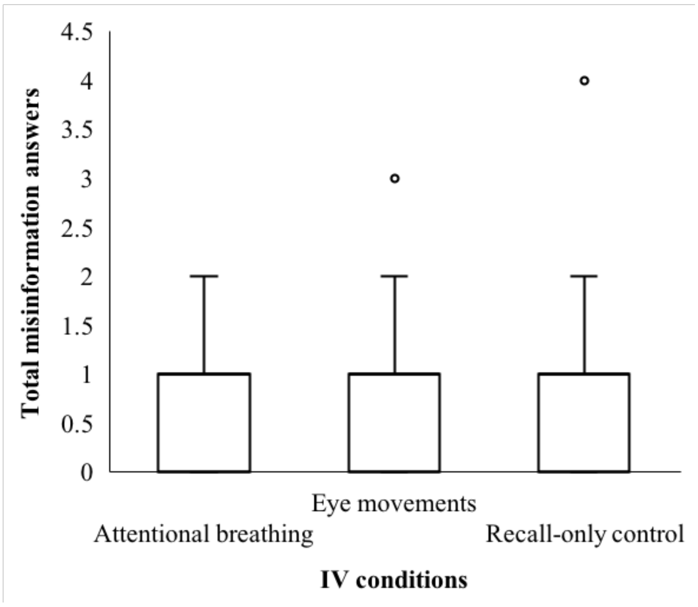


***Figure E4.* Boxplots for misinformation answers in each condition.**

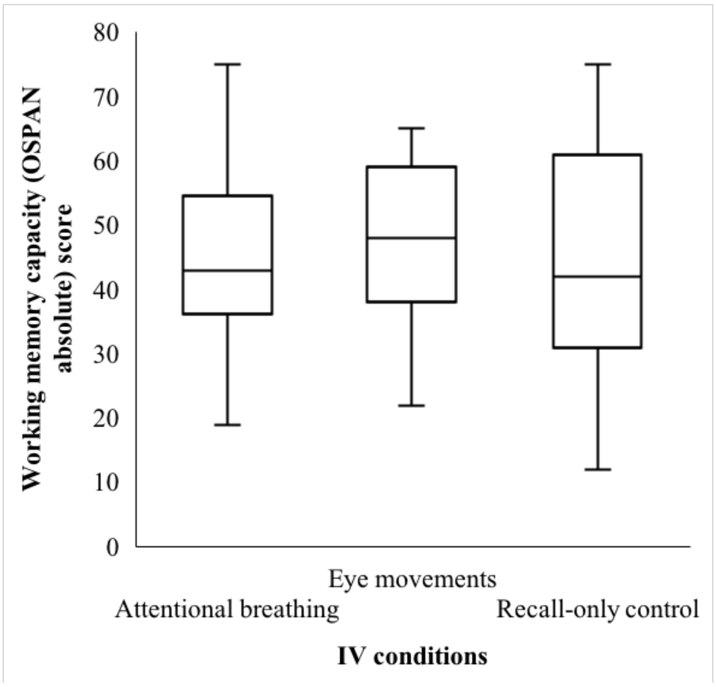


***Figure E5*. Boxplots for working memory capacity absolute scores on the OSPAN in each condition.**

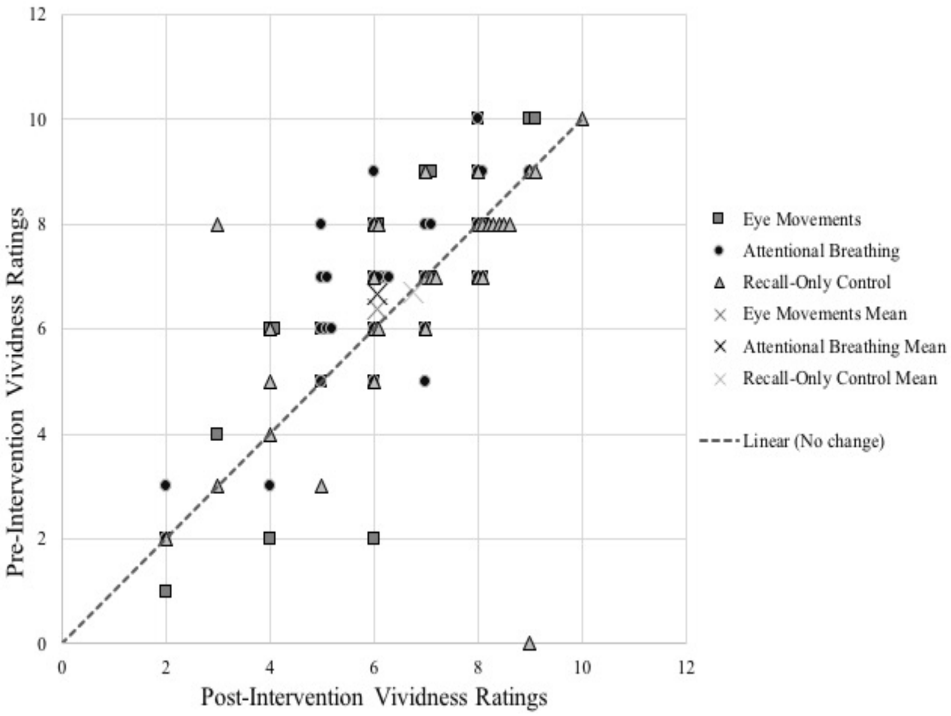


Figure E6. **Modified Brinley plot showing change in memory vividness ratings from pre-intervention to post-intervention in each experimental group. The diagonal line is the line of no change. Data points above the line indicate a decrease in memory vividness and data points below the line indicate an increase. Each data point represents an individual participant. Group means for pre/post memory vividness are also displayed.**

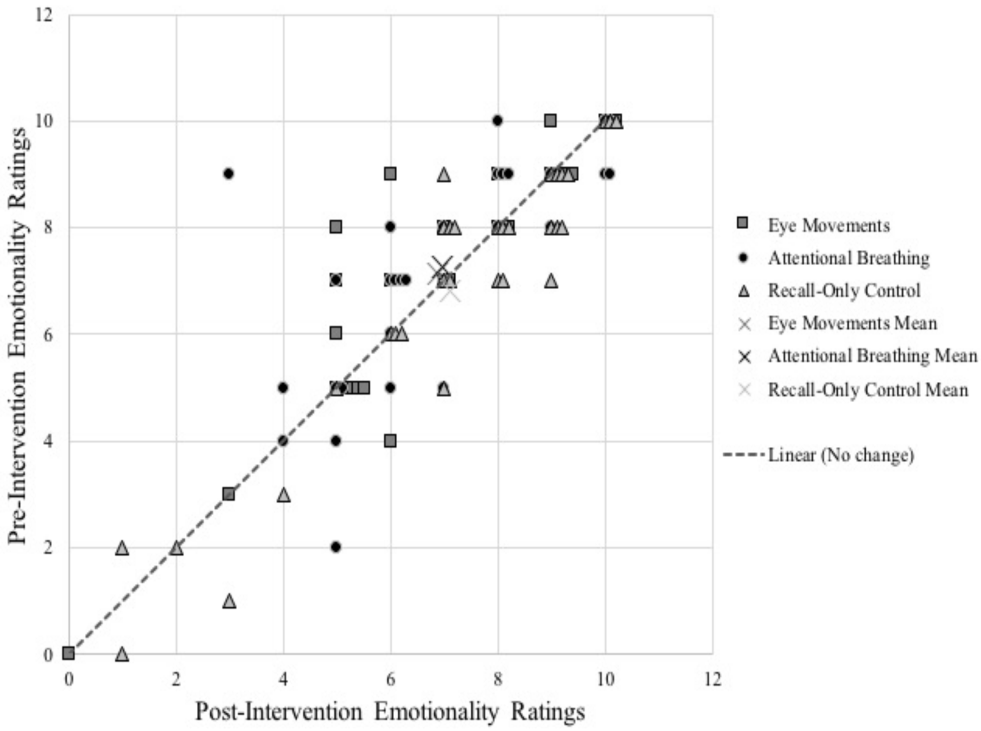


Figure E7. **Modified Brinley plot showing change in memory emotionality ratings from pre-intervention to post-intervention in each experimental group. The diagonal line is the line of no change. Data points above the line indicate a decrease in emotionality and points below the line indicate an increase. Each data point represents an individual participant. Group means for pre/post memory vividness are also displayed.**

Appendix F

Exploratory Analysis Data

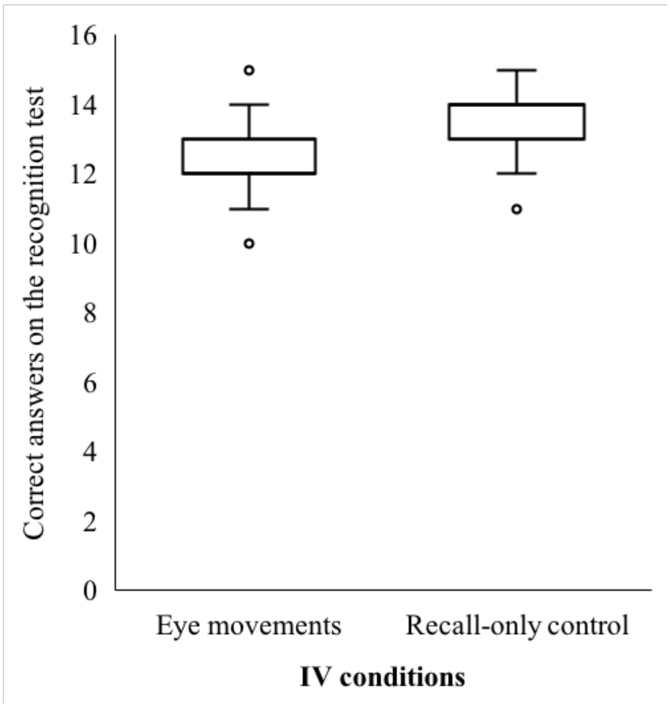


Figure F1. **Boxplots for recognition test accuracy in Houben et al.'s (2018) study for the eye movement and control conditions.**

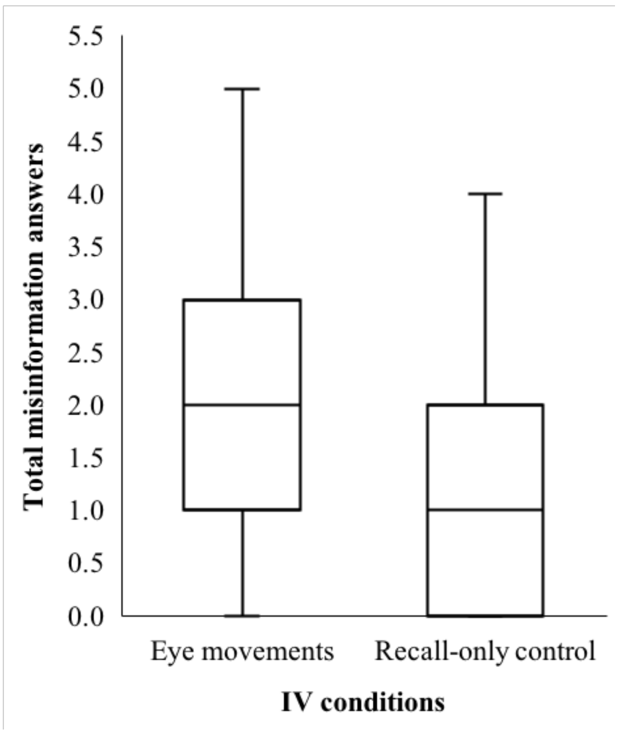


Figure F2. **Boxplots for total misinformation answers in Houben et al.'s (2018) study for the eye movement and control conditions.**