The Role of Eye-Movements in Eye-Movement Desensitization and Reprocessing: Eye-Movements Lower the Number of Intrusive Thoughts of Negative Memories

by

Gauranga Jeram Patel

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Abstract

Eye-Movement Desensitization and Reprocessing (EMDR) was developed as a treatment for Post-Traumatic Stress Disorder (PTSD), and involves the patient thinking about a traumatic event while simultaneously moving their eyes from side to side. Despite substantial support for the efficacy of EMDR questions remain regarding how eye-movements contribute to therapy. One explanation is that eye-movements tax a part of working memory known as the central executive; however, the exact mechanism involved is still unclear. Previous eye-movement research has focussed on self-ratings of vividness and emotionality of negative memories as the primary outcome measures. The focus of the current research was to examine the effect of eye-movements on the suppression of negative autobiographical memories in addition to vividness and emotionality. Non-clinical participants were asked to recall negative autobiographical memories and then verbally reported ratings of vividness and emotionality. In the eye-movement conditions, which varied by speed and direction of movement, eye-movements were stimulated using dots on a computer screen. Participants were then asked to avoid thinking of their memories, and intrusive thoughts were measured by pressing a computer key. Six experiments found that, overall, the effect of eye-movements on self-ratings was inconsistent, but that eye-movements reliably improved suppression of negative autobiographical memories. The findings also support the central executive explanation for the effectiveness of eye-movements in EMDR.

Acknowledgements

I enjoy infuriating people by using the metaphor of climbing a mountain in as many different situations as is reasonable or, they would likely say, unreasonable. So it would be out of character to not do so when acknowledging the many brilliant people who have enabled me to conquer Mount Thesis and get back home safely.

When climbing a mountain it pays to have a good guide. This person should be knowledgeable, skilled, passionate, and have the personality and humour to ease the burden. They should let you find your own way when leading the route, but be ready with guidance. In my supervisor, Assoc. Prof. John McDowall, I found the perfect guide for this adventure. Thank you.

A climber also needs equipment and tools in order to survive and succeed. In the climbing of Mount Thesis my family provided me with the inquisitiveness to ask the questions, the stubbornness to answer them, and the confidence to know I could. These are some of the many tools that I was gifted by my family, and which I relied upon to survive. Thank you.

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Chapter 1

Post-Traumatic Stress Disorder

Experience of Trauma in the Community

Our lives are full of important events that can lead to significant change and become treasured memories. Such positive events may include leaving home for university, travelling to other countries, or the birth of a child. However, we also experience negative events that can be very traumatic, such as being the victim of crime, involvement in a natural disaster, or the sudden death of a loved one. Although the initial response to a negative event can be incredibly intense and upsetting, most people are able to recover and continue with their lives without long-term impediments. For a small number of people though, the memories of negative events can have long-term impacts on their lives.

In the U.S.A., research shows that approximately 61% of males and 51% of females have experienced at least one traumatic event (Kessler, Sonnega, Bromet, Hughes, & Nelson, 1995). Such events include being the victim of a physical attack, being threatened with a weapon, involvement in a natural disaster, or a serious accident. When the definition of a traumatic event is expanded to include things like learning about traumatic events happening to other people or the sudden and unexpected death of a loved one, the prevalence of traumatic events may be as high as 89.6% of the population (Breslau, Davis, Andreski, & Peterson, 1991).

Research from New Zealand shows that approximately 61% of the population has experienced at least one traumatic event (Flett, Kazantzis, Long, MacDonald, & Milar, 2004). Although such research is based on surveys of retrospective memories, we can assume that exposure to traumatic events is relatively common in the general community. Despite the suffering that traumatic events can cause, most people are remarkably resilient and do not develop mental health problems (Ursano et al., 2009). However, for some people debilitating mental health problems can follow exposure to traumatic events.

Clinical Features and Prevalence of Post-Traumatic Stress Disorder

Post-Traumatic Stress Disorder (PTSD) is one such mental health disorder that can follow a traumatic event. The main clinical features of PTSD include re-experiencing, avoidance, arousal, and negative alterations to cognitions and mood symptoms; as described in the Diagnostic and Statistical Manual of Mental Disorders (5th ed.; DSM-5; American Psychiatric Association [APA], 2013). Re-experiencing symptoms can include nightmares and intrusive memories, or ‘flashbacks’ of the traumatic event, that are experienced as occurring in the present and contain distortions in the perception of time, place, and the self (Ehlers, Hackmann, & Michael, 2004). Re-experiencing symptoms can be unintentionally triggered by stimuli with perceptual similarities to those that accompanied the trauma and as such are repetitive, uncontrollable, and distressing (Ehlers et al., 2004).

The avoidance symptoms of PTSD typically take the form of avoidance of stimuli that are similar to the traumatic event (APA, 2013). Such stimuli can include locations or people that remind the person of the event, but can also include the avoidance of thoughts or emotions that are reminiscent of the trauma. The arousal symptoms of PTSD can involve increased startle response and hypervigilance to perceived threats. Negative alterations to cognitions or mood can take the form of negative thoughts, such as “the world is a dangerous place”, and mood changes, such as a persistent negative emotional state. PTSD can be diagnosed one month following a traumatic event, which is typically something involving significant danger to the self or others (APA, 2013).

Returning to the data on prevalence of traumatic events in the community, it becomes obvious that only a minority of people exposed to traumatic events go on to develop mental health problems such as PTSD. For example, Kessler et al. (1995) found that while 61% of males and 51% of females had experienced a traumatic event, only 5% and 10.4% (respectively) may have met criteria for PTSD diagnosis. Lifetime prevalence of PTSD in the general population is approximately 8%, with those in higher risk groups such as survivors of rape or military combat of significantly greater risk (APA, 2013). While PTSD is not the only mental health problem that can be associated with traumatic experiences, it is clear that most people who experience trauma are resilient and do not develop serious mental disorders such as PTSD.

Causes and Consequences of PTSD

Given that only a small proportion of those people who experience a traumatic event go on to develop PTSD, researchers have attempted to investigate what factors lead to the development of the disorder in some but not others. Researchers have found that post-trauma factors are more important in the development of PTSD than pre-trauma factors. For example, Brewin, Andrews, and Valentine (2000) found that while pre-trauma factors such as psychiatric history, childhood abuse, and family psychiatric history had predictive value, factors operating during or after the trauma, such as trauma severity, lack of social support, and additional life stress were much better at predicting PTSD than pre-trauma factors.

Other research has identified seven predictors of PTSD which, in order of effect size from smallest to largest, are: prior trauma, prior adjustment, family history of psychopathology, perceived life threat, perceived support, post-trauma emotions, and post-trauma dissociation (Ozer, Best, Lipsey, & Weiss, 2003). While results from such research indicate that post-trauma factors are important in the development of PTSD, such factors only account for approximately 20% of the variance. Hence, factors unique to the person involved and the traumatic event itself must be the determining factors in who develops PTSD and who does not (Ozer et al., 2003).

Just as there are many contributing factors to PTSD, so there are also numerous negative consequences. Initially it should be noted that the symptoms of PTSD itself can be very damaging to well-being, and indeed must be in order for diagnosis criteria to be met (APA, 2013). For example, avoidance of trauma-related stimuli can result in being unable to attend work or to meet family members or friends. In addition to problems stemming from diagnostic symptoms of PTSD, many other problems are common among persons with PTSD.

PTSD is often comorbid with other mental health disorders. Results from Australian survey-based research shows that up to 85.2% of males and 79.7% of females with PTSD had, within the last 12 months, met criteria for another mental health disorder (Creamer, Burgess, & McFarlane, 2001). Such comorbidity included affective disorders such as depression, various anxiety disorders, and substance abuse disorders. While such research cannot indicate which disorder predated the other, it is consistent with the findings of other research, which indicates PTSD comorbidity is the norm (Creamer et al., 2001).

Research has also investigated the effect of PTSD on well-being, with findings typically highlighting the negative effects of PTSD. One such study compared American veterans of the Vietnam War that had PTSD with those that did not have PTSD, looking at six indicators of wellbeing (bed days from sickness in the last two weeks, employment status, physical health, subjective well-being, physical limitations, and committing severe acts of interpersonal violence within the last year). In this study, veterans with PTSD had significantly worse outcomes on every measure except bed days from sickness (Zatzick et al., 1997).

Psychological Therapy for PTSD

While PTSD can have numerous negative consequences, it is also treatable with psychotherapy. While there are numerous psychotherapies used in practise, versions of cognitive behavioural therapy (CBT) are the most supported by research, as shown by a recent meta-analysis that found more than half of clients who complete therapy showed significant improvements (Bradley, Greene, Russ, Dutra, & Westen, 2005). Similarly, in a meta-analysis of 38 studies, Bisson et al. (2010) found that CBT was more effective than waitlisted control groups or standard care groups. CBT therapies are now considered the ‘gold standard’ in the treatment of PTSD (Forbes et al., 2010).

CBTs for the treatment of PTSD are typically differentiated by their focus on either the exposure or behavioural components versus the cognitive elements of therapy. One therapy focussing on the exposure elements is known as prolonged exposure therapy (Foa, Hembree, & Rothbaum, 2007). The main components of prolonged exposure therapy are imaginal and *in vivo* exposure. During imaginal exposure, clients verbally relate their traumatic experience to the therapist while concentrating on the associated sensations and emotions. In vivo exposure involves revisiting the places, people, or other stimuli associated with the event while concentrating on the safety information provided by the therapist.

Prolonged exposure therapy was developed from learning or conditioning models of PTSD. These models view PTSD as a disorder of extinction, whereby the individuals’ response to the trauma does not diminish naturally over time and the memory is still associated with danger even though the danger has passed (Foa & Kozak, 1986). Hence, the exposure used in the therapy seeks to assist habituation to the trauma memories and stimuli and to incorporate information about safety to decrease associations with danger.

Cognitive processing therapy is another CBT-based treatment for PTSD, however, the emphasis is on the thoughts and emotions associated with trauma rather than the stimuli focus of exposure therapy. Cognitive processing therapy focuses on associated emotions, such as guilt or anger, more global world views, such as that everything is inherently dangerous, and views of the self, such as being useless or incapable. While there is a large component of exposure in the therapy, it is reduced and not as intense as that used in exposure therapy, supposedly making the therapy itself less traumatic for clients (Cukor, Olden, Lee, & Difede, 2010).

Eye-Movement Desensitization and Reprocessing

While CBTs are an effective treatment for PTSD, they are far from being a 'silver bullet' therapy. Indeed, as stated above, CBT therapies result in improvements for approximately 50% of PTSD patients (Bradley et al., 2005), meaning they do not result in improvements for approximately the same percentage of patients. Perhaps in response to this, many other therapies have been proposed as suitable for the treatment of PTSD. Such emerging therapies for PTSD include couple and family therapy, mindfulness, acceptance and commitment therapy, and even the use of virtual reality to assist in reducing avoidance during imaginal exposure (see Cukor, Spitalnick, Difede, Rizzo, & Rothbaum, 2009 for a review of these and other emerging therapies). Eye-Movement Desensitization and Reprocessing, or EMDR, therapy is another alternative to more traditional CBTs and will be expanded upon in the following sections.

Conception and Development

Contrary to popular belief, the therapeutic nature of eye-movements was not discovered while driving or seeing flashes of light. Francine Shapiro, the developer of EMDR therapy, relates that she made the discovery almost by chance (Shapiro, 2001). While walking one day (in 1987), Shapiro noticed that disturbing thoughts were disappearing and changing without any conscious effort. She then paid particular attention to what was happening and noticed that her eyes moved from side to side when a disturbing thought came to mind. Subsequently, she began consciously moving her eyes bilaterally when disturbing thoughts came to mind, and again noticed that the thoughts lost their intensity. Shapiro informally trialled bilateral eye-movements on a large number (approximately 70) of her friends, family, and colleagues before initiating the first controlled study.

In the first published evaluation of Eye-Movement Desensitization (the 'reprocessing' was added at a later date), Shapiro presented a number of case studies and a brief description of the treatment (Shapiro, 1989). In this initial description of the treatment procedure, clients were instructed to visualize the traumatic scene, rehearse the negative cognitions, concentrate on the physical sensations, and visually track the therapist's finger. The finger was moved approximately one foot from side to side at about 2 Hz (2 movements per second) roughly a foot from the clients face between 12 – 24 times in one set. After each set, the client was asked to blank the picture out and take a deep breath before retrieving the traumatic memory again and rating it on the Subjective Units of Distress Scale (SUDS; which is also completed prior to each set).

Clients were asked if the memory was changing in any way after each set, and if new or changed memories were noted then these were also subjected to desensitization before returning to the original memory. Clients were advised to just let whatever happens happen, and report without judging whether it should be happening or not. If new cognitions, emotions, or feelings were positive then the client was encouraged to think about them while another set was completed. When SUDS ratings reached 0 or 1 (normally after just 3 – 15 sets), the client was tested with questions designed to probe the validity of the new cognitions, emotions, or physiological states. Shapiro (1989) then described a case study of a female rape victim whose intrusive thoughts, flashbacks, and nightmares dissipated after just a single 50 minute session. At a three month follow-up session the client reported that her presenting complaints had remained resolved, and continued to rate traumatic memories at 0 on the SUDS scale.

Clinical Process and Use

Since these initial reports the treatment process has changed substantially, leading to a shift toward the integration of a number of clinical orientations. The name change from Eye

Movement Desensitization to Eye Movement Desensitization and Reprocessing (EMDR) reflects this change from a strictly behavioural account to a more integrative information processing paradigm (Shapiro, 2001). For example, rather than just desensitizing traumatic memories using eye-movements, EMDR now incorporates further efforts to identify and establish positive interpretations of traumatic events.

EMDR therapy now involves an 8-phase process that can be repeated numerous times if required (Shapiro, 2001). In the first phase, the clinician takes a thorough client history and plans a treatment protocol. Following this the client is prepared for therapy by being introduced to the EMDR process and expectations for treatment. The third phase involves determining the negative memory that will be the focus of therapy. The fourth phase, desensitization, involves the eye-movement component of the therapy as described above. The fifth phase involves the installation of positive thoughts and emotions to the previously negative memory. The sixth phase of treatment focuses on the associated bodily sensations, with the aim of reducing any residual tension. The final two phases involve debriefing and checking that treatment effects remain and re-evaluating the negative memory. It is important to note that despite the conceptual and structural changes, the eye-movement component has remained largely the same throughout the intervening years.

Shapiro claims that EMDR allows the therapist to assist the client to turn negative memories into adaptive learning experiences:

> For example, when treating the victim of a single rape, the clinician identifies the different aspects of the trauma that are disturbing to the client. These may include intrusive images; negative thoughts or beliefs the client has about herself or her role in the rape; negative emotion such as fear, guilt, or shame and their associated bodily sensations; and conversely, the precise way the client would prefer to think about herself instead…After her clinician has worked with her using the EMDR procedures

> to focus on specific internal responses, the rape victim may be able to recall the rape without feelings of shame or fear…In addition to this positive change in her thoughts and beliefs, she may no longer have intrusive images of the rape (2001, pp. 3).

Hence, EMDR therapy is expected to be successful in any cases where the psychopathology is thought to be caused by negative memories of life events.

Due to its positive effect on memory, EMDR has largely been used in the treatment of Post-Traumatic Stress Disorder (PTSD). EMDR has also been trialled successfully as a treatment for other chronic disorders thought to develop from negative memories, such as medically unexplained symptoms and phantom limb pain (van Rood & de Roos, 2009). Preliminary research also shows that EMDR may be a useful component of therapy for anxiety, couple and family therapy, and traumatised groups particularly where there is a specific historical event that can be targeted (Ricci et al., 2009).

Support for EMDR therapy

While EMDR is a relatively new therapy, it has received a substantial amount of research attention, particularly as a treatment for PTSD. What follows is a brief overview of single studies and meta-analyses evaluating the efficacy of EMDR therapy in the treatment of PTSD. Some studies evaluating EMDR's efficacy have compared measures of symptom severity post-therapy to measures taken pre-therapy, without the use of any comparison or control groups. For example, in a 15-month follow-up study of 66 participants, three 90-minute EMDR sessions resulted in an 84% reduction in PTSD diagnosis and a 68% reduction in PTSD symptoms (Wilson, Becker, & Tinker, 1997). While such results appear promising, research designs that incorporate control groups are necessary to rule out factors such as natural improvement as possible explanations.

Typically, waitlist control groups are used in studies of clinical outcomes. Waitlist control groups are taken from samples of people who have been diagnosed with PTSD but are waiting for their treatment programme to begin. For example, Rothbaum (1997) assigned 21 adult females with PTSD (the participants were rape victims) to either an EMDR therapy or waitlist control group. Participants in the EMDR therapy group were given three 90-minute EMDR sessions; while those on the waitlist did not receive any therapy during the study (for ethical reasons they were given free therapy at the conclusion of the study). Results showed that the EMDR therapy group improved significantly more on measures of PTSD, depression, and anxiety than those in the waitlist control group.

While some studies have used waitlist groups as controls, other studies have incorporated groups given alternative therapies for PTSD in order to see which provide the best results. In a small sample (22 survivors of single-event civilian trauma) study, it was found that EMDR was effective for more of the participants, at three month follow-up, than prolonged exposure (Ironson, Freund, Strauss, & Williams, 2002). A further study found that both prolonged exposure and EMDR significantly reduce symptoms of PTSD in female rape survivors, but that neither therapy produced any advantage when compared with each other (Rothbaum, Astin, & Marsteller, 2005). The efficacy of EMDR in the treatment of PTSD has been supported by the results of many other independent research studies (for example, Lee, Gavriel, Drummond, Richards, & Greenwald, 2002; Power et al., 2002).

The large amount of research into the efficacy of EMDR has allowed the use of meta-analysis techniques. Meta-analysis is a statistical procedure that combines the results of numerous studies, in order to more accurately reflect the effect of the variables measured that are common to all the studies. One meta-analysis report that used results from 34 studies on a variety of populations and measures found that EMDR was more effective than no treatment (waitlist controls) and therapies that are not trauma-focussed (Davidson & Parker, 2001). However, this study also found that EMDR appears to be no more effective than other exposure techniques, such as trauma-focussed CBT.

Many other studies using meta-analysis techniques have also found that EMDR and trauma-focussed CBT are equally effective, and that both treatments are superior to therapies that are not trauma focussed and waitlist controls. For example, meta-analysis comparing EMDR to trauma-focussed CBT found no difference in the efficacy of both treatments (Seidler & Wagner, 2006). While only seven studies were included in the meta-analysis, the results could not conclusively demonstrate the superiority of either treatment.

Another meta-analysis also confirms these results. Following a systematic review and meta-analysis of 38 studies, it was concluded that trauma-focussed CBT and EMDR were equally effective and better than non-trauma-focussed treatments such as stress management, and group therapy (Bisson et al., 2007). The authors suggested that the first line of treatment for traumatised clients should be either EMDR or trauma-focussed CBT. These findings are again supported by yet another meta-analysis of treatment outcome studies (Benish, Imel, & Wampold, 2008). In this meta-analysis only studies that compared two or more 'bona fide' treatments for PTSD were included, resulting in a sample of 15 studies (a large set of criteria, including treatment delivery by a trained therapist, description of the therapy, and other treatment fidelity issues, were used to determine if a treatment was bona fide). The authors concluded that there was no difference in the efficacy of the various treatments, which included versions of trauma-focussed CBT and EMDR.

Criticism of EMDR therapy

The above discussion covered evidence for the efficacy of EMDR as a treatment for PTSD. It is important to note, however, that some research has failed to support the use of EMDR. For example, both Devilly and Spence (1999) and Taylor et al. (2003) found that exposure therapy produced larger reductions in individual symptoms and PTSD diagnosis than EMDR. Additionally, some early review articles (typically dating from the 1990's to early 2000's) have criticised the use of EMDR as a treatment as well as the use of eye-movements in therapy (Lohr, Lilienfield, Tolin, & Herbert, 1999; Muris & Merckelbach, 1999; Herbert et al., 2000). For example, Cahill, Carrigan, and Freuh (1999), state that "there is no convincing evidence that eye-movements significantly contribute to treatment outcome" (p. 6).

Devilly (2002), goes on to claim that distractions, like eye-movements, during therapy may result in treatment benefits dissipating over time since they do not allow for complete imaginal exposure. This criticism is based on direct comparisons between EMDR and more traditional CBTs. Consider that in CBT, particularly during the imaginal components, patients are expected to concentrate as much as possible on their traumatic thoughts. It is thought that this unbroken concentration helps to habituate the traumatic thoughts, emotions, and physiological responses (Foa & Kozak, 1986). Therefore, it is argued that any distracting task, such as eye-movements, will actually reduce habituation to traumatic memories, resulting in treatment being less effective (Devilly, 2002).

Such allegations have been answered by supporters of EMDR who claim that criticism is based on studies that do not correctly utilise EMDR protocols (Perkins & Rouanzoin, 2002). Further to this, Russell (2008), states that resistance to EMDR is "based upon socio-cultural factors and scientific bias versus genuine scientific scepticism" (p. 1737). Socio-cultural factors identified in this article include resistance to EMDR based on professional standing; whereby supporters of EMDR are accused of having insufficient educations or deficient training. Russell (2008) also points out that there have been difficulties dismantling CBT in order to identify the active treatment components, but unlike with EMDR this has not led researchers to question the validity of CBT as a whole.

These contentious and heated discussions have played out in the literature over the past couple of decades with many reviewers supporting EMDR (Schubert & Lee, 2009, for example). Thankfully, as shown in the above section, researchers have also taken to empirically evaluating the efficacy of EMDR as a treatment for PTSD. Due to empirical support for its effectiveness EMDR has been adopted into a number of clinical practice guidelines, including those of the American Psychiatric Association (Forbes et al., 2010). Ongoing research has also investigated whether the eye-movement component of EMDR therapy contributes to therapeutic outcomes.

Do eye-movements contribute to EMDR therapy?

As with the efficacy of EMDR therapy in treating PTSD, the role of eye-movements in therapy has been heavily critiqued, as noted above. Some early research, typically using non-clinical samples, indicated that eye-movements did not contribute to therapy (Dunn, Schwartz, Hatfield, & Wiegele, 1996; Renfrey & Spates, 1994). Devilly, Spence, and Rapee (1998), also found that EMDR with and without eye-movements produced the same results in a sample of military veterans with PTSD. Although such studies led to criticism of EMDR and eye-movements in therapy, the body of research supportive of the use of eye-movements in EMDR has grown.

Arguably the best study to evaluate the contribution of eye-movements to therapy, Lee and Drummond (2008) randomly assigned 48 participants to two conditions: EMDR therapy with eye-movements or EMDR therapy without eye-movements. With this design they could directly study what contributions eye-movements made to therapy. Their results showed that while ratings of distress caused by traumatic memories were reduced after EMDR without eye-movements, distress was reduced significantly more when eye-movements were included during therapy. The result showed that eye-movements are an important component of EMDR therapy and contributed directly to clinical improvements.

Research has also utilised within-subjects designs to evaluate this question. An example of this is a recent study where 18 participants with PTSD selected three images from their traumatic memories to be used in treatment (Lilley, Andrade, Turpin, Sabin-Farrell, &

Holmes, 2009). Each of the three images was assigned to one of three conditions involving concentrating on the memory while either engaging in eye-movements, counting out loud, or doing no simultaneous task. The vividness and emotionality of each of the memories was measured before and after each condition and it was found that these ratings were reduced only after the eye-movement condition. While this study did not use the complete EMDR procedure, it did indicate that eye-movements affect traumatic memories.

In a similar study, one session of EMDR with eye-movements was compared to EMDR with auditory tones and EMDR without any simultaneous task in a sample of 12 PTSD patients (van den Hout et al., 2012). Using a within-group design, the researchers found that eye-movements were superior to recall only and auditory tones at reducing self-ratings of vividness and emotionality of traumatic memories. Interestingly, participants in this study rated auditory tones as more effective than eye-movements; casting doubt on possible criticism that the effectiveness of eye-movements relies on expectancies (van den Hout et al., 2012).

In another recent study, 32 PTSD patients and 32 patients with other mental health disorders completed six minutes of EMDR therapy using disturbing memories (de Jongh, Ernst, Marques, & Hornsveld, 2013). The experiment used a within-group design and each participant completed conditions with eye-movements, auditory tones, and no concurrent task. Results showed that the eye-movement condition lowered self-ratings of emotionality more than the tone and no-task conditions, further supporting the case for the inclusion of eye-movements in therapy (de Jongh et al., 2013).

Research using non-clinical, or analogue, participants (those who do not have symptoms fitting criteria for diagnosis of PTSD) has also found that eye-movements can affect memories of negative or traumatic events. In an early example (Kavanagh, Freese, Andrade, & May, 2001), 18 undergraduate participants were required to select three positive and three negative autobiographical memories and rate the vividness and emotionality of each image on scales from 0 to 10. Participants then completed three experimental conditions; eye-movement, visual noise, and exposure alone with their positive and negative memories. Vividness and emotionality ratings during imaging were lower during eye-movements than in the exposure condition, with visual noise producing intermediate results.

Similar results were found with non-clinical participants by van den Hout, Muris, Salemink, and Kindt (2001). In this study, 30 participants selected positive memories and 30 selected negative memories, rated their vividness and emotionality, and then performed eye-movements, finger tapping (rhythmically tapping two fingers at the same rate as eye-movements), or exposure only (concentrating on memories with no concurrent activity). For negative memories an effect was only found in the eye-movement condition, resulting in lower ratings of vividness and emotionality. A similar pattern occurred for positive memories although the effects were not as large.

Research has shown that EMDR is an effective therapy for PTSD, despite controversy surrounding the eye-movement component of the therapy. Indeed, researchers have shown that the eye-movement component of the therapy plays an important role in ameliorating symptoms of PTSD (Lee & Cuijpers, 2013; Schubert & Lee, 2009). Along with positive results in clinical research, studies using non-clinical participants have shown that eye-movements also affect memories of negative or traumatic events in people not diagnosed with PTSD. Such results support the inclusion of eye-movements in EMDR; however, we now turn our attention to the question of how eye-movements contribute to therapy.

Chapter 2

Neurobiological and Behavioural Explanations

Neurobiology and the Interhemispheric Interaction Explanation

Researchers intent on exploring the neurobiology of the eye-movement component of EMDR typically begin with the assumption that the encoding and retrieval of episodic memories occurs in different parts of the brain. Propper and Christman (2008), use the Hemispheric Encoding/Retrieval Asymmetry model of episodic memory as a starting point. The Hemispheric Encoding/Retrieval Asymmetry model proposes that the left and right hemispheres of the brain have different responsibilities regarding episodic memories. According to this model, the left hemisphere is responsible for the encoding of memories, and the right hemisphere is responsible for the retrieval of memories (Tulving, Kapur, Craik, Moscovitch, & Houle, 1994).

Conclusions from the Hemispheric Encoding/Retrieval Asymmetry model have implications for PTSD treatment, particularly considering that persons with PTSD often have difficulty with episodic memory recall (Ehlers, Hackmann, & Michael, 2004). Specifically, recall of the traumatic memory is often characterised by confusion about the order of events, and difficulty retrieving important details. Persons with PTSD also have difficulty recalling specific information from episodic memories not related to the traumatic event (McNally, Lasko, Macklin, & Pitman, 1995). Therefore, dysfunction in episodic memory recall is a characteristic of PTSD.

Researchers interested in the neurobiology of eye-movements have noted that eye-movements improve episodic memory recall (Christman, Garvey, Propper, & Phaneuf, 2003). This research typically involves participants learning word lists and being tested on recall after a series of experimental conditions such as horizontal-eye-movements, vertical-eye-movements, and no-eye-movements. Results show that recall of the word lists is improved only after the horizontal-eye-movement condition. This research has been replicated using other memory tasks, such as remembering episodic childhood memories and previously recorded journal entries (Propper & Christman, 2008).

To summarise, some researchers believe that episodic memories are encoded and recalled in different regions of the two brain hemispheres. Additionally, research shows that deficits in recall of episodic memories are characteristic of PTSD, and that eye-movements can improve the recall of episodic memories. Proponents of the interhemispheric interaction explanation, therefore, suggest that eye-movements may be beneficial to PTSD treatment by facilitating interaction between the hemispheres and subsequently improving episodic memory recall (Servan-Schreiber, 2000).

Evidence for the effect of horizontal-eye-movements on hemispheric interaction comes from a number of observations. There is evidence that left and right eye-movements activate the contralateral hemisphere (Bakan & Svorad, 1969). Hence, it is assumed that continuous left and right eye-movements will simultaneously activate both hemispheres of the brain. Christman and Garvey (2001) tested this hypothesis by using a free-vision chimeric faces task. In the chimeric faces task, photos of either smiling or neutral faces are cut vertically in half down the middle and mixed to produce faces that are smiling on one side and neutral on the other. Participants are briefly presented with these images and asked to decide whether the face is happy or not, with a preference to either side of the face thought to indicate increased activation of the associated brain hemisphere. Christman and Garvey (2001) found that such activation asymmetries were reduced after horizontal-eye-movements.

It is also claimed that the reduction of asymmetries may facilitate communication between the hemispheres (Propper & Christman, 2008). Some evidence for this is found in research showing that rapid-eye-movement sleep is associated with increased interhemispheric coherence as measured by electroencephalography (EEG: Stickgold, 2002).

It is thought that because the eye-movements found in rapid-eye-movement sleep are predominately horizontal, this suggests that horizontal-eye-movements, as used in EMDR, are associated with increased hemispheric interaction.

Exactly how improving the recall of traumatic memories with eye-movements might help in PTSD therapy has not been addressed directly by research. It is possible that eye-movements may contribute to the reintegration of dissociated aspects of the memories (Servan-Schreiber, 2000). The enhanced integration produced by eye-movements may also assist in the integration of more positive information into traumatic memories, allowing for the intensity of memories to diminish through the therapeutic process (Propper & Christman, 2008). Despite the lack of direct research, the hemispheric interaction hypothesis continues to receive attention.

The interhemispheric interaction hypothesis has received some support in the research literature; however, some studies directly testing its assumptions have not supported it. Gunter and Bodner (2008; Experiment 2) compared vertical- and horizontal-eye-movements, and an eye-fixated control condition while measuring the emotionality and vividness of memories before and after each condition. They reasoned that because vertical-eye-movements do not increase interhemispheric interaction they should not affect negative memories. Their results, however, showed that the emotionality and vividness of memories was reduced after both vertical- and horizontal-eye-movements (Gunter & Bodner, 2008).

Results from research using positive memories are also similar to those of Gunter and Bodner (2008). In this study, non-clinical participants selected three positive memories and then completed a horizontal-eye-movement, vertical-eye-movement, and an eye-fixated control condition with ratings of vividness, pleasantness, and strength taken before and after (Hornsveld et al., 2011). Results showed that the vertical- and horizontal-eye-movements reduced ratings when compared with the eye-fixated condition. Both Gunter and Bodner

(2008) and Hornsveld et al., (2011) concluded that the interhemispheric interaction hypothesis could not fully account for the effect of eye-movements.

A direct test of the interhemispheric explanation, using both memory recall and EEG measures, also failed to concur with proponents of the hypothesis (Samara, Elzinga, Slagter, & Nieuwenhuis, 2011). In this study participants were required to recall previously studied lists of emotional and neutral words after an eye-movement and control condition. EEG activity was also recorded before and after both conditions. Results showed that eye-movements did improve recall of emotional words. However, eye-movements did not alter interhemispheric interaction, and improvements in recall were not related to any changes in interhemispheric interaction.

The results of research suggest that interhemispheric communication does not account for the effectiveness of eye-movements in EMDR therapy. In particular, interhemispheric communication is not responsible for reductions in the self-ratings of memories (Gunter & Bodner, 2008; Hornsveld, et al., 2011). In addition, evidence for eye-movements increasing interhemispheric communication is not conclusive (Samara et al., 2011). While interhemispheric communication may contribute to therapy via some other unidentified process (Gunter & Bodner, 2009), it does not completely account for the effectiveness of eye-movements.

Behaviour and the Orienting Response Explanation

According to the orienting response explanation eye-movements activate an innate and reflexive response that inhibits fear and promotes exploratory behaviour (Denny, 1995). The orienting response, first described by Pavlov (1927), is a behavioural response to novel stimuli in the environment that draws attention to the stimuli in order for a rapid evaluation to occur. The orienting response is thought to consist of two stages. The first stage involves the alerting response to new stimuli, allowing for a rapid evaluation of any danger presented and preparing the organism for a fight or flight response. The second stage occurs if no danger is presented, and no fight or flight response is necessary, and involves reflexive exploration wherein attention and other cognitive processes become more flexible, focused, and efficient (MacCulloch & Feldman, 1996).

The first stage of the orienting response is thought to involve a reduction in breathing rate, pulse, and skin temperature, along with increased skin conductance (Sondergaard & Elofsson, 2008). The first stage is rapid, taking only about 10 seconds for the physiological responses to become significant. Such responses are thought to have arisen from a need to reduce the risk of attracting attention from predators or other dangerous stimuli. If no danger is identified the second stage of the orienting response begins and the physiological responses are relaxed and return to normal. Proponents of the orienting response explanation suggest that the second stage of the orienting response is responsible for the shifts in emotion and cognition that often occur in EMDR therapy (Kuiken, Bears, Miall, & Smith, 2002).

In EMDR therapy it is possible that the novel stimuli of the therapist's finger, which the patient must follow with their eyes, may trigger the orienting response (Kuiken et al., 2002). In the second phase of the orienting response, the rapid habituation to the finger and subsequent relaxation may help to desensitize patients to their trauma memories. Additionally, increased attentional flexibility may help to incorporate new information into memories and allow for exploration of different meanings and interpretations (Sack, Lempa, Steinmetz, Lamprecht, & Hofmann, 2008). Therefore, the orienting response triggered by eye-movements and other stimuli used in the EMDR procedure may help with both the desensitization and reprocessing components of EMDR therapy.

The validity of the orienting response explanation rests on being able to establish whether eye-movements produce physiological responses consistent with those expected from the orienting response research. Namely, eye-movements should rapidly coincide with a reduction in breathing rate, pulse, and skin temperature, along with increased skin conductance. This response should be followed by physiological de-arousal, consistent with the second phase of the orienting reflex. While there has been significant research in this area, results are somewhat conflicting and varied, as will be shown in the brief review to follow.

One early study into the effects of eye-movements on physiological responses did not use negative or traumatic memories; rather, participants were subjected to loud auditory tones (Barrowcliff, Gray, MacCulloch, Freeman, & MacCulloch, 2003). In this study, the tones were presented while the participants had their eyes closed. They were required to open their eyes when they heard the tone and keep their eyes on a dot on a computer screen. The dot was moving from side-to-side in the eye-movement condition and fixed in the middle of the screen in the eye-fixated condition. Results showed lower levels of skin conductance in the eye-movement condition. While this result fits with the relaxing second phase of the orienting response, the authors do not comment on whether there was an immediate increase in skin conductance at the beginning of the task, which would indicate the beginning of the orienting response.

In a follow-up study, Barrowcliff, Gray, Freeman and MacCulloch (2004) found that eye-movements resulted in lower levels of skin conductance while participants were thinking about negative memories. However, skin conductance was not changed for positive memories, despite both positive and negative memories becoming less emotional and vivid after eye-movements. The authors argued that the orienting response would only occur if there was a perceived threat in the environment, such as the negative memory (Barrowcliff et al., 2004). However, this appears to be a departure from the orienting response literature reviewed above, which concurs that any novel stimuli should elicit the orienting response. Additionally, the orienting response explanation cannot explain why subjective ratings of positive memories were reduced following eye-movements despite there being no physiological de-arousal found.

Research measuring physiological correlates of eye-movements has also been conducted in more naturalistic therapy situations and using patients with PTSD. In one such study a number of measures were taken during a single EMDR session: finger temperature, heart rate, skin conductance, expiratory carbon dioxide, and blood oxygen levels (Elofsson, von Scheele, Theorell, & Sondergaard, 2008). Results indicated that eye movements had a number of physiological effects: decreases in heart rate and skin conductance, and increases in finger temperature and breathing frequency. While the observed changes in heart rate concur with an orienting response explanation, the decrease in skin conductance and increases in finger temperature and breathing frequency do not.

A similar study recording physiological correlates in a naturalistic therapy setting found results more in accord with an orienting response explanation. In this study, heart rate, heart rate variability, cardiac sympathetic drive, and breathing rate were measured during multiple EMDR therapy sessions with PTSD patients (Sack, Lempa, Steinmetz, Lamprecht, & Hofmann, 2008). At eye-movement onset a sharp increase in heart rate variability and decrease in heart rate was observed, indicating significant de-arousal. However, as eye-movements continued heart rate variability decreased and respiration rate increased. The authors suggest that the physiological de-arousal at onset of eye-movements is due to the orienting response. Additionally, they argued that the subsequent arousal may have been a stress response triggered by the thoughts of their traumatic memories.

Further observations come from Schubert, Lee, and Drummond (2011), who recorded heart rate, breathing rate, and skin conductance during a single session of EMDR with non-clinical participants. They found that heart rate decreased rapidly at the beginning of eye-movements. As eye-movement sets progressed, skin conductance was reduced and breathing rate and heart rate variability increased. The authors concluded that eye-movements create an orienting response, and this short-term de-arousal may aid in the processing and integration of trauma memories. Pairing negative memories with a relaxation response may also weaken negative appraisal and reduce the automatic avoidance response.

In summary, there does seem to be some support for eye-movements creating an orienting or relaxation response, as found with some physiological measurements. However, conflicting findings, such as increased breathing rate or skin conductance are also typically associated with eye-movements and are not consistent with relaxation (Gunter & Bodner, 2009). Additionally, many of the studies introduced above did not include control groups or conditions making it difficult to draw conclusions regarding any causal relationship between eye-movements and physiological changes. Also, none of the studies mentioned above attempted to look for any relationship between physiological changes and subsequent improvements in memories or PTSD symptomatology. Therefore, while eye-movements may be associated with physiological changes, the profile of these changes is inconsistent and not entirely supportive of an orienting response hypothesis.

Cognition and the Working Memory Explanation

We now move to a discussion of the working memory explanation for the effectiveness of eye-movements. However, before getting to the explanation itself a quick exploration of working memory is required. Following this exploration will be a discussion of the existing research surrounding what part of working memory eye-movements affect.

The Structure of Working Memory

Discussion of the working memory explanation for the effectiveness of eye-movements has used the influential multi-component model of working memory (Baddeley, 1996) as a framework. The multi-component model proposes that working memory consists of an attentional control system of limited capacity, known as the central executive, which is responsible for manipulating information and controlling the two subsystems known as the visuospatial sketchpad and phonological loop. The visuospatial sketchpad is involved in processing visual information, such as shape and colour, and spatial information, such as rotating shapes or remembering a series of locations. The phonological loop is involved in processing verbal and auditory information (Baddeley, 2007; Repovs & Baddeley, 2006).

Considering that the phonological loop is confined to the processing of auditory information, it has been largely ignored by researchers investigating the effect of eye-movements on working memory systems. In contrast, a significant amount of attention has been given to the effects of eye-movements on the visuospatial sketchpad and, to a lesser extent, the central executive. Before moving to a discussion of this research we should first further investigate the roles of both the visuospatial sketchpad and central executive.

Researchers agree that the functions of the visuospatial sketchpad can be further divided into resources for spatial information and visual information (Repovs & Baddeley, 2006). Much of the research in this area uses what are known as double dissociations in order to differentiate between spatial and visual working memory. For example, Klauer and Zhao (2004) used memory for the locations of dots on a computer screen as a measure of spatial resources, and memory for Chinese ideographs (these were completely novel to the participants, who had no experience with written Chinese) as a measure of visual resources. They then used two tasks designed to selectively disrupt either spatial or visual working memory. These disrupting tasks involved either spotting a stationary asterisk in a field of 11 moving asterisks to disrupt spatial memory, or discriminating different colours to disrupt visual memory.

The results of Klauer and Zhao's (2004) research showed that the asterisk task affected memory only for spatial locations, and the colour task disrupted memory only for visual information. It is assumed that if spatial (dot location) and visual (ideograph) working memory use the same resources then both disrupting tasks (asterisks and colours) should equally effect both spatial and visual working memory. Since the spatial task disrupted only spatial working memory and the visual tasks disrupted only visual working memory, this supports the idea that both types of working memory can be differentiated within the visuospatial sketchpad (Repovs & Baddeley, 2006).

Further support for the fractionation of visuospatial working memory comes from research using selective dual task interference techniques (Darling, Della Sala, & Logie, 2007). In this study, participants conducted a delayed recall of the letter P task, whereby they are instructed to remember both the location and the font of a capital letter P presented in varying places on a computer screen. However, before recall of the letter P task, participants completed either a control task (staring at a blank screen), spatial task (complex tapping on a keyboard), or a visual task (dynamic visual noise). Results showed a double dissociation, with the visual task interfering with appearance memory and the spatial task interfering with location memory (Darling et al., 2007).

While research shows that the visuospatial sketchpad can be further fractionated, research also suggests that the central executive plays an important role in both visual and spatial working memory. In one such study participants completed visuospatial short-term memory and working memory span tasks, executive functioning tasks, and a set of tests measuring distinguishable factors of spatial abilities (Miyake, Freidmann, Rettinger ,Shah, & Hegarty, 2001). Factor analysis and structural equation modelling showed that processing and storage in visuospatial working memory and storage in short-term memory implicate central executive functioning.

In a further experiment, which also indicates a role for the central executive in visuospatial processing, participants were required to match and change the angle and colour of semi-circles on a computer screen with reaction time and accuracy as outcome variables

(Mohr & Linden, 2005). While a concurrent phonological task (articulatory suppression) did not interfere with maintenance or manipulation of visuospatial information, a central executive task (random generation) interfered with the manipulation of stimuli but not with maintenance. Results from such research have led to the conclusion that the central executive is closely involved in many different visuospatial tasks (Rudkin, Pearson, & Logie, 2007).

While the central executive has received less research attention than other aspects of working memory, its role is increasingly being investigated. The central executive began as a vague idea, to which was included anything that did not fit clearly into the roles of the visuospatial sketchpad and phonological loop, which were easier to study (Baddeley, 1996). In a broad sense, the central executive is thought of primarily as a central controller responsible for control of the visuospatial sketchpad and phonological loop and also for complex cognitive tasks. In this model the central executive is an attentional control system, responsible for allocating attention to particular subsystems and planning and controlling cognitive processes (Baddeley, 1996).

While explaining the central executive as an attentional control system was useful for early exploration of working memory, it did little to describe specifically what the central executive did and how attention was controlled. Essentially, the central executive remained a dumping ground for any processes that were not clearly controlled by the visuospatial sketchpad or phonological loop (Baddeley, 1996). Now, more attention is being directed at the central executive, since a sound understanding of its roles and capabilities is crucial to any understanding of working memory. As seen above, the central executive is responsible for some roles or processes within visuospatial working memory; the review below will attempt to further describe what those roles may be.

There are three main functions regularly attributed to the central executive; these are mental set shifting, updating and monitoring of information, and inhibition of prepotent responses (Baddeley, 1996). Mental set shifting refers to the process of shifting attention between multiple tasks or operations. Updating and monitoring involves monitoring incoming information to see if it is useful to the task at hand. If incoming information is useful then old information that is no longer relevant must be replaced with the new information or older information must be revised to include the new information. Hence, this process requires the rapid and accurate manipulation of information, rather than simple storage or maintenance. Inhibition refers to the deliberate inhibition of dominant, automatic, or prepotent responses to stimuli.

Researchers have investigated these functions in a number of ways and confirmed them as being central executive tasks. One such study required participants to complete a battery of tests designed to target individual executive functions as well as further tests thought to require more general executive functioning (Miyake et al., 2000). Results from this study found that the three executive functions were moderately correlated with each other but clearly separable. The three functions also contributed differentially to performance on the more general measures of executive functioning.

Further to the work of Miyake et al. (2000), Fisk and Sharp (2004) evaluated the three separable executive processes of updating, shifting, and inhibition. Participants in this study again completed a large number of tests designed to target both specific executive processes and more general executive abilities. A factorial analysis of the tasks was conducted with results largely agreeing with those of Miyake et al. (2000). Essentially, the factors were updating, shifting, and inhibition again, however, a new factor was also found that the authors believed reflected the efficiency of access to long-term memory (Fisk & Sharp, 2004).

More evidence for the varying roles of the central executive comes from neuroimaging research using positron emission tomography while participants conducted a number of tasks designed to specifically require updating, shifting, or inhibition. Results from this research showed that all three processes resulted in activation of some similar and some distinct regions of the prefrontal cortex (Collette et al., 2005). This study again shows that executive functioning is characterised by both unity and diversity of processes.

What Part of Working Memory Do Eye-Movements Affect?

In a series of three experiments, representing an early foray into the field, it was found that eye movements (single eye movement from central fixation to peripheral object and back) interfere with maintenance in spatial (location of X's in a grid of 16 cells) working memory more than visual (sequence of letters in correct order) working memory (Lawrence, Myerson, Oonk, & Abrams, 2001). This study also found that limb movements produced similar effects, suggesting that all spatially directed movements will interfere with spatial working memory maintenance. The authors believe that these results support the hypothesis that spatially directed movements may interrupt a general spatial rehearsal or maintenance mechanism.

Although the previously stated research found equivalent effects for eye and limb movements, subsequent studies have not replicated this finding. A sequence of five studies found that all conditions involving concurrent eye-movement produced significantly greater reduction in spatial span than equivalent limb movement or covert attention shifts (Pearson & Sahraie, 2003). In this study, spatial information was presented sequentially in a computerised version of the Corsi Blocks Task (where participants must remember a sequence of locations), with a retention interval of five seconds when participants completed the manipulations. The manipulations consisted of smooth pursuit and saccadic eye movements, fixated attention shifts, fixated, dynamic visual noise, limb movements, articulatory suppression, free eye movement, and eyes closed conditions. The authors claim that the results show the crucial importance of oculomotor control processes during rehearsal of locations in working memory.

Further research also supports this finding. In a study investigating the effect of eye movements and attention shifts on maintenance of both verbal and spatial working memory it was found that eye movements resulted in greater interference with a visuospatial task than attention shift, which interfered more than fixation, suggesting that eye-movements contribute to interference over and above attention shifts (Lawrence, Myerson, & Abrams, 2004). These results are taken as evidence that the effect of eye movements is localised in the visuospatial sketch pad, rather than the phonological loop or a general maintenance process. These results also clearly indicate that eye movements are crucial to spatial maintenance in working memory, although no clear reason for this is given.

Studies have also demonstrated the effect of smooth pursuit eye movements on spatial working memory, finding interference in encoding when the target stimuli were in a fixed position during eye movements but no interference when the target stimuli moved with the eyes (Kerzel & Ziegler, 2005). This suggests that visuospatial attention is tied to the target during eye-movements, which impairs visuospatial short term memory for the position of peripheral objects.

Following on from interest in the area of eye-movements and working memory, a series of studies completed in the 1970's and 1980's were recently published. While the studies themselves utilised different methodologies and measures, a number of firm conclusions were reached following their integration. Eye-movement control, not simply eye-movements, disrupts working memory for locations but not shapes, and this can be isolated to the storage/maintenance components of working memory (Postle, Idzikowski, Della Sala, Logie, & Baddeley, 2006).

While the effect of eye-movements on the visuospatial sketchpad has been thoroughly researched, comparatively little research has sought to directly evaluate the possible effects on the central executive. It is, however, important to note that the research listed above concurs that eye-movements seem to affect spatial aspects of the visuospatial sketchpad. This is important given that the spatial aspects of visuospatial processing also require central executive resources (Miyake et al., 2001; Mohr & Linden, 2005; Rudkin et al., 2007). Therefore, the central executive must be implicated in research that shows eye-movements affect the spatial aspects of working memory.

In addition to support from studies looking specifically at visuospatial processes, studies have sought to directly test what effect eye-movements have on central executive functioning (van den Hout et al., 2011). Findings showed that eye-movements significantly increased reaction times during central executive tasks when compared to auditory beeps, suggesting that eye-movements directly tax central executive resources. These findings are supported by a second study that also found eye-movements decrease performance on a reaction time task (Altink, van Terwisga, Helms, & Oostenbroek, 2012). In this within-group study, 36 participants were required to press a key as soon as possible after hearing a tone while completing eye-movement, word-tracking task, and no simultaneous task conditions. Again, eye-movements and the word-tracking task (designed to tax central executive processing) slowed reaction times compared to the no task control condition.

Further support for a central executive account comes from studies looking at other tasks that change the subjective ratings of negative memories. It has been shown above that eye-movements performed while holding a negative memory in mind lower ratings of the vividness and emotionality of the negative memories (Kavanagh et al., 2001; van den Hout et al., 2001). However, many other suitably difficult tasks lower the vividness and emotionality of negative memories when concurrently conducted. For example, Isaacs (2004) evaluated the effectiveness of numerical distraction therapy in the treatment of PTSD. Participants with PTSD were required to count backwards by twos while holding their traumatic memories in mind. Twenty-four of the twenty-six participants reported positive changes in the content or vividness of traumatic images and reductions in the intensity of their negative feelings towards them. Similar results have also been found using counting with non-clinical participants using negative memories; resulting in lowered ratings of vividness and emotionality (van den Hout et al., 2010).

Research using auditory tones has also found them to be effective in lessening PTSD symptoms. In one such study participants with PTSD completed three sessions of EMDR therapy with three types of auditory and kinaesthetic stimulation, consisting of tones and vibrations respectively (Servan-Schreiber, Schooler, Dew, Carter, & Bartone, 2006). Results suggest that both auditory tones and kinaesthetic stimulation can reduce ratings of subjective units of distress associated with traumatic memories. However, the methodology of this study is questionable because a control condition involving therapy with no concurrent stimulation could have answered questions about what role the therapy process played in the treatment gains.

In a specific test of whether eye-movements have their effect on memories at the level of the visuospatial sketchpad or the central executive, Gunter and Bodner (2008; Experiment 3) compared auditory shadowing and copying a complex figure. Participants in this study held negative memories in mind while listening to a simple speech recording or while copying the Rey complex figure (an array of complex shapes). Results from both groups showed that both tasks resulted in lowered vividness and emotionality of negative memories.

Results from the studies reviewed above show that many tasks can result in subjective changes to traumatic and negative memories. What is important to note is that these tasks, particularly counting and auditory shadowing, are thought to engage central executive resources, not visuospatial sketchpad resources (Gunter & Bodner, 2008). Many researchers now agree that a central executive account of the effectiveness of eye-movements is the most convincing (Gunter & Bodner, 2008; Koppel, 2009; van den Hout et. al., 2010, van den Hout et al., 2011). It is posited that any distracter task that adequately taxes the central executive will, when conducted while holding a negative memory in mind, lower self-ratings of the emotionality and vividness of that memory. However, exactly how using executive resources alters a negative memory is unexplored (Gunter & Bodner, 2009).

So we may move onto the question of how concurrently loading central executive resources with a negative memory and eye-movements produces changes in the negative memory. Importantly, working memory research up to this point has focussed on how eye-movements affect self-ratings of the vividness and emotionality of memories, with these self-ratings as dependent variables. While self-ratings have brought us to the conclusion that eye-movements have their effect on memories at the level of the central executive, we should look more closely at the roles of the central executive in order to address any questions regarding how eye-movements are effective.

Suppression

Understanding Suppression

The current view of the role of the central executive is that it controls a number of functions: Primarily, these are task shifting, updating and monitoring, and inhibition (Collette et al., 2005; Fisk & Sharp, 2004; Miyake et al., 2000). Task shifting refers to the ability to shift attention between different sub-tasks or elements within the same task. Updating and monitoring involves evaluating new information and revising the existing contents of working memory. Inhibition is the ability to suppress or control dominant or prepotent responses to stimuli – from now on 'suppression' will be the term used, as this is favoured in the relevant literature.

Before relating suppression to the context of this research we should first explore exactly what is meant by this term. In everyday usage, according to the *Collins Concise New Zealand Dictionary* (2008), the term suppression can be used in numerous ways but typically means to prevent something from happening, bring a stop to something that is already underway, or reduce the effects of something. In this way appetite suppressant pills can stop a person getting hungry, a political rebellion can be suppressed once it has started, and suppressors on firearms can make them quieter. The term also has numerous more technical uses in fields as divergent as genetics, engineering, physics, and psychology.

In psychology, there are two main definitions for the concept of suppression (Aron, 2007). The first is borrowed directly from biology and refers to the ability of neurons to serve either excitatory or suppressive functions (inhibition is often the term used in such literature). The second refers to the ability to suppress cognitions and behaviours. Without getting into any argument regarding mind/brain distinctions note that neuronal suppression will not be further discussed within this thesis, since it does not appear in PTSD and EMDR research (see MacLeod, Dodd, Sheard, Wilson, & Bibi, 2003 for further reasoning behind abandoning neuronal suppression at this time).

In terms of cognitive and behavioural suppression, perhaps the best example of suppression of behaviour is given by Anderson and Levy (2009). These authors relate the story of how one of them accidentally knocked a pot plant off a desk. He reached out to try to catch the plant, but realised that it was a cactus and stopped himself from grabbing it out of the air. Although the plant was ruined, he managed to avoid having his hand pierced by cactus needles. These authors go on to state that “Without the capacity to override prepotent responses, we could not adapt behaviour to changes in our goals or circumstances” (pp.189). Therefore, behavioural suppression is critically important to functioning well.

Cognitive suppression refers to the clearing of actions or attention from consciousness, or suppression of previously activated thoughts or processes, or resistance to unwanted interference (Harnishfeger, 1995). Perhaps the best definition is given by MacLeod (2007, pp.5) who states that “Cognitive inhibition is the stopping or overriding of a mental process, in whole or in part, with or without intention." It is evident from this definition that cognitive suppression could arguably cover a wide range of events, from finally pushing an annoying song out of mind to unknowingly forgetting a friend's old phone number after learning their new one. It is, therefore, important to further explore cognitive suppression in order understand what type of suppression will be investigated in this thesis.

Although behavioural suppression is an important area of research, given that the topic of this thesis is the thoughts and memories involved in PTSD, behavioural suppression will not be expanded on further. Regarding cognitive suppression, the level of intent is important to discuss within the scope of the current research. In the examples in the above paragraph, pushing an annoying song out of mind could be classed as an intentional act of suppression while unknowingly forgetting a friend's old number may be more unintentional. To further explore this theme, we should look briefly at two varying, but related, experimental paradigms used to investigate cognitive suppression.

To further investigate the intentionality of cognitive suppression we shall briefly explore two experimental paradigms: Retrieval Induced Forgetting and List-Method Directed Forgetting. The reason these two paradigms have been selected, among many others, is because they involve the forgetting (or suppression of retrieval) of similar stimuli (pre-learnt words) but differ on the amount of intentionality involved in this forgetting (Anderson, 2005). Specifically, Retrieval Induced Forgetting is thought to involve low levels of intentionality while List-Method Directed Forgetting is thought to involve high intentionality.

In the Retrieval Induced Forgetting procedure participants learn many lists of category-exemplar word pairs (for example: fruit-orange, fruit-apple, drink-scotch, and drink-vodka). Then they practise retrieving, or remembering, half the exemplars from half the categories through cued stem recall tests (for example: they would complete the word stem for fruit-or____ where orange is the correct answer). Participants are then tested for recall (they are not cued with the partial stem of the exemplar words) for all the word pairs. Participants typically remember more of the practised exemplars from practised categories (fruit-orange) relative to the baseline unpractised exemplars from unpractised categories (drink-scotch). Interestingly though, recall for unpractised exemplars from practised categories (fruit-apple) is worse than for baseline (Anderson, Bjork, & Bjork, 1994).

The favoured explanation for the Retrieval Induced Forgetting effect is that "inhibitory control is recruited to combat interference during retrieval, with inhibition manifesting as recall impairment for competitors on the final test (Anderson, 2005, pp.307)." Hence, remembering fruit-orange engages suppression of possible competing answers such as fruit-apple that do not need to be recalled. Then during the final recall test the ongoing suppression of fruit-apple makes it harder to recall (although other explanations have been posited: see Anderson, 2003 for a review). Importantly, the suppression of competing exemplars is not intentional, it is an automatic mechanism used to facilitate recognition during practise (Anderson, 2005).

In a typical List-Method Directed Forgetting experiment a participant will initially be told they are to remember a list of words. However, after presentation of the first 12 words (known as List 1) they are told that list was a practise and they don't need to remember those words. Then 12 more words are presented (List 2), which the participant is instructed to remember. After a break the participant is then required to recall as many words from both lists as they can remember (MacLeod, 1998). Normally participants recall fewer of the to-be-forgotten words in List 1 than the to-be-remembered words from List 2, and this is referred to as the directed forgetting effect.

It is commonly thought that the directed forgetting effect is caused by suppression of List 1, which then makes words from List 1 harder to recall in the final test (Bjork, 1998). It is important to note that cognitive suppression in List-Method Directed Forgetting appears to involve a high degree of intentionality. Indeed, participants are specifically instructed to not remember, or forget, the words in List 1 after they have already learnt them: Participants must intentionally suppress List 1 in order to facilitate remembering of List 2 (Bjork, 1998). Hence, while the end result of List-Method Directed Forgetting is similar to that of Retrieval Induced Forgetting, namely the forgetting of words due to suppression of recall, the two tasks differ in the level of intentionality involved (Anderson, 2005).

Suppression and PTSD

Suppression plays an important but under-explored role in PTSD. Levy & Anderson (2002) posited that when people have re-experiencing symptoms, these are due to an inability to suppress the prepotent response of the traumatic memory when the person is exposed to sensory stimuli that are similar to the original traumatic event. This capacity to suppress distracting or disturbing memories is a central executive process that is mediated by processes similar to those used to control prepotent behavioural responses to stimuli. This control of prepotent responses is accomplished by suppression, often in order to enable more flexible and context-sensitive responses to be initiated (Levy & Anderson, 2002).

Suppression also plays an important role in task shifting, where one response or process is suppressed so that another can become the focus of attention (Friedman et al., 2006; Levy & Anderson, 2002). This may be represented in PTSD by an inability to switch attention from cued traumatic memories to more contextually based representations. This inability to switch between memory representations may result in intrusive memories being experienced as happening in the present and still containing all the traumatic emotions and cognitions from the original event (Brewin, Gregory, Lipton, & Burgess, 2010). In other words, an inability to suppress traumatic memories may be responsible for the re-experiencing symptoms that are the hallmarks of PTSD, and may stop the integration of more adaptive information.

The importance of suppression in PTSD is supported by findings that show people with PTSD have difficulty effectively suppressing traumatic memories. For example, one study used the Item-Method Directed Forgetting task, which is similar to the List-Method explored above but words are presented individually with forget/remember cues presented after each word. Using this task with 30 PTSD patients and 30 controls the researchers found that patients remembered fewer words overall and less of the to-be-remembered words (Cottencin et al., 2006). Patients also recalled more of the words-to-forget than the control participants, indicating an underlying deficit in memory suppression processes.

Similar findings using Directed Forgetting tasks have also been found with female survivors of childhood sexual abuse (McNally, Metzger, Lasko, Clancy, & Pitman, 1998). In this study survivors of childhood sexual abuse who had PTSD were compared to abuse survivors without PTSD, and a control group who reported no childhood sexual abuse or PTSD. Participants were tested on lists of words containing neutral, positive, and trauma related words. Again, it was found that abuse survivors with PTSD recalled fewer of the to-be-remembered words (but only from the positive and neutral lists) than participants in the other two groups, however, there was no difference found in recall of the to-be-forgotten words. While this pattern of results does not explicitly indicate suppression failures, the authors state that the results may indicate an inability to shift attention away from trauma related words.

Research finds similar effects with personally relevant memories also. In one particular study, military service members with PTSD reported greatest intrusion of combat thoughts during a suppression task and demonstrated a post-suppression rebound effect in a neutral task (Aikins et al., 2009). In this study the military service members who had experienced combat and developed PTSD were compared to service members who had experienced combat but not PTSD and to a group of service members who had neither experienced combat or developed PTSD. This thorough methodology shows that difficulties with suppressing traumatic memories are associated with PTSD, not just with exposure to traumatic events.

Shipherd and Beck (1999) also found evidence for post-suppression rebound in female assault survivors. In this study all participants were survivors of assault but only half had developed related PTSD. Participants were initially asked to monitor their thoughts, then to suppress trauma related thoughts, and then to monitor their thoughts again. The results showed that the participants with PTSD had higher levels of trauma-related thoughts during the post-suppression monitoring period than those without PTSD. Interestingly, participants with PTSD also reported more difficulty controlling their thoughts during the suppression period than the non-PTSD group.

Research on participants with acute stress disorder has also shown that they have deficits in thought suppression (Nixon et al., 2008). This study compared acutely traumatised people with and without acute stress disorder, in their ability to suppress both neutral thoughts (white bear) and thoughts of their traumatic event. Results showed that participants with acute stress disorder had significantly more neutral and trauma related thoughts during suppression, however, measures of rebound were not taken.

In a comprehensive review of the topic, Garaerts and McNally (2008) concluded that most studies showed that trauma survivors, especially those with PTSD, are characterised by inability to forget or suppress disturbing material. However, they stated that the literature with respects to rebound effects was less conclusive. Indeed, two earlier meta-analysis concur with this finding, the authors of both studies concluding that participants with clinical diagnoses do not show greater rebound effects than those without diagnoses (Abramowitz, Tolin, & Street, 2001; Rassin, Merckelbach, & Muris, 2000).

Influencing Suppression and Intrusive Memories

Given the importance of intrusive memories and suppression in PTSD and other disorders (Cottencin et al., 2006) it is no surprise that researchers have attempted to induce and control intrusive memories in the laboratory environment. One popular way to induce negative intrusive memories is known as the trauma film paradigm (Holmes & Bourne, 2008). Typically, the trauma film paradigm involves participants watching a short film (approximately ten minutes long) that depicts traumatic events. Such traumatic events involve actual or threatened death or serious injury. Scenes in a trauma film can include motor vehicle accidents, warfare, physical violence, and emergency hospital surgery.

Researchers have also found that distracting tasks conducted either during or directly after viewing a trauma film can lower the number of subsequent intrusive thoughts (see Holmes & Bourne, 2008 for a review). For example, one study required participants to view a trauma film while either tapping a complex pattern on a keyboard, chewing gum, or doing no concurrent task (Krans, Naring, Holmes, & Becker, 2010). Participants then recorded their intrusive thoughts about the film in a diary for a week. The results showed that participants that viewed the film while tapping the complex pattern had fewer intrusions during the week than those who chewed gum or did nothing. Such results are typical (Brewin & Saunders, 2001; Stuart, Holmes, & Brewin, 2006), and researchers conclude that any suitably taxing visuospatial task conducted while watching a trauma film will lower the number of intrusions afterwards (Holmes, Brewin, & Hennessey, 2004).

Research has also shown similar effects with emotionally negative pictures. Pearson and Sawyer (2011) conducted an experiment where participants viewed traumatic pictures while completing difficult verbal and visuospatial tasks and recorded intrusive thoughts in a diary over the next week. Interestingly, the results showed that both the verbal and visuospatial tasks lowered the number of intrusions. Pearson and Sawyer (2011) concluded that tasks that sufficiently tax the central executive will lower the number of intrusions when conducted concurrently with viewing traumatic images.

Studies have also shown that working memory tasks conducted shortly after viewing a trauma film can lower intrusions (Holmes, James, Coode-Bate, & Deeprose, 2009). The rationale for this study was that there may be a six hour window in which to disrupt the formation and consolidation of memories. Participants in the study watched a trauma film and then, 30 minutes (Experiment 1) or 4 hours (Experiment 2) later, either played the computer game Tetris or did no task. Holmes et al. (2009) found that participants in the Tetris condition reported fewer intrusions during the following week than those in the no-task condition. These findings are similar to those of Deeprose, Zhang, de Jong, Dalgleish, and Holmes (2012), who found a visuospatial task, conducted either immediately or 30 minutes after viewing a trauma film reduced the number of intrusive thoughts during the following week.

The above research shows that suppression can be influenced by working memory tasks when they are conducted during the consolidation of memories. While this is important in itself, it is hard to directly apply these findings to EMDR therapy or eye-movement research. This is because in EMDR therapy the events that have led to the development of PTSD would have occurred much more than six hours previously and would be thoroughly consolidated. There does not appear to be any published research investigating the effect of working memory tasks on intrusions in memories that are well consolidated.

There may be no published research investigating the effect of working memory tasks on suppression of consolidated memories, but there is one investigating the effect in the other direction. Antrobus, Antrobus, and Singer (1964) conducted an exploratory study where participants were asked to suppress or generate a wish. At the same time, the experimenters measured the number of blinks and eye-movements using electrodes. The findings showed that participants blinked and moved their eyes more when they were suppressing a wish compared to when they were thinking about it.

Antrobus et al. (1964) attributed the increase in eye-movements when instructed to suppress to rapid shifts in cognitive activity associated with attempting to suppress the thoughts. However, the authors also state that the eye-movements may have just been caused by an emotional response to being asked to conduct a difficult task. It is certainly troublesome to draw conclusions from this single study although it does provide support to the idea that suppression and working memory tasks such as eye-movements are related.

Speculatively, the findings of Antrobus et al. (1964) could be related to Shapiro's account of how she discovered the therapeutic effect of eye-movements. Shapiro (2001) stated that she noticed her eyes naturally started moving from side to side when she had negative thoughts, and that these thoughts then disappeared or changed. The empirical findings of Antrobus et al. (1964) seem to support the observations of Shapiro (2001) in that eye-movements and suppression are somehow related.

Conclusion

While most people show resilience following traumatic events some go on to develop disorders such as PTSD, which negatively affect their quality of life (Ursano et al., 2009). One hallmark symptom of PTSD is known as reexperiencing symptoms; these include nightmares and intrusive memories of the traumatic event (American Psychiatric Association, 2000). People with PTSD have difficulty controlling these reexperiencing symptoms; they cannot control when they are experienced or suppress them once they have started (Ehlers et al., 2004). Additionally, research shows that people with PTSD also have difficulty with controlling and suppressing traumatic memories in laboratory situations (Cottencin et al., 2006).

While CBT's are the established treatment for PTSD, therapies such as EMDR also show promise. Research consistently shows that EMDR is effective in ameliorating the symptoms, such as reexperiencing, and reducing the diagnosis of PTSD (Bisson et al., 2007), and EMDR has subsequently been accepted into the treatment guidelines for many organisations (Forbes et al., 2010). Despite this acceptance, questions remain over the eye-movement component of the therapy: specifically, whether eye-movements contribute to therapy and possible explanations for this effect (Perkins & Rouanzoin, 2002).

Researchers have shown that EMDR with eye-movements does lead to greater improvement than EMDR without eye-movements (Lilley et al., 2009). Research using non-clinical participants has also found that eye-movements lead to lower self-ratings of vividness and emotionality of negative memories than exposure only (Kavanagh et al., 2001). A number of explanations have been posited to explain the effects of eye-movements. The Interhemispheric Interaction Explanation states that increased communication between the brain hemispheres may assist the reintegration of dissociated aspects of traumatic memories or assist in the integration of positive information (Propper & Christman, 2008). According to the Orienting Response Explanation eye-movements activate a relaxing response that may aid in the processing of traumatic memories (Barrowcliff et al., 2004).

Research support for both the Interhemispheric Interaction (Samara et al., 2011) and Orienting Response (Gunter & Bodner, 2009) explanations is inconsistent and cannot fully explain the effect of eye-movements. Support for the Working Memory Explanation is more substantial and more capable of explaining the effect of eye-movements (Gunter & Bodner, 2008). The Working Memory Explanation states that eye-movements serve as a distracting task, taxing working memory processes while conducted concurrently with remembering a traumatic memory, resulting in memories being less vivid and emotional (van den Hout et al., 2010). Research also suggests that eye-movements have their effect through the central executive (van den Hout et al., 2011).

The central executive serves numerous functions but, importantly for PTSD research, one of those functions is suppression (Miyake et al., 2000). While cognitive suppression can differ in terms of intent (Anderson, 2005), it is clear that people with PTSD have difficulty with suppressing their traumatic memories (Ehlers et al., 2004). Interestingly, research has shown that visuospatial and central executive tasks can lower the number of intrusive thoughts of traumatic events, when these tasks are conducted before the traumatic memories are consolidated (Holmes & Bourne, 2008). However, it remains unknown if such tasks can affect suppression of memories that are already consolidated.

Following this line of reasoning it seems that research is required to investigate whether tasks that tax central executive resources may result in an improved ability to suppress consolidated traumatic and negative memories. The eye-movement component of EMDR can play a role in this investigation: eye-movements have already been shown to lower self-ratings of vividness and emotionality of negative memories. This is a novel area of study: there is no published research merging suppression and eye-movement methodologies, nor is there any regarding improving the suppression of consolidated memories in this manner. Given this, a number of hypotheses can be posited for this thesis:

1. Eye-movements will lower self-ratings of vividness and emotionality of negative memories.
2. Eye-movements will lower the number of intrusive thoughts about negative memories.
3. The central executive explanation will be the best fit for results.

Chapter 3

Pilot Study

To test the hypothesis that eye-movements will improve suppression compared to no-eye-movements requires the combination of two previously distinct research methodologies: eye-movement and suppression. Relevant eye-movement research has typically focussed on the effect that eye-movements have on self-ratings of the vividness and emotionality of negative memories along with a small number of physiological measures. These studies rely on measuring these variables before and after the eye-movements, thus allowing for pre or baseline results to be compared with results post the experimental manipulation. Both between-group (separate groups completing the control and experimental conditions) and within-group (all participants completing all conditions) designs are commonly used in such experiments.

Contemporary eye-movement research typically relies on inducing eye-movements by asking participants to follow a stimulus (usually a dot or circle of 1-2 centimetre diameter) shown on a computer screen. The stimulus blinks from one side of the screen to the other at a speed of 1-2 movements per second for around 25 seconds before a break of between 5-10 seconds and is normally repeated 4-6 times. As a control or no-eye-movement condition participants usually keep their eyes on a dot fixed in the middle of the screen for the same time periods as for the experimental eye-movement condition.

The methods used in suppression research have grown to be more varied than that of eye-movement research. However, the methodology used in the classic “white bear” experiments remains a popular way of measuring cognitive suppression of thoughts with a self-report mechanism. In the classic white bear experiment participants are asked to either express or suppress thoughts of a white bear. In the expression condition participants are to try to think about a white bear while verbalizing their thoughts and ringing a bell whenever they think of a white bear. The suppression period is similar, but participants are instructed to try to avoid thinking of a white bear. Both periods last for five minutes and half complete the suppression first and half the expression first (Wegner, Schneider, Carter, & White, 1987).

Results from the Wegner et al. (1987) study showed that suppressing a thought is very difficult, with participants having thoughts of the white bear at an average rate of approximately once per minute. Additionally, when expression followed suppression there were significantly more thoughts of the white bear during expression than when expression came before suppression. This finding has become known as the rebound effect: if a thought is suppressed the frequency of the thought will subsequently increase (Wenzlaff & Wegner, 2000). The vast majority of studies into cognitive suppression of thoughts and memories have since attempted to investigate not the suppression itself but rather the rebound effect, and have used slight variations on this methodology.

The pilot study sought to explore a pairing of eye-movement research and suppression research methodologies. To achieve this, participants in the pilot study completed either a no-eye-movement or fast-eye-movement condition prior to attempting to suppress their thoughts. Since participants are required to concentrate on their thoughts during the eye-movement conditions this effectively means participants are completing an expression condition prior to suppression. For the pilot study the target thought was to be thoughts of a white bear, in accord with much previous suppression research.

It was hypothesised that participants in the fast-eye-movement condition (the term ‘fast-eye-movement’ is used here to differentiate this condition from those used in other studies in this thesis, such as slow-eye-movement) would have fewer intrusive thoughts of white bears during suppression compared to participants in the no-eye-movement condition.

Method

Design

This study used a between-groups design to compare a fast-eye-movement condition to a no-eye-movement condition, with number of target thoughts during a suppression period as the dependent variable.

Participants

Twenty students from Victoria University of Wellington (6 males; age *M*=26.05, *SD*=5.33) participated in the experiment. Participants were blind to the experimental manipulation.

Materials

In the no-eye-movement condition a black dot with a circumference of two centimetres appeared in the middle of the white computer screen. The computer screen measured 30cm x 30cm and participants sat approximately 50cm from the screen. The dot stayed on the screen for 25 seconds, before being replaced by a message saying “Rest your eyes and relax”, which was present for five seconds. This sequence repeated six times. The fast-eye-movement condition was identical except that the dot blinked from one side of the screen to the other at the rate of two movements per second.

During the suppression period the computer screen was blank white for five minutes, and the programme recorded the number of presses and the time of each press. Using the button presses as a more covert reporting method (compared to more traditional overt methods such as verbalizing thoughts or ringing a bell) is thought to provide a clearer measure of thoughts (Abramowitz, Tolin, & Street, 2001).

Procedure

The experiment was completed individually in front of a computer, in a quiet laboratory room in the psychology faculty building on the university campus, with the experimenter present at all times. After written consent was gained, participants were told:

> When I tell you to start, close your eyes and spend the next minute imagining a white bear. Concentrate on the white bear as much as you can; try to create the strongest and most detailed image of it that you can. Your thoughts can include what it looks like, how it moves, and what it does. Keep concentrating on the white bear until I tell you to stop. Now close your eyes and think about the white bear.

This imaging period was used to ensure that participants developed a strong memory of the white bear. This strays somewhat from other suppression research methodology in that participants are normally introduced to the 'white bear' thought just before beginning either suppression or expression conditions. However, it was done to create as vivid a picture of a white bear as possible in the mind of participants; otherwise the first time they would need to think about the white bear would be during the fast-eye-movement or no-eye-movement conditions, with the possible problem of this affecting the encoding or formation of thoughts and memories about a white bear.

Following the imagining period participants were randomly assigned to complete either the no-eye-movement or fast-eye-movement treatment condition. In both conditions participants were verbally instructed as follows:

> In this part of the experiment you are required to think about the white bear while looking at a dot on the computer screen. It's important that you keep your eyes on the dot on the screen and your head as still as possible, but blink whenever you need to. Just like before, concentrate on your thoughts of the white bear as much as you can. You will get short breaks where you can rest your eyes and think about something else.

At the end of the treatment conditions the participants were verbally given the instructions for the suppression period:

> The next part of the experiment will last five minutes. Unlike before, this time you should try to avoid thinking about the white bear. Whenever you do have a thought about the white bear, press the spacebar once.

At the conclusion of the experiment participants were verbally debriefed and the rationale of the study was briefly explained to them.

Results

Results showed no significant difference between the mean number of presses in the no-eye-movement (*M*=23.80, *SD*=14.37) and fast-eye-movement (*M*=22.40, *SD*=16.73) conditions, $t(18)=.20$, $p=0.84$, $d=.09$.

An important note for the result sections in this thesis: Some of the data violated tests of normal distribution. This was particularly the case for data for the number of presses during suppression. Some data failed the Shapiro-Wilk test of normality, with significant scores ($p<.05$) indicating data were not normally distributed. Subsequent tests of skewness and kurtosis indicated data were skewed to the right (skewness>0) and had a leptokurtic distribution with a pronounced peak (kurtosis>0). This indicates data were grouped close to the 0 end of the scale and had a large range. This was expected considering suppression data had no set ceiling (consider the range of data in the fast-eye-movement condition of the pilot study was 53 presses).

Previous published studies in the fields of suppression and eye-movement have not mentioned the normality of their data. It is, therefore, unknown if the violations of normality found in the current studies are something common to this type of research or unique to this thesis. In cases in this thesis where assumptions of normality were violated non-parametric tests were conducted. Importantly, the patterns of results for non-parametric tests were the same as for parametric tests on the same data. Therefore, only the results of parametric tests have been included, to improve ease of communication and make comparisons within and between studies easier.

Discussion

The results of the pilot study did not show any significant difference in the number of intrusions between the fast- and no-eye-movement conditions. This result does not support the hypothesis of the study, which was that fast-eye-movements would result in fewer intrusions than no-eye-movements. However, the pilot study showed that a combination of eye-movement and suppression research methodologies is possible: The instructions were largely understood and followed by participants and the computer programming effectively presented the dot stimuli and measured participants' responses during the suppression stage.

While the hypothesis was not supported, designing and running the pilot study did provide a number of observations and limitations that needed to be addressed in future studies. One such limitation was the use of a white bear as the target thought. While the white bear is used frequently in suppression research, eye-movement research normally uses personal autobiographical memories that are produced by the participants. Personal memories are used in eye-movement research to make the results more externally valid and generalizable to the traumatic memories that are addressed in EMDR therapy.

However, while autobiographical memories are used in eye-movement research, some problems with using them have arisen in suppression literature. Since negative autobiographical memories are typically subjected to successful suppression over long periods of time, expected results are sometimes not found in laboratory suppression research (see Wenzlaff & Wegner, 2000). However, such conflicting results are found in studies investigating the rebound effect rather than studies investigating suppression itself, such as the current studies. Another problem with using the white bear target thought is that self-ratings, particularly of emotionality, will not be as valid. While the vividness of a white bear thought may be high, it is assumed that the emotionality of such thoughts will be negligible. Without these self-ratings it makes it much more difficult to compare the current studies to previous eye-movement research that has relied heavily on self-ratings of memories.

Another problem raised from the pilot study was the large range in number of intrusions between participants (the difference between least and most presses was 53). This created very large standard deviations and made statistical comparison troublesome. It was interesting in this regard that some participants told the experimenter during the debriefing that they did not know whether to respond to thoughts of the words 'white bear' or only to thoughts of the image of a white bear. Hence, instructions about exactly what thoughts participants are to respond to during the suppression period need to be included in future instructions. Additionally, the large range in number of intrusions may just be reflecting large differences in the ability to suppress thoughts. Future studies should utilise within or mixed model designs to account for such variation in underlying ability.

Study One

The pilot study did not support the hypothesis that fast-eye-movements would result in fewer intrusions than no-eye-movements. However, a number of limitations in the design of the study were noted and these included using a white bear as the target thought instead of personal autobiographical memories, making the instructions on what thoughts to respond to more clear, and using a within-groups design. It was hypothesised that these changes would make the results easier to compare with previous research and more generalizable.

The aim of Study One was to build on the lessons of the pilot study and used personal autobiographical memories rather than thoughts of a white bear. Additionally, a within-group design was used, where each participant completed both the fast- and no-eye-movement conditions. This allowed for direct comparison between the conditions by controlling for differences in the ability to suppress and in the interpretation of instructions. Measures of the vividness and emotionality of the memories were also included in order to follow more established eye-movement methodology and also to allow for comparisons between the current studies and the findings of other researchers in the area who have largely used self-ratings to evaluate the effect of eye-movements. The hypothesis of Study One was that fast-eye-movements would lower self-ratings of vividness and emotionality and also result in fewer intrusive thoughts during suppression when compared to no-eye-movements.

Method

Design

This study used a within-group design to compare a fast-eye-movement condition to a no-eye-movement condition, with number of target thoughts during a suppression period and self-ratings of vividness and emotionality as the dependent variables.

Participants

Forty-four under-graduate students from Victoria University of Wellington (5 males; age *M*=20.84, *SD*=7.21) received course credit for participating in the experiment. Participants were blind to the experimental manipulation and had no previous knowledge of EMDR (participants were asked if they had ever "heard of EMDR therapy" in order to avoid mentioning eye-movements, which may have emphasised the active nature of the fast-eye-movement condition).

Participant numbers in this study, and the others in this thesis, were set due to a number of factors. Such factors included using a comparative number of participants to previous studies and the relative power of the various methodologies used in the various studies. Power analysis was not carried out to determine participant numbers.

Materials

Participants were provided with a pen and lined paper to write about their memories, as well as an envelope in which to put the paper afterwards to ensure privacy. Verbal responses to self-ratings of vividness and emotionality were recorded by the experimenter on 10-point Likert scales.

The computer programme for the fast-eye-movement and no-eye-movement conditions as well as the suppression period was identical to that used during the Pilot Study.

Procedure

The experiment was completed individually in front of a computer in a quiet laboratory room in the psychology faculty building on the university campus. After written consent was gained, participants were verbally asked to choose two memories from their past according to protocol adapted from Van den Hout et al. (2001):

> Once instructed to start, please recall an event that made you feel very fearful, anxious, or distressed. This event should still have some emotional impact. Examples of this type of event include going unprepared into an examination or witnessing an accident. When you have an event in mind, please write a few sentences describing the event on the sheet provided. Please do this until you have described two events.

The experimenter left the room for five minutes so that participants could recall and write in private. Participants were also provided with an envelope to put their writing in and were advised that they could take the envelope with them after the experiment and that nobody else was going to find out about the actual events that took place.

When the experimenter returned to the room, participants verbally rated the vividness and emotionality of their memories by being asked:

> Form an image or memory of the event described on your sheet, and keep your eyes open. Remember where it happened, who was present, and anything else you can think of. Bring it to mind as vividly as if it were happening right now. Please tell me how vivid the memory is on a scale of

> one to ten; where one is not clear at all and ten is extremely clear. Please tell me how emotional the memory is on a scale of one to ten; where one is not at all distressing and ten is extremely distressing.

The experimenter recorded the participants' responses. After these baseline measures of vividness and emotionality were taken participants started the experiment.

The order of treatment conditions was counterbalanced with half completing the no-eye-movement condition first and half completing the fast-eye-movement condition first. The memories were also counterbalanced with half using the 'strongest' memory first and half using the 'weakest' memory first: The combination of vividness and emotionality ratings was used as an indication of the 'strength' of memories.

The verbal instructions and programmes used in both conditions and the suppression measure were identical to those in the pilot study. However, in Study One, participants completed the treatment condition, re-rated their memories for vividness and emotionality, and then completed the suppression measure. Additionally, the experimenter was absent from the room during the suppression period to avoid distracting the participant.

At the conclusion of the experiment participants were verbally debriefed and the rationale of the study was briefly explained to them.

Results

Five participants were excluded from analysis for failing to complete the experiment or understand the instructions (e.g. they felt uncomfortable with the task and did not want to continue or they forgot to press the spacebar during the suppression period), resulting in a sample of 39 (4 males; age *M*=20.85, *SD*=7.21) participants. The numbers of presses in the suppression section were separated per minute, giving the number of presses for each of the five minutes of suppression and also a total press count. Mean pre and post ratings of vividness and emotionality are shown on Table 1.1, along with total number of presses during suppression and presses per minute of suppression. Baseline ratings of vividness (*t*(38)=.75, *p*=.46, *d*=.15) and emotionality (*t*(38)=.27, *p*=.79, *d*=.06) did not differ between no-eye-movement and fast-eye-movement conditions.

Table 1.1

Means and standard deviations (in parentheses) for self-ratings and presses during suppression: Study One.

	Vividness		Emotionality		Presses					
	Pre	Post	Pre	Post	Total	Min.1	Min.2	Min.3	Min.4	Min.5
No-eye-movement	7.44 (1.93)	7.41 (2.01)	6.69 (2.42)	6.64 (2.42)	6.49 (5.24)	2.59 (1.90)	1.36 (1.33)	1.10 (1.29)	.85 (1.04)	.59 (.88)
Fast-eye-movement	7.69 (1.38)	7.00 (1.84)	6.82 (1.89)	6.36 (2.33)	6.00 (5.45)	2.23 (1.63)	1.26 (1.14)	.95 (1.12)	.92 (1.51)	.64 (1.35)

Changes in the rating of vividness and emotionality were assessed using separate 2(Time: pre vs. post) x 2(Treatment Condition: fast-eye-movement vs. no-eye-movement) repeated measures ANOVAs. For emotionality there was no significant main effect for Treatment Condition, *F*(1, 38)=.03, *p*=.86, η_p^2=.00, or for Time, *F*(1, 38)=1.33, *p*=.26, η_p^2=.03, and no interaction, *F*(1, 38)=1.05, *p*=.31, η_p^2=.03.

For vividness there was no main effect for Treatment Condition, *F*(1, 38)=.06, *p*=.80, η_p^2=.00, nor for Time, *F*(1, 38)=3.29, *p*=.08, η_p^2=.08. There was an interaction between Treatment Condition and Time, *F*(1, 38)=4.49, *p*=.04, η_p^2=.11. Follow-up *t*-tests showed no difference between mean vividness ratings pre or post for the no-eye-movement condition, *t*(38)=.12, *p*=.90, *d*=.01. There was a significant difference between mean vividness ratings pre and post for the fast-eye-movement condition, *t*(38)=2.39, *p*=.02, *d*=.43.

Number of presses during suppression was analysed using a 2(Treatment Condition: fast-eye-movement vs. no-eye-movement) x 5(Time: minute 1 vs. minute 2 vs. minute 3 vs. minute 4 vs. minute 5) repeated measures ANOVA. The main effect for Treatment Condition,

F(1, 38)=1.33, p=.26, η_p^2=.03, was not significant. The main effect for Time, F(4, 152)=43.35, p<.01, η_p^2=.53, was significant. Follow-up t-tests showed that presses per minute fell from minute one to minute two (t(38)=6.36, p<.01, d=.83), were static from minute two to minute three (t(38)=1.74, p=.09, d=.26), and static from minute three to minute four (t(38)=1.13, p=.26, d=.13), and fell from minute four to minute five (t(38)=2.38, p=.02, d=.25). The interaction, F(4, 152)=.73, p=.57, η_p^2=.02, was not significant. The total number of presses and presses per minute for the two conditions are shown in Figure 1.1.

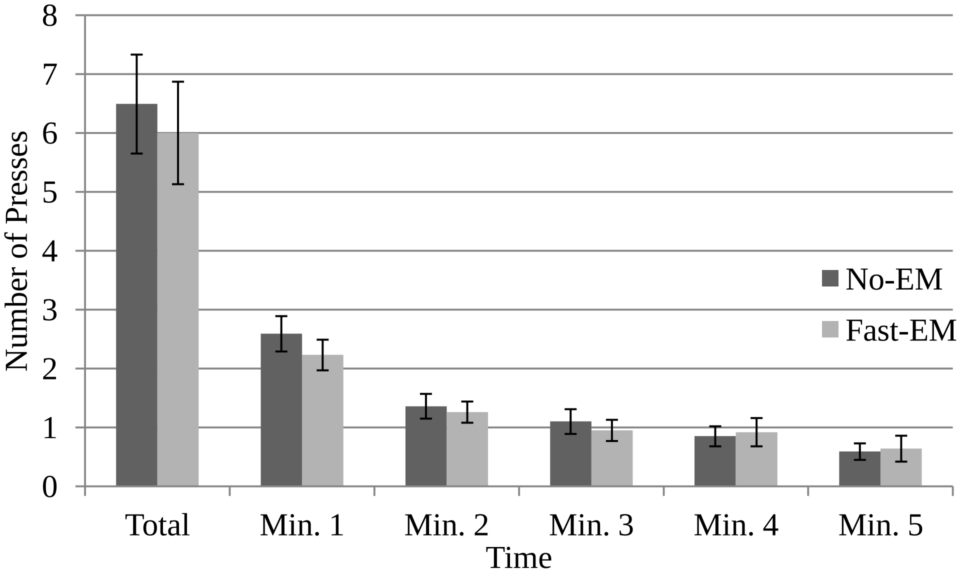

Figure 1.1. Total number of presses during suppression and number of presses per minute for the no-eye-movement (No-EM) and fast-eye-movement (Fast-EM) conditions.

The sample was split into two groups, one group for whom fast-eye-movements lowered vividness more than no-eye-movements (N=20), and one group for whom the fast-eye-movements did not have an effect (N=19) on vividness of memories. Paired samples t-tests compared total number of presses and number of presses per minute between fixated and moving conditions for both of these groups. There were no significant differences in the group for which fast-eye-movements had no effect. There was a significant difference in mean number of presses in the first minute of suppression between no-eye-movement (*M*=3.33, *SD*=1.88) and fast-eye-movement (*M*=2.44, *SD*=1.46) conditions for the group that were affected by eye-movements, *t*(17)=2.25, *p*=.04, *d*=.54, indicating more presses in the no-eye-movement condition. There were no other significant differences.

Discussion

The results of Study One did not show any significant difference in the number of intrusions between the fast- and no-eye-movement conditions. This result did not support the hypothesis of the study, which was that fast-eye-movements would result in fewer intrusions than no-eye-movements. Results from Study One showed that self-ratings of vividness were lowered by the fast-eye-movement condition but not the no-eye-movement condition, however, no effect was found for emotionality. While the finding for vividness accords with the hypothesis that fast-eye-movements would lower self-ratings, the finding for emotionality does not.

To further investigate what effect fast-eye-movements had on intrusions, the participants were split into two groups. One group were participants whose memories had been affected by fast-eye-movements, as shown by their self-ratings of vividness lowering after the treatment condition. Participants whose memories were not affected by fast-eye-movements, as shown by their self-ratings of vividness not changing, were placed in the second group. Participants whose self-ratings of vividness were affected by fast-eye-movements also had the number of intrusions affected: they pressed less following fast-eye-movements when compared to no-eye-movements.

Importantly, there was no statistical or methodological reasoning for dividing the sample into two groups. Because this division was done arbitrarily it was not meant to be a test of the hypothesis. It was, however, done to investigate whether changes to methodology may provide a fairer test of the hypothesis. In the case of Study One it is important to note that participants concentrated on their memories and re-rated them directly after the treatment conditions and prior to the suppression condition. It is possible that completing the tasks in this order may have affected the results by negating the effect of fast-eye-movements. This is especially possible given how delicate measures of suppression are and how prone to such phenomena as the rebound effect (Wenzlaff & Wegner, 2000).

Fast-eye-movements lowered the ratings of vividness of negative memories, which was to be expected given the large body of literature that has found this same result (e.g. Gunter & Bodner, 2008; Kavanagh et al., 2001; van den Hout et al., 2001). However, no effect was found for the self-ratings of emotionality, which is unusual and has only been reported in one previous study (Koppel, 2009). Most reported research has found that eye-movements affect self-ratings of both vividness and emotionality of negative memories (Lee & Drummond, 2008 did not find an effect for vividness). Neither Koppel (2009) nor Lee and Drummond (2008) were able to satisfactorily explain the discrepancies between their own research and the existing body of literature. Similarly, it is unclear why an effect was found for vividness but not emotionality in Study One since the methodology closely follows previous research.

Getting participants to re-rate the vividness and emotionality of their memories prior to the suppression period is a limitation of Study One that has already been mentioned. A further limitation, inherent in the use of a within-group design, is the possibility of carry-over effects between the fast- and no-eye-movement conditions. While counterbalancing was used to address this and other issues, such as fatigue, it is important to note that participants went directly from suppressing one memory to recalling and rating the next memory in Study One. This may have affected the second memory and counterbalancing should be supplemented with a distraction task or rest in future studies.

Study Two

The results of the pilot study and Study One have not supported the hypothesis that fast-eye-movements would lower the number of intrusions during suppression. However, analysis of data for part of the group in Study One did suggest that fast-eye-movements may affect suppression. It was concluded that certain changes to the sequencing of events during experiments may help to focus the results on the suppression period. Additionally, Study One found support for the hypothesis that fast-eye-movements would lower self-ratings of vividness, but the same hypothesis in regards to emotionality was not supported.

The aim of Study Two was to investigate the effects of eye-movements on suppression of memories but to avoid having participants re-rate the vividness and emotionality of their memories before conducting the suppression task. Instead, participants re-rated their memories after the suppression period in order to provide a better measure of the number of intrusions during the suppression period. In addition, a distractor task was completed between the treatment conditions in order to limit any possible carry-over effects. The hypothesis of Study Two was that fast-eye-movements would lower self-ratings of vividness and emotionality and result in fewer intrusions during suppression.

Method

Design

This study used a within-group design to compare a fast-eye-movement condition to a no-eye-movement condition, with number of target thoughts during a suppression period and self-ratings of vividness and emotionality as the dependent variables.

Participants

Thirty-one under-graduate students from Victoria University of Wellington (15 males; age M=18.48, SD=.72) received course credit for voluntarily participating in the experiment. Participants were blind to the experimental manipulation and had no previous knowledge of EMDR.

Materials

Participants were provided with a pen and lined paper to write about their memories, as well as an envelope in which to put the paper afterwards to ensure privacy. Verbal responses to self-ratings of vividness and emotionality were recorded by the experimenter on 10-point Likert scales.

The computer programme for the fast- and no-eye-movement conditions and suppression period was the same as for Study One although there were changes to the timing due to time constraints. In Study Two the dot conditions were only presented to participants four times, rather than six times, and the suppression period lasted for three minutes rather than six. Importantly, these alterations do not deviate extensively from existing practise in their respective fields. For example, many suppression studies use only three minutes rather than five (e.g. Harvey & Bryant, 1998; Nixon, Flood, & Jackson, 2007). Additionally, eye-movement studies have used four presentations of the stimulus totalling similar times as was used in Study Two (e.g. Gunter & Bodner, 2008).

A letter cancellation task was used as a simple distraction task between treatment conditions to attempt to reduce any carry-over effects. In the letter cancellation task, participants were required to put a line through any letter A that they saw on a page of text. The page of text was an excerpt from Plato's The Republic. Participants were given two minutes to complete the task and were instructed to work as quickly and accurately as possible. No participants were able to finish the task within the time limit and were advised afterwards that this was expected.

Two questionnaires were included: the White Bear Inventory (WBSI: Wegner & Zanakos, 1994) and a version of the Thought Control Questionnaire (TCQ: Wells & Davies, 1994). The WBSI was included in Study Two as it is often used during suppression experiments with scores being positively related to number of intrusions (Muris, Merckelbach,

& Horselenberg, 1996).The WBSI is a 15-item inventory designed to measure chronic tendencies to suppress unwanted intrusive thoughts (α=.89 from Wegner & Zanakos, 1994), where each item is rated on a 5-point scale (1= totally disagree to 5 = totally agree). Example items are: "I have thoughts that I cannot stop" and "I always try to put problems out of mind".

The TCQ is a 30-item self-report measure that assesses thought control strategies across five factors: distraction (α=.72), worrying about something else (α=.71), punishment (α=.64), re-appraisal of the thought (α=.67), and social support (α=.79: from Wells & Davies, 1994). For the purposes of this study the wording of items was changed from the present tense to the past tense, and participants were instructed to answer according to what strategies they used only during the experiment. Additionally, the social support items were removed as participants could not use that strategy. The TCQ was included in this altered form in order to gain insight into the strategies used only during the experiment, with the additional aim of investigating if eye-movements aided a particular strategy.

Procedure

The procedure for the start of the experiment was the same as Study One: After consent was gained participants were asked to choose memories and write about them while the experimenter was outside the room. When the experimenter returned to the room, participants verbally rated the vividness and emotionality of their memories in the same manner as Study One. The experimenter recorded the participants' responses. After these baseline measures of vividness and emotionality were taken participants started the experiment.

The order of treatment conditions was counterbalanced with half completing the no-eye-movement condition first and half completing the fast-eye-movement condition first. The memories were also counterbalanced with half using the 'strongest' memory first and half using the 'weakest' memory first: The combination of vividness and emotionality ratings was used as an indication of the 'strength' of memories.

The verbal instructions for both treatment conditions and the suppression period were identical to those in Study One. However, in Study Two participants rated the vividness and emotionality of their memories, completed the treatment condition, completed the suppression period, and then re-rated the vividness and emotionality of their memories. Participants then completed the letter cancellation task before starting the next treatment condition. Following completion of both treatment conditions participants completed the TCQ and WBSI as pen-and-paper questionnaires.

At the conclusion of the experiment participants were verbally debriefed and the rationale of the study was briefly explained to them.

Results

Table 2.1 shows pre and post emotionality and vividness scores, and total number of presses and presses per minute, as a function of eye-movement condition. Baseline ratings for vividness, $t(30)=.66$, $p=.52$, $d=.15$, and emotionality, $t(30)=.64$, $p=.53$, $d=.12$, of memories did not differ across the two conditions.

Table 2.1

Means and standard deviations (in parentheses) for self-ratings and presses during suppression: Study Two.

	Vividness		Emotionality		Presses			
	Pre	Post	Pre	Post	Total	Min.1	Min.2	Min.3
No-eye-movement	7.81 (1.42)	7.87 (1.50)	6.48 (2.08)	6.26 (2.21)	5.65 (3.10)	2.58 (1.77)	1.68 (1.08)	1.39 (1.15)
Fast-eye-movement	7.48 (2.05)	6.94 (2.02)	6.81 (1.99)	5.65 (2.18)	4.39 (2.18)	2.35 (1.82)	1.19 (1.33)	0.81 (0.95)

Changes in the rating of vividness and emotionality were assessed using separate 2(Time: pre vs. post) x 2(Treatment Condition: fast-eye-movement vs. no-eye-movement) repeated measures ANOVAs. For vividness there was no main effect for Time, $F(1, 30)=1.10$, $p=.31$, $\eta_p^2=.04$, no main effect for Treatment Condition, $F(1, 30)=2.20$, $p=.15$, $\eta_p^2=.07$, and no interaction, $F(1, 30)=2.98$, $p=.09$, $\eta_p^2=.09$. For emotionality there was no main effect for Treatment Condition, $F(1, 30)=.10$, $p=.75$, $\eta_p^2<.01$, although there was a main effect for Time, $F(1, 30)=8.31$, $p=.01$, $\eta_p^2=.22$, indicating that, overall, emotionality ratings were lower at post-test compared to pre-test. There was also an interaction between Treatment Condition and Time, $F(1, 30)=8.49$, $p=.01$, $\eta_p^2=.22$. In investigating the interaction, no difference was found between emotionality ratings pre- and post-test in the no-eye-movement condition, $t(30)=.79$, $p=.43$, $d=.10$, but there was a significant difference for the fast-eye-movement condition, $t(30)=3.96$, $p<.01$, $d=.72$, with post measures lower than pre measures.

The total number of presses and presses per minute during the suppression period for each condition are shown on Figure 2.1. A 3(Time: minute one vs. minute two vs. minute three) x 2(Treatment Condition: eye-movement vs. no-eye-movement) repeated measures ANOVA was conducted to investigate the difference in number of presses per minute between the two treatment conditions. There was a main effect for Treatment Condition, $F(1, 30)=5.19$, $p=.03$, $\eta_p^2=.15$, indicating that there were less presses during the suppression period in the fast-eye-movement condition than in the no-eye-movement condition. There was a main effect for Time $F(2, 29)=24.50$, $p<.01$, $\eta_p^2=.63$, and t-tests showed that presses fell from minute one to minute two ($t(61)=4.75$, $p<.01$, $d=.68$), and from minute two to minute three ($t(38)=2.04$, $p=.045$, $d=.31$). There was no interaction, $F(2, 29)=.53$, $p=.59$, $\eta_p^2=.04$.

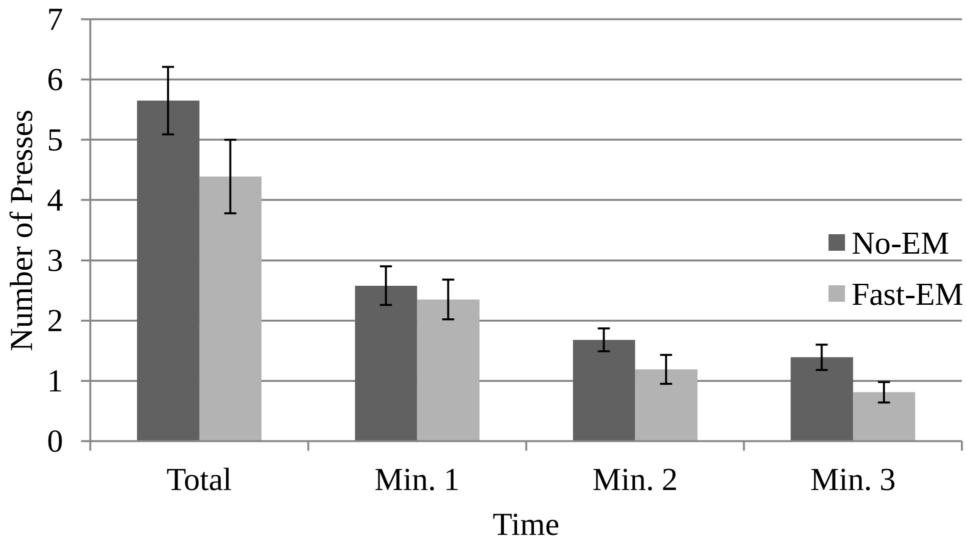

Figure 2.1. Total number of presses during suppression and number of presses per minute for the no-eye-movement (No-EM) and fast-eye-movement (Fast-EM) conditions.

Reliability statistics, means, and standard deviations for the TCQ factors were as follows: Distraction (α=.63, *M*=17.82, *SD*=2.79), worry (α=.84, *M*=11.81, *SD*=4.39), re-appraisal (α=.75, *M*=9.71, *SD*=3.08), and punishment (α=.64, *M*=7.39, *SD*=1.75). None of the TCQ factors correlated with vividness or emotionality ratings, or with number of presses in either condition. Scores on the WBSI (α=.85, *M*=52.00, *SD*=9.98) were correlated with number of presses in the eye-movement condition, $r(28)=.42$, $p=.03$, $R^2=.18$, such that higher WBSI scores were associated with a higher number of presses.

Discussion

Results from Study Two showed that fast-eye-movements reduced self-ratings of emotionality, but not vividness, of negative memories. Eye-movements also had an effect on suppression, with participants pressing less after the fast-eye-movement condition than after the no-eye-movement condition. The results of Study Two supported the hypothesis that fast-eye-movements would lower the number of intrusions during the suppression period. The hypothesis that fast-eye-movements would lower self-ratings of vividness and emotionality was only supported with regards to emotionality.

This study also found that WBSI scores were positively correlated with total number of presses in the fast-eye-movement condition. Additionally, TCQ scores indicated that distraction was the most common suppression strategy used during the experiment followed by worry, re-appraisal, and then punishment. None of the TCQ factors were related to any of the dependent variables in this study.

Previous research has found that eye-movements affect self-ratings of vividness and emotionality of negative memories (e.g. Gunter & Bodner, 2008; Kavanagh et al., 2001; van den Hout et al., 2001). However, in this study the effect was only found for emotionality, which accords with only one known previously published study (Lee & Drummond, 2008). Lee and Drummond (2008) were unable to satisfactorily explain the discrepancies between their own research and the existing body of literature and, similarly, it is unclear why an effect was found for emotionality but not vividness in this study, particularly considering that the opposite was found in Study One: fast-eye-movements lowered ratings of vividness but not emotionality.

Although there is no apparent explanation for the discrepancies between the findings for self-ratings in this study compared to Study One and previous research, there are important methodological differences to consider. In earlier research and Study One, participants typically re-rated their memories immediately following the treatment conditions. In the current study, however, participants completed three minutes of suppression along with the time spent receiving instructions before re-rating their memories. It is possible that the time delay, concentrating on instructions, or the suppression task itself has somehow interfered with the effect on vividness. For example, the well documented rebound effect

(Wenzlaff & Wegner, 2000) may be intensifying the negative memories following the suppression period, counteracting any effect from the eye-movements.

Participants in Study Two recorded fewer intrusions during the suppression period after fast-eye-movements than after no-eye-movements. This is not consistent with the findings from the complete sample in Study One but is consistent with results from the part of the sample whose self-ratings of vividness were affected by fast-eye-movements. It is possible that the methodological changes made in Study Two were critical to the effect on intrusive thoughts. This suggests that the effect of fast-eye-movements on intrusions is not robust, since concentrating on the memories for ten seconds and rating them appears to be sufficient to ameliorate the effect of fast-eye-movements.

The number of intrusions reduced significantly from minute one to minutes two and three in both conditions. This may indicate that the reduction is caused by a natural process or the same strategy in both conditions, and that eye-movements assist this process. Distraction was the strategy used most by participants to avoid thinking about their negative memories, as indicated by TCQ scores. Eye-movements require central executive attention to be distracted from recall of memories (van den Hout et al., 2011), when both tasks are conducted concurrently. Therefore, it is possible that they may continue to allow the central executive to use distraction to avoid intrusions even after eye-movements have stopped. Unfortunately, there is no way to test this hypothesis with the results of the current study.

Previous research has found that WBSI scores are related to number of intrusions in suppression paradigms (Muris, Merckelbach, & Horselenberg, 1996). However, there was a positive correlation between WBSI scores and number of intrusions only in the fast-eye-movement condition. This correlation indicates that higher WBSI scores were associated with more intrusions during suppression after the fast-eye-movement condition than lower WBSI scores. It is unknown why no relationship was found in the no-eye-movement condition, as this would have been expected based on previous findings in the literature (Muris et al., 1996).

The WBSI measures chronic tendencies and failures to suppress unwanted intrusive thoughts. Given the positive correlation between WBSI scores and intrusions following fast-eye-movements it is possible that participants who often attempt and fail to suppress negative thoughts receive less benefit from fast-eye-movements. Conversely, memories that are difficult to suppress may not receive the same benefits from fast-eye-movements. A limitation of Study Two is that all participants completed the WBSI after both treatment conditions. This may have made suppression failures more salient for those who had more intrusions during the fast-eye-movement condition, resulting in higher scores given on the WBSI questionnaire.

Overall, the results from Study Two indicate that eye-movements assist in the suppression of negative thoughts when compared to no-eye-movements. However, Study Two did not include a direct test of the central executive account. So while the results of Study Two support the second hypothesis of this thesis they cannot speak to the actual mechanism of action, which is the third hypothesis. This is critical considering that the central executive, interhemispheric interaction, and orienting response explanations for the effect of eye-movements are equally able to explain the findings of Study Two.

Study Three

The results from Study Two showed that fast-eye-movements improved suppression of negative memories compared to no-eye-movements but were unable to provide support for the central executive explanation. The aim of Study Three was to test more thoroughly the central executive account of the effectiveness of eye-movements. The central executive account predicts that the more demanding a task is the greater the effect will be on negative memories (Gunter & Bodner, 2008). In regards to the current experiments, the central executive account predicts that conducting a more difficult task will result in fewer intrusions during suppression than a less difficult task.

In order to test this hypothesis, Study Three involves comparing fast-eye-movements to both slow-eye-movement and no-eye-movement conditions. Maxfield, Melnyk, and Hayman (2008) also compared fast-, slow-, and no-eye-movement conditions with self-ratings of vividness and emotionality as dependent variables. They reasoned that fast-eye-movements required greater central executive resources than slow-eye-movements, and both fast- and slow-eye-movements required more resources than no-eye-movements. They, therefore, hypothesised that fast-eye-movements would lower self-ratings more than slow-eye-movements, which would lower self-ratings more than no-eye-movements. Overall, the results of their studies generally supported this hypothesis (Maxfield et al., 2008).

In addition to adding a slow-eye-movement condition, Study Three also included the Reading Span Task (Engle et al., 1999), which is a well-used, reliable, and validated measure of central executive capacity (Conway, Kane, Bunting, Hambrick, Wilhelm, & Engle, 2005). Researchers have found that more effective thought suppression is related to higher central executive capacity (Brewin & Beaton, 2002; Brewin & Smart, 2005; Levy & Anderson, 2008). The Reading Span Task was, therefore, included as a further test of the central executive account of the effectiveness of eye-movements. Scores on the Reading Span Task should be negatively related to number of intrusions during suppression. Additionally, if eye-movements are affecting central executive functions then this relationship may be greater in the fast- and slow-eye-movement conditions than the no-eye-movement condition.

The hypothesis of Study Three was that fast-eye-movements would affect the dependent variables more than slow-eye-movements, which would affect them more than no-eye-movements. Additionally, as mentioned above, a negative relationship between number of intrusions and scores on the Reading Span Task was expected.

Method

Design

This study used a within-group design to compare a fast-eye-movement condition, a slow-eye-movement condition, and a no-eye-movement condition, with number of target thoughts during a suppression period and self-ratings of vividness and emotionality as the dependent variables.

Participants

Thirty-three under-graduate students from Victoria University of Wellington (11 males; age *M*=20.21, *SD*=5.55) received course credit for participating in the experiment. Participants were blind to the experimental manipulation and had no previous knowledge of EMDR therapy.

Materials

Participants were provided with a pen and lined paper to write about their memories, as well as an envelope in which to put the paper afterwards to ensure privacy. Verbal responses to self-ratings of vividness and emotionality were recorded by the experimenter on 10-point Likert scales.

The computer programme for the fast- and no-eye-movement conditions was the same as that used in Study Two. The slow-eye-movement condition was similar but the dot blinked from side-to-side at the rate of one movement per second. The suppression period for all conditions was the same as that used in Study Two.

Participants had to complete two letter cancellation tasks during the course of the experiment, one after the first condition and one after the second condition. One letter cancellation task was completed on a page of text that was an excerpt from Plato's The Republic, as in Study Two. The other cancellation task was completed on a page of text that was an excerpt from Marcus Aurelius' Meditations, where participants had to put a cross through any letter E that they saw. Participants were given two minutes to complete the tasks and were told to work as quickly and accurately as possible. No participants were able to finish the task within the time limit and were advised afterwards that this was expected.

The Reading Span Task, a commonly used measure of central executive capacity, was based on that described by Engle et al. (1999). Participants read sentences and an unrelated, one-syllable, all-capitalised word aloud, which were displayed individually on a computer screen. For example: 'For many years, my family and friends have been working on the farm. SPOT.' After the participant read the sentence and word aloud they pressed the spacebar to make the next sentence in the set appear. The number of sentences in each set varied randomly between three and five, with each set length presented three times. At the end of the set of sentences, the participant was prompted to recall the capitalised words. After the word recall for each sequence, the participant was asked a comprehension question about one of the sentences in the sequence, ensuring the participant attended to the sentences. There was one practise set before beginning the task. The task was scored by counting the total number of words recalled across all the sequences (as recommended by Friedman & Miyake, 2005), giving a maximum score of 42.

Procedure

The experiment was completed individually in front of a computer in a quiet laboratory room in the psychology faculty building on the university campus. After written consent was gained, participants were verbally asked to choose three memories from their past using the same instructions as given in Study One. The experimenter left the room for five minutes so that participants could recall and write in private. Participants were also provided with an envelope to put their writing in for privacy.

The verbal instructions for treatment conditions and the suppression period were identical to those in Study One. However, in Study Three participants rated the vividness and emotionality of their memory, completed the treatment condition, completed the suppression period, and then re-rated the vividness and emotionality of their memory. Participants then completed a letter cancellation task before starting the next treatment condition. The order of the three treatment conditions was counterbalanced between participants.

Participants completed the Reading Span Task after finishing all the treatment conditions. The TCQ and WBSI questionnaires used in Study Two were not included because of time constraints. At the conclusion of the experiment participants were verbally debriefed and the rationale of the study was briefly explained to them.

Results

Three participants were excluded from analyses as the computer programme did not record their data during the suppression period (*N*=30; 10 males; age *M*=20.40, *SD*=5.56).

Table 3.1 shows pre and post emotionality and vividness scores as a function of eye-movement condition. Changes in the rating of vividness and emotionality were assessed using separate 2(Time: pre vs. post) x 3(Treatment Condition: fast-eye-movement vs. slow-eye-movement vs. no-eye-movement) repeated measures ANOVA's. For emotionality there was no main effect for Time, $F(1, 29)=3.68$, $p=.07$, $\eta_p^2=.11$, or Treatment Condition, $F(2, 28)=.08$, $p=.93$, $\eta_p^2=.01$, and no interaction, $F(2, 28)=.87$, $p=.43$, $\eta_p^2=.06$.

Table 3.1

Means and standard deviations (in parentheses) for self-ratings and presses during suppression: Study Three.

	Vividness		Emotionality		Presses			
	Pre	Post	Pre	Post	Total	Min.1	Min.2	Min.3
No-eye-movement	7.33 (1.24)	7.53 (1.53)	5.73 (1.64)	5.60 (1.59)	6.60 (4.90)	3.57 (2.21)	1.60 (1.85)	1.43 (2.05)
Slow-eye-movement	7.07 (1.89)	7.13 (2.18)	5.87 (2.05)	5.37 (2.44)	5.50 (4.07)	3.00 (2.23)	1.37 (1.50)	1.13 (1.38)
Fast-eye-movement	7.80 (1.40)	7.07 (1.64)	5.97 (2.28)	5.67 (2.39)	4.03 (2.51)	2.77 (1.77)	0.70 (0.75)	0.57 (0.77)

For vividness there were no main effects for Time, *F*(1, 29)=.83, *p*=.37, η_p^2=.03, or Treatment Condition, *F*(2, 28)=.57, *p*=.57, η_p^2=.04; however, there was an interaction, *F*(2, 28)=7.53, *p*<.01, η_p^2=.35. Analysis showed no difference between mean vividness ratings pre and post for the no-eye-movement, *t*(29)=.95, *p*=.35, *d*=-.18, and slow-eye-movement, *t*(29)=.27, *p*=.79, *d*=-.04, conditions, but a significant decrease between mean vividness ratings pre and post for fast-eye-movement, *t*(29)=3.52, *p*<.01, *d*=.65.

Figure 3.1 shows total number of presses during suppression and number of presses per minute. A 3(Time: minute one vs. minute two vs. minute three) x 3(Treatment Condition: fast-moving vs. slow-moving vs. static) repeated measures ANOVA was conducted to investigate the difference in number of presses per minute between the three eye-movement conditions.

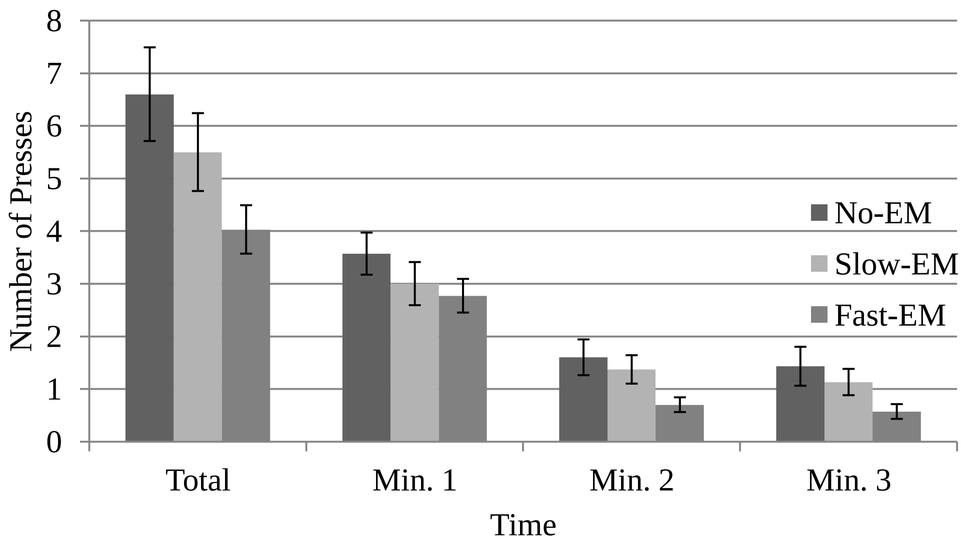

Figure 3.1. Total number of presses during suppression and number of presses per minute for the no-eye-movement (No-EM), slow-eye-movement (Slow-EM), and fast-eye-movement (Fast-EM) conditions.

There was a main effect for Treatment Condition, $F(2, 28)=4.21$, $p=.03$, $\eta_p^2=.23$, indicating that participants pressed less during the suppression period after the fast-eye-movement condition than after the slow-eye-movement, $t(29)=2.18$, $p=.04$, $d=.43$, and no-eye-movement, $t(29)=2.83$, $p=.01$, $d=.56$, conditions (The difference between slow and no-eye-movement conditions was not significant, $t(29)=1.37$, $p=.18$, $d=.25$). There was a main effect for Time, $F(2, 28)=29.84$, $p<.01$, $\eta_p^2=.68$, with t-tests showing number of presses fell from minute one to minute two ($t(29)=7.08$, $p<.01$, $d=1.45$), but not from minute two to minute three ($t(29)=1.28$, $p=.21$, $d=.17$),. There was no interaction, $F(4, 26)=.25$, $p=.91$, $\eta_p^2=.04$.

Analyses also showed that reading span scores ($M=28.10$, $SD=4.42$) and total number of presses in the fast eye-movement condition were negatively correlated, $r=-.382$, $p=.037$, $R^2=.15$. This correlation shows that participants with higher reading span scores recorded fewer presses in the suppression period following the fast-eye-movement condition than participants with lower reading span scores. The correlation between changes in vividness ratings in the fast-eye-movement condition and reading span scores was not significant, $r=.028$, $p=.88$.

Discussion

Study Three found that self-ratings of vividness were affected only by fast-eye-movements. This supports the hypothesis that fast-eye-movements would lower self-ratings. However, fast-eye-movements did not significantly lower emotionality ratings, and slow-eye-movements had no effect on either vividness or emotionality. Fast-eye-movements also decreased the number of intrusions in the suppression period when compared to both slow-eye-movements and no-eye-movements. This finding supports the hypothesis that fast-eye-movements would lower intrusions but does not support the hypothesis that slow-eye-movements would also lower intrusions when compared to no-eye-movements. Additionally, reading span scores were negatively correlated with the number of intrusions in the fast-eye-movement condition.

The current methodology again failed to replicate past findings that eye-movements reduced both the emotionality and vividness of negative memories, or that these changes would be correlated with measures of central executive functioning (e.g. Gunter & Bodner, 2008; Kavanagh et al., 2001; van den Hout et al., 2001). Both Study One and Study Three found that fast-eye-movements lowered self-ratings of the vividness of negative memories, but not self-ratings of emotionality. However, these findings did not replicate those of Study Two, where it was found that fast-eye-movements only affected self-ratings of emotionality. As discussed earlier, the current methodology varies from that used by other researchers, particularly concerning the addition of a suppression period. However, it remains unclear as to why the results from Studies One and Three are not in accordance with those from Study Two considering that the methodology of these studies is largely similar.

The slow-eye-movement condition did not significantly affect self-ratings of vividness or emotionality. This does not replicate the results of previous research where studies using eye-movements of similar speed to the slow-eye-movement condition have found that self-ratings of vividness and emotionality are lowered (e.g. Gunter & Bodner, 2008; Maxfield et al., 2008; van den Hout et al., 2011). Again, it is important to note the significant differences between the design of Study Three and designs of experiments in the literature (as discussed in Study Two). Additionally, this may be a result of slow-eye-movements not being difficult enough to tax executive resources sufficiently to provide a significant change in the current sample.

Fast-eye-movements decreased the number of intrusions in the suppression period compared to both slow-eye-movements and no-eye-movements. This finding agrees with the results of Study Two, which also found fast-eye-movements lowered the number of intrusions, and adds further support to the hypothesis that eye-movements assist in the suppression of memories. While the slow-eye-movement condition lowered the number of intrusions compared to the no-eye-movement condition, the effect was not large enough to reach statistical significance in the current sample size. The finding that fast-eye-movements have a larger effect on intrusions than slow-eye-movements suggests tasks which tax the central executive more will have a greater effect on suppression.

The finding that reading span scores were negatively correlated with number of intrusions in the fast-eye-movement condition is also consistent with a central executive account. This correlation shows that persons with higher central executive capacity had fewer intrusions following the fast-eye-movement condition than those with lower capacity. Hence, it is possible that eye-movements may assist existing executive abilities to suppress thoughts of negative memories. Additionally, it is also possible that participants with higher central executive capacity were more able to hold the memory in mind while conducting eye-movements at the same time, whereas those with lower capacity were not able to think about their memories while conducting the eye-movements because the task was too difficult. This conclusion is supported by other researchers who have also posited that the speed of the eye-movements in EMDR therapy should be matched to central executive capacity for best results (Gunter & Bodner, 2008).

Overall, the results from Study Three support the central executive explanation for the effectiveness of eye-movements. It is interesting that the slow-eye-movement condition did not significantly differ from the no-eye-movement condition given that predictions based on the central executive account and previous research suggested that slow-eye-movements would lower self-ratings and intrusions more than no-eye-movements. However, since the fast-eye-movement condition did differ from the other two conditions this shows that it is not merely eye-movements that produce an effect, but the difficulty of them and the extent to which they require executive resources.

One possible limitation to the current studies is the reliance on participant-generated personal autobiographical memories. The problem with using such memories is that, particularly in a within-groups design, it is unknown to what extent the memories that participants are using are similar or different. For example, participants may have one very traumatic memory with the other memories being far less traumatic. Counterbalancing may account for this to some extent, and there have been no differences noted in baseline self-ratings between conditions. However, the use of novel stimuli may be explored in an effort to control for this, particularly given that some studies looking at the rebound effect have had unexpected results using personal autobiographical memories (Wenzlaff & Wegner, 2000).

Study Four

Studies Two and Three have both shown that fast-eye-movements lower the number of intrusive thoughts during a suppression period compared to no-eye-movements. In addition to this, Study Three found some support for a central executive explanation of the effect of fast-eye-movements. However, it was noted that a limitation of the previous studies was the use of participant-generated personal autobiographical memories. Study Four was designed to test this and explore a possible alternative for participant-generated memories. Instead of the participants retrieving their own memories they were provided with negative emotional stimuli so that they would all be using the same memories, thus bringing memories under experimental control.

When trying to select the stimuli to be used in Study Four the major decision revolved around whether to use videos or pictures. Traumatic videos used in research, sometimes known as the trauma film paradigm, are often from five to over ten minutes long and show scenes such as victims of war or motor vehicle crashes. Researchers have investigated the effect of different visuospatial and verbal distraction tasks on intrusions from trauma films and typically found fewer intrusions following distractions (for a review see Holmes & Bourne, 2008). However, this research has largely investigated the effects on intrusive thoughts when tasks are conducted at the same time as the film is viewed. Essentially, this is targeting the encoding of memories rather than the recall of memories that is the subject of Study Four.

Two known studies have investigated the effect that visuospatial tasks have on intrusions from a trauma film when the tasks are completed after the film. In both of these studies participants saw a traumatic film and were then given either a no-task control or visuospatial treatment with intrusive thoughts measured by diary entries over the following week (Holmes et al., 2009; Vink, 2011). In each study the visuospatial task chosen by the experimenters was the computer game Tetris. Only one study found that the visuospatial treatment group had fewer intrusive thoughts than the control group (Holmes et al., 2009).

Emotional pictures have also been shown to create unwanted intrusions (Hall & Berntsen, 2008; Pearson, Ross, & Webster, 2012). One study has also evaluated the effect of visuospatial tasks on intrusions from pictures in much the same way as research using trauma films (Krans, Langner, Reinecke, & Pearson, 2013). In this study participants viewed 36 negative pictures from the International Affective Picture System database (IAPS: Lang, Bradley, & Cuthbert, 2008) while conducting visuospatial or verbal treatment conditions and intrusions were measured for a week with diary entries. Results showed no difference in number of intrusions between the treatment conditions.

Since the aim of this study was to try to gain as much control as possible over the thoughts that participants were trying to suppress, it was decided that pictures would be the best stimuli. This is because using a trauma film does not actually provide control over exactly what image the participant will try to suppress. Indeed, a ten minute long film offers numerous different images that the participant will potentially concentrate on and there is no way to control exactly what part of the film the participant is engaging with. For the same reason the number of pictures viewed per treatment condition was limited to one. By using a single picture we can be more certain that the participant is concentrating on that particular image during the treatment condition and then trying to avoid thoughts of the exact same image during the suppression period.

Another advantage of using pictures over trauma films is that pictures such as those from the IAPS database have been normed on large samples. For example, the IAPS pictures are normed for emotional valence, arousal level, and the dominance of the image. This enables experimenters to select images that are different and yet have similar effects and characteristics. For Study Four this means that two pictures can be chosen that are as alike in their valence, arousal, and dominance as is possible. No similar normed ratings are available for trauma film stimuli.

The hypothesis of Study Four is that fast-eye-movements will affect the dependent variables more than no-eye-movements. Additionally, based on the result of Study Three, a negative relationship between number of intrusions and scores on the Reading Span Task is expected.

Method

Design

This study used a within-group design to compare a fast-eye-movement condition and a no-eye-movement condition, with number of target thoughts during a suppression period and self-ratings of vividness and emotionality as the dependent variables.

Participants

Twenty under-graduate students from Victoria University of Wellington (11 males; age *M*=18.90, *SD*=1.17) received course credit for participating in the experiment.

Participants were blind to the experimental manipulation and had no previous knowledge of EMDR therapy.

Materials

Verbal responses to self-ratings of vividness and emotionality were recorded by the experimenter on 10-point Likert scales. The computer programme for the fast- and no-eye-movement conditions and suppression periods was almost identical to that used in Study Two. The only difference was that participants were shown pictures before the treatment conditions. The same version of the Reading Span Task from Study Three was used.

The negative pictures used in Study Four are shown in Figure 4.1. The pictures used were number 2703 (“children”) and 6560 (“gun”), taken from the IAPS database (Lang et al., 2008). Both the children (valence *M*=2.19, *SD*=1.49; arousal *M*=6.01, *SD*=2.44; dominance *M*=3.45, *SD*=2.10) and gun (valence *M*=2.16, *SD*=1.41; arousal *M*=6.53, *SD*=2.42; dominance *M*=3.11, *SD*=2.41) pictures were matched as closely as possible for valence, arousal, and dominance. The pictures were fitted to take up the whole computer screen when presented.

Figure 4.1. The children and gun pictures used as memory stimuli in Study Four.

Procedure

The experiment was completed individually in front of a computer in a quiet laboratory room in the psychology faculty building on the university campus. After written consent was gained, the experiment was started.

The presentation of the pictures was counterbalanced, with half seeing the children picture first and half seeing the gun picture first. Participants were instructed to keep their eyes on the picture and concentrate on it as much as possible. Order of treatment condition was also counterbalanced, with half completing the no-eye-movement condition first and half completing the fast-eye-movement condition first. Hence, participants saw one picture on screen and then rated that picture for vividness and emotionality. They then completed a treatment condition and then the suppression task before re-rating their memory of the picture. They then moved on to complete these tasks with the second picture.

Participants completed the Reading Span Task after finishing all the treatment conditions. At the conclusion of the experiment participants were verbally debriefed and the rationale of the study was briefly explained to them.

Results

The baseline vividness ratings for the child (*M*=7.95, *SD*=1.28) and gun (*M*=8.25,*SD*=.97) pictures did not differ significantly, *t*(19)=1.00, *p*=.33, *d*=.23. Similarly, baseline emotionality ratings for the child (*M*=6.70, *SD*=1.59) and gun (*M*=7.05, *SD*=1.64) pictures did not differ significantly, *t*(19)=.98, *p*=.34, *d*=.22. Table 4.1 shows pre and post emotionality and vividness scores, and total number of presses and presses per minute, as a function of eye-movement condition.

Changes in the rating of vividness and emotionality were assessed using separate 2(Time: pre vs. post) x 2(Treatment Condition: fast-eye-movement vs. no-eye-movement) repeated measures ANOVA's. For vividness there was no main effect for Treatment

Condition, $F(1, 19)=.64$, $p=.43$, $\eta_p^2=.03$, however, there was a main effect for Time, $F(1, 19)=49.15$, $p<.01$, $\eta_p^2=.72$. The main effect for Time indicates that ratings of vividness were lower in the post-ratings than in the pre-ratings for both treatment conditions. There was no interaction, $F(1, 19)=.77$, $p=.39$, $\eta_p^2=.04$.

Table 4.1

Means and standard deviations (in parentheses) for self-ratings and presses during suppression period: Study Four.

	Vividness		Emotionality		Presses			
	Pre	Post	Pre	Post	Total	Min.1	Min.2	Min.3
No-eye-movement	8.15 (1.27)	6.65 (1.14)	7.00 (1.62)	5.90 (2.38)	7.00 (4.26)	3.65 (2.58)	2.05 (1.28)	1.25 (1.12)
Fast-eye-movement	8.05 (.99)	6.25 (1.65)	6.75 (1.62)	5.40 (1.88)	7.05 (4.64)	3.75 (2.53)	1.95 (1.70)	1.35 (.99)

For emotionality there was no main effect for Treatment Condition, $F(1, 19)=1.18$, $p=.29$, $\eta_p^2=.06$, however, there was a main effect for Time, $F(1, 19)=31.27$, $p<.01$, $\eta_p^2=.62$. The main effect for Time indicates that ratings of emotionality were lower in the post-ratings than in the pre-ratings for both treatment conditions. There was no interaction, $F(1, 19)=.66$, $p=.43$, $\eta_p^2=.03$.

Figure 4.2 shows the total number of presses and presses per minute during suppression for the two conditions. A 3(Time: minute one vs. minute two vs. minute three) x 2(Treatment Condition: fast-eye-movement vs. no-eye-movement) repeated measures ANOVA was conducted to investigate the difference in number of presses per minute between the two conditions. There was a main effect for Time, $F(2, 38)=27.85$, $p<.01$, $\eta_p^2=.59$, with *t*-tests showing that number of presses fell from minute one to minute two ($t(19)=4.96$, $p<.01$, $d=.93$), and from minute two to minute three ($t(19)=3.19$, $p<.01$, $d=.61$).

There was no main effect for Treatment Condition, $F(1, 19)=.03$, $p=.87$, $\eta_p^2<.01$, and no interaction, $F(2, 38)=.12$, $p=.89$, $\eta_p^2=.01$.

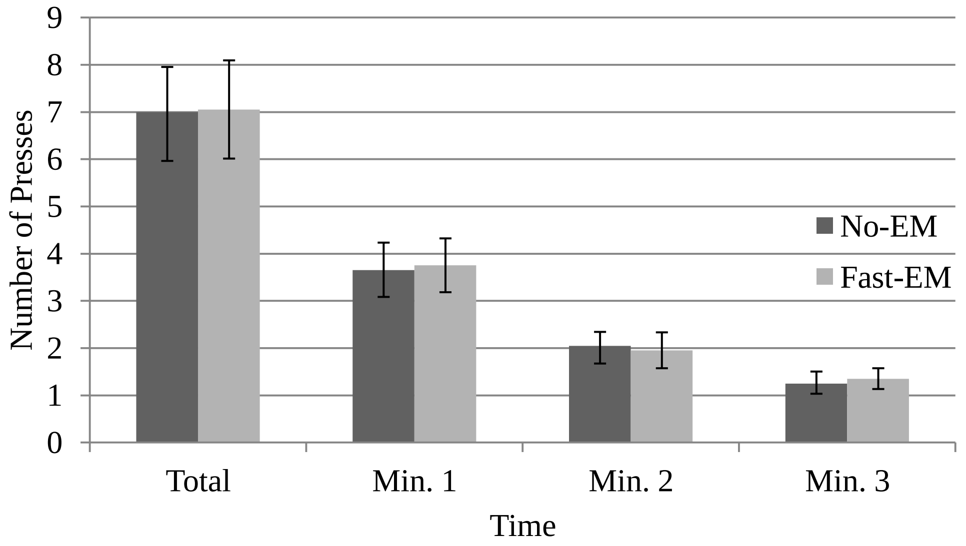

Figure 4.2. Total number of presses during suppression and number of presses per minute for the no-eye-movement (No-EM) and fast-eye-movement (Fast-EM) conditions.

Correlational analysis showed that Reading Span Task scores (*M*=28.15, *SD*=3.66) and number of presses in the fast-eye-movement condition were negatively correlated, $r=-.48$, $p=.03$, $R^2=.23$, indicating that participants with higher reading span scores recorded fewer presses in the suppression period following the fast-eye-movement condition than participants with lower reading span scores.

Discussion

Results from Study Four showed that fast-eye-movements did not significantly affect self-ratings of vividness and emotionality or number of intrusions when compared to no-eye-movements. This finding does not support the hypothesis that predicted a difference between the two treatment conditions. Study Four found that Reading Span Task scores were negatively correlated with the number of intrusions following the fast-eye-movement condition, as predicted.

The results from Study Four did not show the predicted differences between the fast and no-eye-movement conditions for either the self-ratings or suppression tasks. Perhaps for this reason there are no known published studies investigating the effect of eye-movements on novel negative stimuli such as photos or videos. This result conflicts with the results of the previous studies in this thesis that found fast-eye-movements lower self-ratings and intrusions of negative personal memories. However, this may be due to the stimuli used differing so greatly.

In evaluating the results of Study Four it is interesting to note the self-ratings of vividness and emotionality for the photo stimuli. Clearly the stimuli were initially remembered very vividly with participants rating them higher than negative personal memories have been rated in previous studies. They were also rated as emotional as negative personal memories have been. However, ratings of vividness and emotionality both fell substantially following both of the treatment conditions. This is in contrast to results from the previous studies that found self-ratings to be relatively stable in the no-eye-movement condition and to reduce slightly in the fast-eye-movement conditions.

That self-ratings were initially so high and then dropped significantly in both conditions is perhaps due to the participants being unable to form lasting images in their minds based on the ten seconds they got to view the photos. This inability to form lasting images then arguably led to the natural lowering of vividness and emotionality as participants simply forgot the photos during the following treatment conditions. Additionally, participants were asked to rate the photos immediately after they were presented on the screen when the memories of the photos were understandably very intense. Perhaps if participants were given some time or a distraction task after the presentation of the images this would provide a more stable baseline measure.

While alterations to this exploratory study may improve the validity of the design it is clear that using personal negative autobiographical memories is the preferred stimuli at this stage. Personal autobiographical memories have greater validity than pictures, and they are the target thoughts primarily used in previous eye-movement research. Rather than aiming to standardise the memories used in the studies it may be more useful to take more measures of the participants chosen events in order to ensure that they are as similar as possible. Additionally, moving to a between-groups design may help to alleviate concerns regarding cross-over effects.

Study Five

Study Two and Three have provided support for the hypothesis that eye-movements would lower the number of intrusive thoughts of a negative event. Study Three and Four have also provided support for the hypothesis that this effect is related to central executive capacity. However, none of the previous studies have tested the two other possible explanations: the interhemispheric interaction and orienting response explanations. The aim of Study Five is to test the central executive explanation against the orienting response explanation.

The orienting response explanation states that eye-movements create physiological de-arousal or relaxation that can persist for up to ten minutes after eye-movements stop (Kuiken et al., 2002). The relaxation caused by eye-movements then lowers the intensity of negative memories, resulting in lower self-ratings of vividness and emotionality (Barrowcliff et al., 2004). Regarding intrusive thoughts, relaxation may increase cognitive flexibility (Sack et al., 2008) enabling participants to disengage from the negative memories more easily. Hence, both the orienting response and central executive explanations result in the prediction that eye-movements will lower the number of intrusions compared to no-eye-movements.

Both the orienting response and central executive explanations predict that eye-movements will lower the number of intrusive thoughts. However, the central executive account predicts that eye-movements will only have this effect on negative memories when the memories are thought about during the eye-movements (van den Hout et al., 2001). This is because the two tasks must be competing for attention in the central executive to produce the effect. If an effect is found for eye-movements even when they are conducted without thinking of the negative memory then this finding would not support the central executive account.

The orienting response explanation, in contrast, predicts that the relaxation caused by eye-movements should produce an effect even if eye-movements are not conducted at the same time as thinking of the memory (Gunter & Bodner, 2008). Hence, if an effect is found for eye-movements conducted without thinking about the negative memory then this finding would support the orienting response explanation. To test the competing explanations, Study Five follows that of Gunter and Bodner's (2008) Experiment One, which tested the same explanations. In their study, Gunter and Bodner (2008) measured the effect of eye-movements on self-ratings of negative memories and some physiological measures. However, they used a mixed-model design incorporating two groups: one group held their memories in mind (the in-mind group) while conducting the treatment conditions and the other group did not hold their memories in mind (the not-in-mind group).

The hypothesis for Study Five is that the fast-eye-movement condition will only affect memories in the in-mind group, with no effect expected for the not-in-mind group. This hypothesis is driven by the findings of Gunter and Bodner (2008), however Study Five will also include suppression of negative memories as a dependent variable. This hypothesis is consistent with the central executive explanation for the effectiveness of eye-movements. Additionally, a negative relationship between scores on the Reading Span Task and intrusive thoughts in the fast-eye-movement condition of the in-mind group is expected, as found in Studies Three and Four.

Method

Design

This study used a mixed-model design to compare a fast-eye-movement condition to a no-eye-movement condition, with number of target thoughts during a suppression period and self-ratings of vividness and emotionality as the within-group dependent variables. The sample was also split into two groups; one group held their memories in-mind while completing the treatment conditions and one group did not hold their memories in-mind.

Participants

Eighty-eight under-graduate students from Victoria University of Wellington (22 males; age *M*=19.00, *SD*=2.67) received course credit for participating in the experiment. Participants were blind to the experimental manipulation and had no previous knowledge of EMDR.

Materials

Participants were provided with a pen and lined paper to write about their memories, as well as an envelope in which to put the paper afterwards to ensure privacy. Verbal responses to self-ratings of vividness and emotionality were recorded by the experimenter on 10-point Likert scales. The computer programme for the fast- and no-eye-movement conditions and suppression periods was identical to that used in Study Two. The same version of the Reading Span Task from Study Three was also used.

Procedure

The experiment was completed individually in front of a computer in a quiet laboratory room in the psychology faculty building on the university campus. The procedure closely followed that used in Study Two; however the participants were randomly split into the in-mind and not-in-mind groups. Those participants in the in-mind group were instructed to concentrate on their memories during the treatment conditions as usual. However, those in the not-in-mind group were given no instructions regarding what to think about, closely following the procedure of Gunter and Bodner (2008). Based on the success of their results, the first author of the Gunter and Bodner (2008) paper concluded that not giving any instructions regarding thoughts was sufficient to minimise thoughts of negative memories in the not-in-mind group (personal communication, 2012). Additionally, participants completed the Reading Span Task after finishing both treatment conditions.

Results

Means and Standard Deviation for pre and post ratings of vividness and emotionality as well as total number of presses and presses per minute are shown on Table 5.1. ANOVA showed no significant differences in pre ratings between the in-mind and not-in-mind groups, however, the difference between the conditions for pre vividness ratings, $F(1,86)=3.89$, $p=.052$, $\eta_p^2=.04$, were approaching significance.

Table 5.1

Means and standard deviations (in parentheses) for self-ratings and presses during suppression: Study 5.

Group	Treatment	Emotionality		Vividness		Presses			
		Pre	Post	Pre	Post	Total	Min.1	Min.2	Min.3
In-mind	Fast-eye-movement	6.50 (1.98)	6.05 (2.19)	6.95 (1.61)	6.91 (1.59)	5.93 (4.81)	3.23 (3.34)	1.52 (1.55)	1.16 (1.52)
	No-eye-movement	6.59 (2.13)	6.59 (2.38)	7.59 (1.54)	7.73 (1.70	7.82 (7.56)	4.05 (3.64)	2.05 (2.30)	1.73 (2.05)
Not-in-mind	Fast-eye-movement	7.14 (1.85)	6.57 (1.82)	7.64 (1.63)	7.25 (1.84)	6.59 (4.71)	3.34 (2.54)	1.66 (1.58)	1.64 (1.56)
	No-eye-movement	7.18 (1.86)	6.59 (2.17)	7.70 (1.47)	7.09 (1.75)	6.25 (5.04)	2.82 (2.03)	1.86 (1.69)	1.57 (1.99)

Separate 2(Treatment Condition: fast-eye-movement vs. no-eye-movement) x 2(Time: pre vs. post) x 2(Group: in-mind vs. not-in-mind) ANOVAs were conducted for vividness and emotionality ratings. For vividness a main effect of Time was found, $F(2, 86)=3.99$, $p=.05$, $\eta_p^2=.04$, indicating that ratings of vividness were lower in post-test when compared with pre-test. There was no main effect for Treatment Condition, $F(2, 86)=2.35$, $p=.13$, $\eta_p^2=.03$, and no main effect for Group, $F(2, 86)=.29$, $p=.59$, $\eta_p^2<.01$. The only significant interaction was between Time and Group, $F(2, 86)=5.75$, $p=.02$, $\eta_p^2=.06$. Follow-up testing showed no difference in vividness ratings pre ($M=7.27$, $SD=1.16$) to post ($M=7.32$, $SD=1.19$) for the in-mind group, $t(43)=.27$, $p=.79$, $d=.04$. However, a difference was found in vividness ratings pre ($M=7.67$, $SD=1.11$) to post ($M=7.17$, $SD=1.35$) for the not-in-mind group, $t(43)=3.32$, $p<.01$, $d=.51$.

For Emotionality a main effect for Time was found, $F(2, 86)=18.47$, $p<.01$, $\eta_p^2=.18$; indicating that ratings of emotionality were lower in post-test when compared with pre-test. There was no main effect for Treatment Condition, $F(2, 86)=.39$, $p=.53$, $\eta_p^2=.01$, and no main effect for Group, $F(2, 86)=2.05$, $p=.16$, $\eta_p^2=.02$. The interaction between Time and Group, $F(2, 86)=3.52$, $p=.064$, $\eta_p^2=.04$, was not significant nor were the other interactions.

Figure 5.1 shows the total number of presses and presses per minute for both the treatment conditions in both groups. Regarding the number of intrusions during the suppression period a 2(Treatment Condition: fast-eye-movement vs. no-eye-movement) x 3(Time: min 1 vs. min 2 vs. min 3) x 2(Group: in-mind vs. not-in-mind) ANOVA was conducted. A main effect was found for Time, $F(2, 86)=53.02$, $p<.01$, $\eta_p^2=.56$, with t-tests showing that number of presses fell between minute one and minute two ($t(87)=9.16$, $p<.01$, $d=.78$), and minute two and minute three ($t(87)=2.45$, $p=.02$, $d=.16$). There was no main effect for Treatment Condition, $F(2, 86)=2.35$, $p=.13$, $\eta_p^2=.03$. There was an interaction between Treatment Condition and Group, $F(2, 86)=5.34$, $p=.02$, $\eta_p^2=.06$. Follow-up *t*-tests showed that participants in the in-mind group pressed less following the fast-eye-movement condition than the no-eye-movement condition, $t(43)=2.72$, $p=.01$, $d=.49$. No difference in number of presses was found between the treatment conditions in the not-in-mind group, *t*(43)=.49, *p*=.63, *d*=.07.

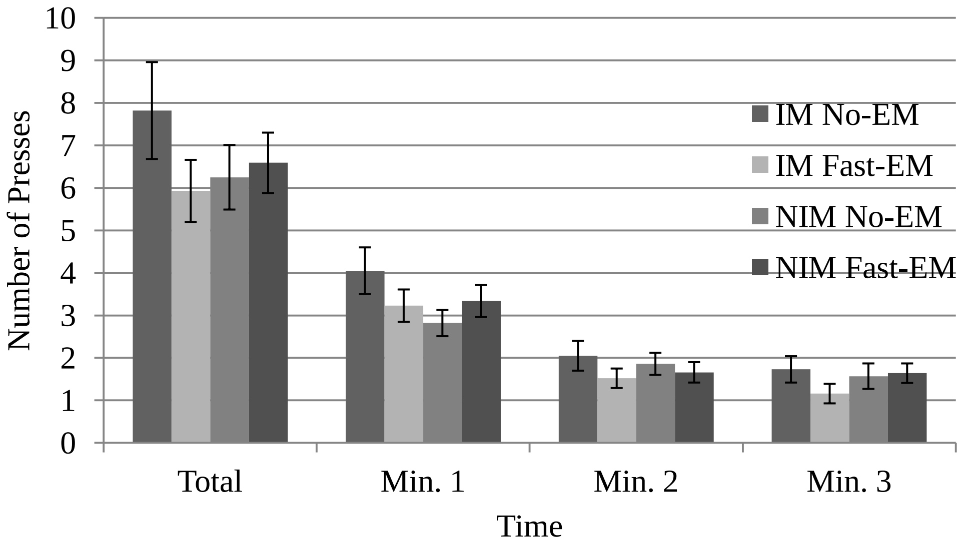

Figure 5.1. Total number of presses during suppression and number of presses per minute for the no-eye-movement (No-EM) and fast-eye-movement (Fast-EM) conditions in the in-mind (IM) and not-in-mind (NIM) groups.

Scores on the Reading Span Task (*M*=27.72, *SD*=4.59) were positively correlated with presses in the fast-eye-movement condition, *r*(88)=.25, *p*=.02, R^2=.06. However, this correlation was significant only for the not-in-mind group, *r*(44)=.36, *p*=.02, R^2=.13, and not for the in-mind group, *r*(44)=.14, *p*=.36, R^2=.02.

Discussion

In Study Five fast-eye-movements did not affect self-ratings in either group, although vividness was lower post compared to pre across both treatment conditions in the not-in-mind group. For intrusions during the suppression period there was an effect found for the in-mind group, whereby fast-eye-movements lowered the number of intrusions compared to no-eye-movements. There was no effect between the treatment conditions for the not-in-mind group.

Scores on the Reading Span Task were positively correlated with number of intrusions in the fast-eye-movement condition but only for the not-in-mind group.

The null finding for self-ratings with the in-mind group does not replicate findings from Study One, Two, and Three that have found fast-eye-movements affect either vividness or emotionality ratings. Nor are they consistent with results from other researchers, who reliably find that eye-movements affect self-ratings of vividness and emotionality (e.g. Gunter & Bodner, 2008; Kavanagh et al., 2001; van den Hout et al., 2001). Since the in-mind condition did not differ from Study Two and only slightly from Study Three it is unknown why the expected effect was not found. However, taken independently these results do not support the hypothesis that eye-movements lower self-ratings of negative memories when they are recalled following a period of suppression.

It is also inconsistent with at least one published study that in the not-in-mind group, vividness ratings did fall overall. This is in contrast to the results of Gunter and Bodner (2008) who did not report such an interaction. The orienting response hypothesis does predict that self-ratings will fall even when memories are not-in-mind. However, it does not predict that this will occur for both treatment conditions since the no-eye-movement condition will not produce a relaxation effect. Hence, this finding cannot be seen as support for the orienting response hypothesis.

While interpreting the drop in vividness ratings for the not-in-mind group it is important to recognise that participants in this group spent a substantial amount of time not thinking about their memories. Indeed, participants in the not-in-mind group spent over five minutes trying not to think about their memories. First they were conducting the treatment conditions where they were not required to think about the memories and then completed a further three minutes of active suppression. It is possible that spending this amount of time disengaged with the negative memory has allowed the vividness of the recalled memory to weaken.

Study Five again shows, as did Study Two and Three, that fast-eye-movements can lower the number of intrusions during a suppression period when compared to no-eye-movements. Importantly for the central executive explanation this effect was only found for the in-mind group, and not for the not-in-mind group. This finding supports the hypothesis that eye-movement effects on intrusions are related to central executive functions, since the memory must be held in mind for the eye-movements to have any effect. In contrast, the findings do not support an orienting response explanation since the eye-movements did not have an effect on intrusions in the not-in-mind group.

Results from Study Five found a positive correlation between scores on the Reading Span Task and number of intrusions in the fast-eye-movement condition of the not-in-mind group. This correlation indicates that the higher participants central executive capacity the more intrusions they are likely to have in the suppression period following fast-eye-movements but only if the memory is not held in-mind. It is also unusual that no negative correlation was found between Reading Span Task scores and intrusions following fast-eye-movements for the in-mind group. This result was expected given this correlation was found in Studies Three and Four.

Taken independently this positive correlation suggests that as executive capacity increases the effects of fast-eye-movements on intrusions decreases. This may be due to participants with greater executive capacity finding the fast-eye-movements less taxing. How this applies only to the not-in-mind group is unknown. Researchers have found that conducting eye-movements prior to recall of autobiographical memories can improve the quality of recall (Christman et al., 2003). Perhaps, in Study Five, the fast-eye-movements in the not-in-mind group have somehow made memories more available. This increased availability has then increased the number of intrusions during suppression. However, this is entirely speculative and how exactly this effect is related to central executive capacity, as measured by the Reading Span Task, is unknown.

A further conclusion that can be made from the results of Study Five is that the effect of fast-eye-movements on intrusive thoughts is unlikely to be due to an expectancy effect. It is arguable that the results of previous studies have been due to participants expecting more benefits from the more active treatment condition. Clearly, the fast-eye-movement condition is more active that the no-eye-movement condition and concerns regarding an expectancy effect are more compelling given the reliance on within-subjects designs. For example, participants may infer that the experimenter expects fewer intrusions after the fast-eye-movement condition and may then report fewer intrusions. If the expectancy affect criticism is correct, both groups should have generated the same expectancies and had similar results for their respective fast-eye-movement conditions. However, this study only found an effect for fast-eye-movements in the in-mind group.

Again, a weakness with the design of Study Five is the reliance on a within-group design. While Study Five shows that results are unlikely to have been influenced by expectancies, concerns remain regarding carryover effects despite counter-balancing and the use of a distraction task between conditions. Additionally, only the self-ratings of vividness and emotionality were used to ensure memories were as similar as possible.

Study Six

Studies Two, Three, and Five found that eye-movements lowered the number of intrusive thoughts of a negative memory and provided some support for the central executive explanation. Additionally, the results from Study Five did not support the orienting response explanation as expected results were not found for the not-in-mind group. The next explanation to test is the interhemispheric interaction explanation, which claims that the effect of eye-movements on negative memories is due to an increase in the communication between the two hemispheres of the brain (Propper & Christman, 2008).

The interhemispheric interaction explanation for the effectiveness of eye-movements on self-ratings, but not intrusions, has been tested against the central executive explanation in previous research. The findings of two particular studies, discussed earlier, did not find support for the interhemispheric interaction explanation (Gunter & Bodner, 2008; Hornsveld et al., 2011). These researchers posited that vertical eye-movements do not increase interhemispheric interaction and so should not influence self-ratings of negative memories according to the interhemispheric interaction explanation. However, vertical eye-movements do require central executive resources and so should affect self-ratings if the central executive account is correct. It was found that vertical eye-movements did have an effect equal to horizontal eye-movements, which supports the central executive explanation but not the interhemispheric interaction explanation.

Study Six included a vertical and horizontal eye-movement condition in order to test the two explanations with regards to the suppression of memories. In addition it was decided to include a counting condition that does not require eye-movements at all. The counting condition was included to further test the interhemispheric interaction explanation. There is no research to suggest that counting increases interhemispheric communication. Therefore, if the interhemispheric communication explanation is correct this condition should not affect suppression of negative memories. Difficult counting tasks do, however, require central executive resources (Kristjansdottir & Lee, 2011). Therefore, if the central executive explanation is correct then the counting condition will have an effect on suppression.

Additionally, since counting does not affect the visuo-spatial sketchpad the counting condition will also help differentiate the location of the effect of eye-movements in working memory (Gunter & Bodner, 2008). If the central executive explanation is correct then counting, which requires central executive resources but not visuo-spatial resources, should affect intrusions. The counting condition can also be seen as a further test of the orienting response explanation: counting should not create an orienting response and, therefore, should not affect memories according to the orienting response explanation.

Study Six also directed addressed three on-going limitations from previous studies. The first of these is concerns regarding any possible carry-over effects from using within-subjects designs. While Study Five used a mixed-model design all the previous studies apart from the Pilot Study have used a within-subjects design where every participant completes every treatment condition using a different memory for each. While this was done to control for large variation in the number of intrusions that different participants had, as shown in the Pilot Study, it does raise a number of difficulties regarding possible carry-over effects between both treatment conditions and memories.

To move to a between-subjects design, where each participant only completes one treatment condition with one memory, it was decided that participants should complete one suppression period before the treatment condition and then another suppression period following. This allows for the first suppression period to be taken as a baseline measure of suppression of that particular participant and memory. This can then be compared to the suppression period after the treatment condition to see if there are any changes.

A second limitation of the previous studies is the reliance on self-ratings of vividness and emotionality to ensure memories are as similar as possible between participants and groups. Clearly, there is more to memories and negative experiences than just those two ratings. For this reason Study Six incorporated a questionnaire designed to screen for diagnostic criteria of PTSD. This measure will further allow comparison between the groups to help ensure there are no differences between the memories used in the treatment conditions.

The third limitation of the methodology of previous studies is the reliance on the Reading Span Task as a measure of central executive capacity. While the Reading Span Task is an accurate measure of executive capacity it measures very general resources rather than specific abilities. Therefore, Study Six included a task designed to measure the central executive function of suppression, rather than executive capacity generally. This task allows checks to be made regarding the suppression abilities of the participants in each treatment group, to ensure suppression ability is consistent between the groups.

The hypothesis of Study Six is that fast-eye-movements, vertical-eye-movements, and counting will lower self-ratings and number of intrusions compared to the no-eye-movement control as predicted by the central executive explanation.

Method

Design

This study used a between-groups design to compare fast-eye-movements, vertical-eye-movements, no-eye-movements, and counting treatment conditions. The dependent variables were number of intrusions during a suppression period and self-ratings of vividness and emotionality both before and after the treatment conditions.

Participants

One-hundred and seventy-two under-graduate students from Victoria University of Wellington (45 males; age *M*=18.73, *SD*=1.37) received course credit for voluntarily participating in the experiment. Participants were blind to the experimental manipulation and had no previous knowledge of EMDR.

Materials

Verbal responses to self-ratings of vividness and emotionality were recorded by the experimenter on 10-point Likert scales. The computer programme for the fast- and no-eye-movement conditions and suppression periods was identical to that used in Study Two, except that a 3-minute suppression period, identical to that used in Study Two, preceded the treatments. Participants in the vertical-eye-movement condition were given the same instructions as those in the fast-eye-movement condition. While the size of the dot and the speed of movement was the same as the fast-eye-movement condition, the dot in the vertical-eye-movement condition blinked from the top to the bottom of the screen. The same stimuli were used in the no-eye-movement and counting conditions, but different instructions were given.

The Impact of Event Scale-Revised (IES-R: Weiss & Marmar, 1997) was developed as a screening tool to match DSM-IV criteria for PTSD and has been validated with a number of different populations (Weiss, 2007). The IES-R was included in the experiment to help ensure that the events and memories participants used were as similar as possible between the experimental groups. The IES-R requires participants to respond to a 22-item questionnaire about how distressed they have been by difficulties related to a specific event during the last week. Responses to items are recorded on Likert scales from 0 (Not at all) to 4 (Extremely). The IES-R (α=.95) includes three subscales: Avoidance (α=.86: 8-items such as “I stayed away from reminders about it”), Intrusions (α=.90: 8-items such as “Any reminder brought back feelings about it”), and Hyperarousal (α=.85: 6-items such as “I was jumpy and easily startled”), with both the total scores and subscales having good consistency and reliability (Beck et al., 2008).

Participants also completed a version of the Directed Forgetting Task (DFT). There are two types of DFT commonly used in the literature: the item-method task and the list-method task. In the item-method version participants are shown a list of items that are presented one at a time and are each followed by a cue to either remember or forget the item. In the item-method task participants typically recall more items they were instructed to remember than items they were instructed to forget during a recall task. In the list-method version participants see the whole list of items before being given the instruction to either remember or forget them, and recall is again generally worse for items in the list they were instructed to forget (see Bjork, 1998, for a review of the different methods).

Research suggests that the two versions of the DFT involve inhibition for memory at different stages. The item-method involves inhibition at the encoding stage, whereby efforts to encode the item are either abandoned or increased depending on whether the instruction is to forget or remember. The list-method involves inhibition at the retrieval stage, whereby the items are already encoded but recall of the items in the forget list is inhibited (Barnier et al., 2007). Since this experiment is concerned with the suppression of autobiographical memories that are already encoded the list-method of the DFT was used. In the DFT participants were given the following instructions:

> This is a memory task where you have to try to remember words. You will be shown the words on the computer screen one at a time. The words will be shown in the middle of the screen for three seconds each and there will be a gap of two seconds between words. Press the spacebar to begin.

Participants were then shown a list of 12-words (the forget-list) that were presented individually in the middle of the computer screen in size 12 Times New Roman font. After presentation of the forget-list a new set of instructions were given:

> What you have done so far has been practice; therefore you should forget about all of the to-be-learned words that have been presented. The list you will see next is the one we want you to remember, so forget the practice list and concentrate on this new list.

Participants were then shown another list of 12 different words (the remember-list). After presentation of the remember-list participants were asked to count backwards from 30 in sets of 2, as a distraction task. Participants were then asked to recall all the words they could remember from the forget-list by writing them down in any order, and were given one minute to recall as many as possible. Finally, participants were asked to recall as many words from the remember-list as possible and were again given one minute. Participants recalled the lists in this order since it produces "perfect measures of list 1 forgetting… (Pastotter, Kliegl, & Bauml, 2012, pp.11), and the aim of the DFT in this experiment was to measure ability to suppress the retrieval of memories.

Words for the DFT were selected from the Affective Norms for English Words database (Bradley & Lang, 1999) and were matched between the lists for valence (*t*(22)=.38, *p*=.71, *d*=.17), arousal (*t*(22)=.29, *p*=.78, *d*=.12), frequency (*t*(22)=.08, *p*=.94, *d*=.03), and length (*M*=5.67, *SD*=1.23 for both lists). Words were presented randomly within the lists (List one: cannon, cellar, frog, truck, journal, razor, scissors, ankle, hammer, skull, tank, and trumpet. List two: stove, runner, lump, whistle, glacier, avenue, narcotic, tool, swamp, fabric, storm, and clock). List presentation was counterbalanced between participants with half receiving list one first (as the forget-list) and half receiving list two first.

Procedure

The experiment was completed individually in front of a computer in a quiet laboratory room in the psychology faculty building on the university campus. Participants were first asked if they had any knowledge of EMDR therapy, and only those who responded negatively (all of the potential participants) were allowed to continue with the experiment. Participants were randomly assigned to one of the four treatment conditions. Their gender and ages were recorded and then participants were asked to:

> Please recall an event that made you feel very fearful, anxious, or distressed. This event should still have some emotional impact. Examples of this type of event include going unprepared into an exam or witnessing an accident.

Once the participant had indicated they had selected a memory they were asked to concentrate on it for ten seconds and then to rate the vividness and emotionality of the memory as in previous studies.

After rating the memories participants were instructed to suppress the memories for three minutes with instructions as given in previous studies. Following this ‘pre’ suppression period participants were given the instructions for their particular treatment condition. For the fast-eye-movement and no-eye-movement conditions the instructions given were identical to those from previous studies. Participants in the vertical-eye-movement condition were given the same instructions as those in the fast-eye-movement condition. Participants in the counting condition were given the following instructions:

> In this part of the experiment you are required to think about the memory while keeping your eyes on a dot on the computer screen. Keep your eyes on the dot and your head as still as possible, but blink whenever you need to. At the same time, count backwards out loud from 300 in sets of 2, so you would go 300, 298, 296, 294, etcetera. Concentrate on the memory as much as you can. You will get short breaks where you can rest your eyes and think about something else.

After completion of the treatment conditions participants were again instructed to suppress their memories for three minutes. Following this ‘post’ suppression period, participants again rated the vividness and emotionality of their memories. Participants then completed the IES-R questionnaire and then the DFT.

Results

ANOVA showed no significant differences between the four treatment groups in self-ratings of vividness ($F(3,171)=.14$, $p=.94$, $\eta_p^2=.003$) and emotionality ($F(3,171)=.91$, $p=.44$, $\eta_p^2=.016$) made before the treatment conditions (pre ratings). Similarly, no difference between treatment groups was found in number of presses during the suppression period before treatment conditions, $F(3,171)=.15$, $p=.93$, $\eta_p^2=.003$.

Separate 2 (Time: pre vs. post) x 4 (Treatment Condition: no-eye-movement vs. fast-eye-movement vs. vertical-eye-movement vs. counting) were conducted for vividness and emotionality ratings. For vividness neither the main effect for Time, $F(1,168)=.24$, $p=.63$, $\eta_p^2=.001$, nor the interaction, $F(3,168)=1.03$, $p=.38$, $\eta_p^2=.018$, were statistically significant. For emotionality the main effect for Time, $F(1,168)=6.23$, $p=.01$, $\eta_p^2=.036$, was significant indicating that emotionality ratings tended to be lower overall for the post ratings than the pre ratings. The interaction, $F(3,168)=1.28$, $p=.28$, $\eta_p^2=.022$, was non-significant.

Table 6.1

Means and standard deviations (in parentheses) for self-ratings, total number of presses, press index, and IES-R total and subscale scores.

	Vividness		Emotionality		Presses		Press Index	IES-R			
	Pre	Post	Pre	Post	Pre	Post		Total	Avoi	Intr	Hyp
NoEM	7.74 (1.22)	8.07 (1.33)	7.49 (1.50)	7.47 (1.93)	8.67 (7.77)	9.02 (8.17)	-.35 (4.49)	25.53 (15.35)	1.38 (.84)	1.27 (.85)	.80 (.75)
FastEM	7.81 (1.55)	7.91 (1.57)	6.91 (2.07)	6.74 (2.23)	7.95 (6.32)	5.65 (4.87)	2.30 (4.31)	27.35 (16.52)	1.42 (.75)	1.39 (.96)	.89 (.77)
VertEM	7.65 (1.23)	7.26 (1.45)	6.98 (1.47)	6.58 (2.30)	7.88 (6.11)	6.37 (5.41)	1.51 (3.51)	25.91 (17.66)	1.33 (.83)	1.28 (.93)	.90 (.87)
Count	7.81 (1.35)	7.65 (1.43)	7.16 (2.02)	6.81 (1.89)	8.58 (7.48)	6.67 (6.24)	1.91 (4.17)	27.81 (16.56)	1.49 (.82)	1.31 (.86)	.96 (.77)

To create an index of suppression (Press Index) the number of presses in the second period of suppression were subtracted from the number of presses in the first period of suppression (Descriptive statistics for this and other measures are shown on Table 6.1).

Therefore, a positive value on this index indicates fewer presses after the treatment condition compared to before the treatment condition, while a negative value indicates more presses after the treatment condition. This creates a single value that partially controls for the large variation in number of presses between participants and allows for comparison between treatment groups.

An ANOVA showed a significant difference in Press Index scores between the Treatment Conditions, $F(3,168)=3.46$, $p=.018$, $\eta_p^2=.058$. Follow-up *t*-tests showed a significant difference between no-eye-movement and fast-eye-movement ($t(84)=2.79$, $p=.006$, $d=.61$), vertical-eye-movement ($t(84)=2.14$, $p=.035$, $d=.47$), and counting ($t(84)=2.41$, $p=.018$, $d=.53$) Treatment Conditions. The fast-eye-movement, vertical-eye-movement, and counting Treatment Conditions did not significantly differ from each other. This result indicates that participants in the no-eye-movement condition pressed more post compared to pre than did those participants in the other Treatment Conditions (shown in Figure 6.1).

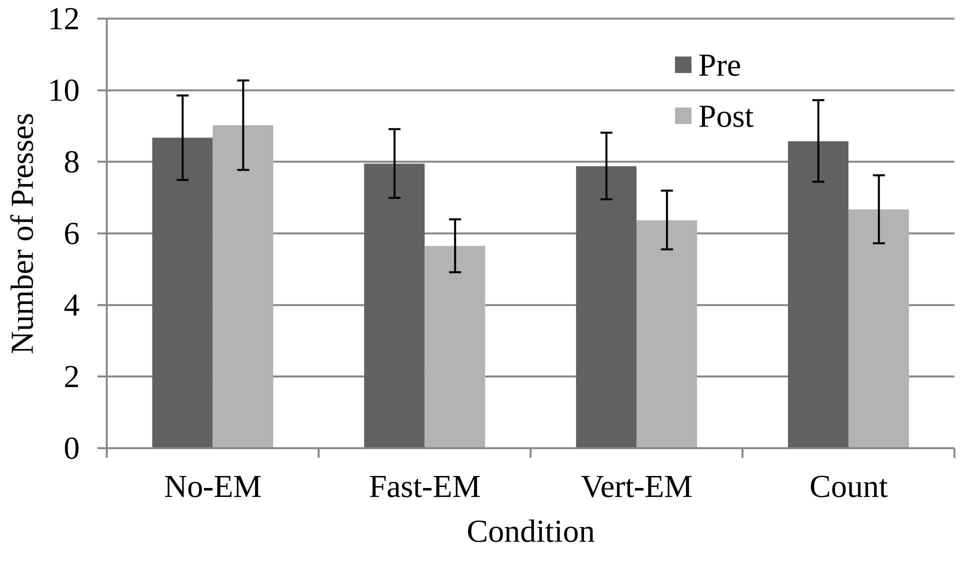

Figure 6.1. Presses during suppression pre and post treatment for the no-eye-movement (No-EM), fast-eye-movement (Fast-EM), vertical-eye-movement (Vert-EM), and counting (Count) conditions.

Internal consistency of total IES-R (α=.92) scores and the avoidance (α=.80), intrusion (α=.87), and hyperarousal (α=.82) subscales was good. ANOVA's showed no difference between the Treatment Conditions with total scores on the IES-R ($F(3,168)=.19$, $p=.904$, $\eta_p^2=.003$) or the avoidance ($F(3,168)=.32$, $p=.814$, $\eta_p^2=.006$), intrusion ($F(3,168)=.18$, $p=.913$, $\eta_p^2=.003$), or hyperarousal ($F(3,168)=.31$, $p=.817$, $\eta_p^2=.006$) subscales. This indicates that the effect that memories had on the participants over the week prior to the experiment was similar between all the Treatment Conditions.

ANOVA showed that the groups did not differ significantly on the forget-list of the DFT, $F(3,168)=1.18$, $p=.32$, $\eta_p^2=.021$. However, there was a difference found for the remember-list, $F(3,168)=3.09$, $p=.03$, $\eta_p^2=.052$. Follow-up *t*-tests showed a significant difference on number of remember-list words recalled between the no-eye-movement condition and both the vertical-eye-movement ($t(84)=2.26$, $p=.03$, $d=.49$) and counting ($t(84)=2.87$, $p=.005$, $d=.63$) conditions, but no other significant differences were found.

There were small significant correlations between the forget-list of the DFT ($M=4.41$, $SD=2.77$) and both presses pre ($r(172)=.17$, $p=.024$, $R^2=.029$) and presses post ($r(172)=.20$, $p=.008$, $R^2=.04$) indicating that number of words recalled from the list that could be forgotten increased along with the number of intrusions during the suppression periods. The remember-list of the DFT ($M=5.73$, $SD=2.56$) was moderately correlated with the forget-list ($r(172)=.43$, $p<.001$, $R^2=.18$) but not with any other factors.

Discussion

Study Six shows that the treatment conditions did not differ in their effects on self-ratings of vividness or emotionality. They did, however, differ on presses during the suppression periods: the number of presses went down from pre to post in the fast-eye-movement, vertical-eye-movement, and counting conditions while remaining static in the no-eye-movement condition. Small correlations were found between the forget-list of the DFT and presses during both suppression periods.

The finding that the treatment conditions did not affect self-ratings of vividness and emotionality does not accord with the findings of Study One, Two, and Three. Those earlier studies found that fast-eye-movements did affect either vividness or emotionality of negative memories. As mentioned before, many other researchers have also found that horizontal and vertical eye-movements along with counting tasks have reduced self-ratings of negative memories (e.g. Gunter & Bodner, 2008; Kavanagh et al., 2001; van den Hout et al., 2001). This discrepancy is likely due to the difference in methodology between Study Six and previous studies and research. Study Six is particularly different given that participants had to go through two periods of suppression before re-rating their memories.

Study Six also shows that fast-eye-movements lower the number of intrusions compared to no-eye-movements, as has also been found in Study Two, Three, and Five. Vertical-eye-movements and counting also lowered the number of intrusions compared to the no-eye-movement condition. The finding for vertical-eye-movements supports previous research that has found vertical-eye-movements affect negative memories by lowering self-ratings (Gunter & Bodner, 2008). The finding for counting also supports previous research that has found counting affects negative memories by lowering self-ratings (Gunter & Bodner, 2008; Kristjansdottir & Lee, 2011; Isaacs, 2004; van den Hout et al., 2011).

The results of Study Six offer further support to the central executive explanation of the effectiveness of eye-movements. As the central executive explanation predicted, the fast- and vertical-eye-movement conditions along with the counting condition all resulted in fewer intrusions compared to the no-eye-movement condition. Since the interhemispheric interaction explanation does not predict a result for vertical-eye-movements and counting condition the current results do not support this explanation. Additionally, since the orienting response explanation does not predict a result for the counting condition the results do not support this explanation. The result found for the counting condition offers further support for the central executive explanation since this finding suggests the locus of the effect is not the visuo-spatial system of working memory.

The results from IES-R scores and self-ratings of vividness and emotionality show that the characteristics of the memories and events participants chose were similar between the treatment groups. Scores on the IES-R also indicate that participants had current and significant troubles regarding their negative events. Indeed, scores compare well with studies of participants who have experienced a traumatic event involving death or serious injury, or the threat of. For example, one study of 239 university students who had experienced a traumatic event found scores on the IES-R of *M*=16.5, *SD*=16.8 (Adkins, Weathers, McDevitt-Murphy, & Daniels, 2008). Another study of emergency room patients who had experienced a traumatic event found scores of *M*=28.45, *SD*=23.73 at approximately 168 days after admission (King et al., 2009). While such comparisons are rudimentary, it is clear that participants in Study Six suffered significant difficulties regarding the events that they chose to use during the experiment.

The groups did not differ on recall of the forget-list of the DFT. The correlations found between scores on the forget-list of the DFT and numbers of intrusions during the suppression periods were small. Nevertheless, the correlations indicate a relationship between central executive suppression abilities and suppression of negative memories in the current studies. The finding that remember-list DFT scores were different between both vertical-eye-movement and counting conditions and the no-eye-movement condition is more difficult to explain. Research has found that tasks such as eye-movements can improve recall of some memories (Christman et al., 2003). However, if this was the case an effect would also be expected for the fast-eye-movement condition.

Study Six successfully addressed the noted limitations of previous studies. A between-subjects design was used, the IES-R was added to aid comparison of memories between groups, and the DFT was used as a specific measure of central executive suppression. Despite this attempt to address limitations, many other limitations can be noted that are consistent throughout the different studies. These limitations will be noted and expanded upon in the general discussion to follow.

Chapter 4

General Discussion

The current studies investigated the hypothesis that eye-movements would lower self-ratings of the vividness and emotionality of negative memories when compared to no-eye-movements. However, the results were inconsistent in this regard and did not completely support the hypothesis. A second hypothesis was that eye-movements would improve suppression of memories of negative events when compared to no-eye-movements. The results showed that fast-eye-movements reliably lower the number of intrusive thoughts during suppression when compared to no-eye-movements, in support of the hypothesis. The third hypothesis was that the results would fit the central executive explanation. The results supported the central executive explanation more than either the orienting response or interhemispheric interaction explanations.

Summary of Findings

The pilot study was intended as an exploratory study into a possible mixture between eye-movement and suppression research. The pilot study used a between-groups design to evaluate the effect of eye-movements on suppression of thoughts of a white bear. Results showed that fast-eye-movements did not affect suppression of thoughts of a white bear, when compared to no-eye-movements. The pilot study indicated that a within-group design may be preferable and that personal autobiographical memories should be used to more closely follow the methodology of eye-movement research.

Study one used a within-group design to compare the effect of fast-eye-movements and no-eye-movements on self-ratings and suppression of negative autobiographical memories. Results showed that fast-eye-movements lower self-ratings of vividness but not emotionality of memories. Fast-eye-movements did not affect suppression for the whole sample. However, participants whose self-ratings of vividness were affected by fast-eye-movements also had fewer intrusions following eye-movements than following the no-eye-movement control.

Study two included minor adjustments to the methodology in order to focus the experiment on the suppression of memories. A within-group design was used with the suppression period occurring before re-rating the memories. Two questionnaires, the TCQ and WBSI, were also included to attempt to get a better understanding of the results. Results showed that eye-movements lowered self-ratings of emotionality and resulted in fewer intrusive thoughts than the no-eye-movement condition. A positive correlation was found between WBSI scores and intrusions in the eye-movement condition.

Study three used a within-group design and tested fast-eye-movements against a no-eye-movement control, but also included a slow-eye-movement condition. This extra condition was included as a test of the central executive explanation, as was the inclusion of the Reading Span task. Results found that fast-eye-movements lowered self-ratings of vividness and resulted in fewer intrusions than slow- or no-eye-movements. The difference in number of intrusions between slow- and no-eye-movements was not statistically significant. Scores on the Reading Span Task were negatively correlated with number of intrusions in the fast-eye-movement condition.

Study four substituted negative autobiographical memories for pictures from the International Affective Picture System database (Lang et al., 2008). Results showed that fast-eye-movements did not lower self-ratings of pictures or result in fewer intrusive thoughts than the no-eye-movement condition. Scores on the Reading Span Task were negatively correlated with number of intrusions in the fast-eye-movement condition.

Study five was designed as a test of the central executive and orienting response explanations. Participants were randomly placed in one of two groups; the in-mind group concentrated on their negative memories during the treatment conditions and the not-in-mind group were given no instructions. Results showed that self-ratings did not differ between the treatment conditions in either group. Participants in the in-mind group had fewer intrusions following fast-eye-movements than no-eye-movements but this effect was not found for the not-in-mind group. Scores on the Reading Span Task were positively correlated with number of intrusions in the fast-eye-movement condition only in the not-in-mind group.

Study six was designed as a test of the central executive, orienting response, interhemispheric interaction, and visuospatial sketchpad explanations. Using a between-groups design, intrusions before and after treatment were compared across fast-, vertical-, and no-eye-movement conditions along with a counting condition. Results showed that the fast- and vertical-eye-movement and counting conditions lowered the number of intrusions but the no-eye-movement condition did not. No effects were found for self-ratings. Scores on the Directed Forgetting Task (DFT) were positively correlated with presses pre and post in the whole sample.

Do Eye-Movements Lower Self-Ratings?

Five studies in this thesis measured self-ratings of vividness and emotionality of negative autobiographical memories as a dependent variable. Of those five studies only the first three found eye-movements to lower self-ratings. However, study one and three found only vividness ratings were lowered and study two found only emotionality ratings were lowered. The inconsistent nature of the findings provides only mixed support to the hypothesis that eye-movements lower self-ratings of negative memories.

Published research has shown that eye-movements reliably lower self-ratings of vividness and emotionality (Altink et al., 2012; Barrowcliff et al., 2004; Engelhard et al., 2011; Gunter & Bodner, 2008; Kavanagh et al., 2001; Kemps & Tiggemann, 2007; Kristjansdottir & Lee, 2011; Lilley et al., 2009; Maxfield et al., 2008; Smeets et al., 2012; van den Hout et al., 2001; van den Hout et al., 2011). It is probable that differences in methodologies between these studies and the studies in this thesis have led to the inconsistent findings. An important difference is the addition of a period of suppression directly after the treatment condition and prior to the re-rating of memories. This period of suppression may have affected subsequent self-ratings, perhaps through some kind of rebound effect (Wenzlaff & Wegner, 2000).

If the effect of eye-movements on self-ratings was influenced by a single methodological change then this effect may not be particularly robust. It is possible that either the time taken to complete the suppression condition, or the suppression condition itself may have influenced results. It is important to note here that most previous researchers have re-measured self-ratings directly after finishing the eye-movement task. However, three known studies have re-tested self-ratings at one-week follow up (Gunter & Bodner, 2008; Kavanagh et al., 2001; Lilley et al., 2009). Of these three studies, two found that the effect of eye-movements on self-ratings was not present after one-week (Kavanagh et al., 2001; Lilley et al., 2009).

The effect of eye-movements on self-ratings of negative memories may not be robust with regards to both time (Kavanagh et al., 2001; Lilley et al., 2009) and interference (the current thesis). This does not mean, however, that the effect is not useful in the short-term or during an EMDR therapy session. Perhaps the effect of eye-movements on negative memories could best be thought of as a helpful part of the therapeutic process rather than as an outcome of therapy itself. This is an important topic and will be expanded upon further in the discussion of the implications of this thesis.

Do Eye-Movements Lower the Number of Intrusive Thoughts?

Five studies in this thesis measured the number of intrusions of a negative memory during a period of suppression as a dependent variable. Of those five studies, only study one did not find that fast-eye-movements lowered the number of intrusions and this may have been due to methodological issues. These findings support the hypothesis that eye-movements result in fewer intrusive thoughts about negative memories.

Previous researchers have also found that intrusive thoughts about negative memories can be affected by working memory tasks. This research has used traumatic films or pictures and working memory tasks have been conducted either during or shortly after viewing traumatic stimuli. Such research shows that working memory tasks such as tapping a complex pattern lower the number of intrusive thoughts of the stimuli compared to no-task controls (Deeprose et al., 2012; Holmes & Bourne, 2008; Holmes et al., 2004; Holmes et al., 2009; Krans et al., 2010; Pearson & Sawyer, 2011). However, such findings are difficult to generalise to EMDR therapy and eye-movement research since the tasks are thought to interfere with the encoding of memories rather than already consolidated memories.

The current studies expanded on research using trauma films or pictures by using consolidated autobiographical memories of negative events. Additionally, the current studies investigated suppression with a high degree of intentionality compared to trauma film research where participants are not specifically instructed to avoid thoughts of the film. The current research also measured suppression over a very short time (three minutes) compared to trauma film research that has typically measured suppression over an entire week. Despite obvious differences in methodology, the results from both types of study do agree that working memory tasks associated with memories of negative events lower the number of intrusive thoughts when compared to no-task controls.

Which Explanation Best Fits the Results?

The current studies best support the central executive explanation for the effectiveness of eye-movements rather than the orienting response or interhemispheric interaction explanations. Studies three, four, five, and six found relationships between central executive tasks and the number of intrusions following eye-movements. Study five results supported the central executive explanation but not the orienting response explanation. Study six supported the central executive explanation but did not support the interhemispheric interaction, orienting response, or visuospatial sketchpad explanations.

It is important to note that the current studies cannot exclusively attribute the effect of fast-eye-movements to the central executive explanation. This is because effects from the fast-eye-movement condition may have been caused by mechanisms from all three explanations. Each explanation makes the same predictions for the effect of eye-movements (Gunter & Bodner, 2009; Shapiro, 2001). For example, fast-eye-movements may well tax central executive resources as well as creating an orienting response and improving interhemispheric interaction. The results cannot distinguish between these explanations within a single task. Additionally, since reliable results were not found for self-ratings it is possible that other mechanisms may account for eye-movement effects on self-ratings but not suppression.

While each explanation makes the same predictions about the effect of fast-eye-movements, they differ regarding the other treatment conditions. The orienting response and interhemispheric interaction explanations cannot account for the finding that vertical-eye-movements and counting had similar effects on negative memories as did fast-eye-movements (Gunter & Bodner, 2008). The central executive explanation can account for these findings. Because of inconsistent results, the same conclusion cannot be drawn for the effect of eye-movements on self-ratings of negative memories.

Limitations and Recommendations for Future Research

The most important limitation to note, particularly before generalising this research to EMDR therapy, is the sole use of non-clinical participants. This limitation is particularly salient given that it has been suggested that memories specific to PTSD may be subject to different storage and retrieval than memories for normal events (Brewin, Dalgliesh, & Joseph, 1996). However, the use of analogue, or non-clinical, samples is common in eye-movement research (Barrowcliff et al., 2004; Christman et al., 2003; Gunter & Bodner, 2008; Koppel, 2009; van den Hout et. al., 2010), and it is important to note that findings from such analogue studies are similar to those using PTSD patients (Isaacs, 2004; Servan-Schreiber et al., 2006; van den Hout et al., 2012).

Another limitation of the current studies is that only one measure of suppression was used. In the current studies suppression was typically only measured for three minutes following the treatment condition. The suppression task also involved a high level of intent in that participants were told to actively avoid thinking about the negative event. Due to this, the current studies can only speak to high intent and short-term suppression. Future research could extend this methodology by evaluating longer suppression periods with less intent. For example, not instructing participants to avoid thinking about the event, or using diary recordings for up to a week follow-up.

While there are limitations in using analogue samples, there are also some benefits. For example, the current studies were felt to be ethically suited to use with an analogue sample. This is because participants would be completing some conditions (the no-eye-movement controls) that were not expected to provide any benefit. Additionally, studies that used within-subjects designs would have been confounded by the use of an event associated with PTSD in one condition and a possibly un-associated event in the other condition. The expansion of the current studies to clinical participants is certainly warranted and would increase the confidence of generalisations to EMDR therapy.

The Proposed Mechanism of Action

The current studies have shown that eye-movements and other dual-tasks result in fewer intrusive thoughts during suppression. There is also some support, both from the current studies and other researchers, for the hypothesis that these effects involve central executive processes (Gunter & Bodner, 2008; van den Hout et al., 2011; Altink et al., 2012). However, what is not clear is exactly what central executive mechanism is at work in producing these effects.

Previously researchers seem to have avoided attempting to explain how taxing central executive resources while holding a memory in mind can affect the memory. Researchers have typically stopped at a description of what happens rather than an explanation (Gunter & Bodner, 2008). For example, Engelhard, van Uijen, and van den Hout (2010, pp. 6), state that the result of their study "…fits with WM [working memory] theory which suggests that any secondary task that uses up WM resources during memory recall reduces vividness and emotionality of emotional memories". This example shows that the effect of eye-movements on memories is not being explained but described.

Interestingly, the problem of explaining exactly how eye-movements affect central executive functioning and then recalled memories is similar to problems cognitive researchers have had with the central executive. Baddeley (1996) describes how early researchers exploring working memory functioning resorted to attributing anything that did not fit nicely into one of the slave systems (visuospatial sketchpad and phonological loop) to the central executive. In this way the central executive became a convenient homunculus: an imaginary person sitting in the head mysteriously making decisions.

It appears that eye-movement researchers may have created their own homunculus for the central executive. While researchers appear confident that eye-movements affect memories through central executive functioning, exactly how this happens is rarely explored. Some attempts have been made, however. Gunter and Bodner (2008), state that dividing executive attention between the memory and eye-movements might facilitate habituation to the memory or alter emotional and cognitive reactions to it. However, exactly how dividing attention facilitates habituation or alters reactions is not fully explored other than that it may make therapy less aversive.

Another possible explanation is that eye-movements interfere with refreshment of the image between long-term and short-term memory (Smeets et al., 2012). This interference affects the quality or vividness of the image, which then results in lower emotionality. What both these explanations have in common is a reliance on the idea that dividing attention between the memory and eye-movements results in changes to the memory. The explanation of Smeets et al. (2012), however, relies on changes being made in the visuospatial sketchpad, which is troublesome considering the consensus that the central executive is the key component in the effect of eye-movements.

There is a further explanation that may better account for research findings. Concentrating on a memory and conducting eye-movements both require central executive resources (Gunter & Bodner, 2008; van den Hout et al., 2011; Altink et al., 2012). This implies that when thinking about a memory and conducting eye-movements, central executive attention must be divided between the two tasks (Gunter & Bodner, 2008). Studies have already shown that some central executive suppression is involved in tasks that require divided attention or attention switching (Fisk & Sharp, 2004; Friedman et al., 2006). Essentially, one task must be at least partially suppressed so that the other can be conducted.

In the case of eye-movements and recall of memories, it is the memory that must be suppressed so that eye-movements can continue. This is because suppression of the eye-movements is not possible since the client or participant must keep their eyes on the moving stimulus. Emotional memories that have been suppressed are harder to recall at the same intensity later (Depue, Curran, & Banich, 2007; Levy & Anderson, 2008), and this may explain the reductions in self-ratings typically seen following eye-movement conditions. Practice with a central executive task, such as suppression, can also improve subsequent performance on that task (Bomyea & Amir, 2011; Klingberg, 2010). Hence, partial suppression of emotional memories during eye-movements may result in memories that are less vivid and emotional and easier to suppress.

A further possible mechanism may be that of divided attention itself. Although a new area of research, studies have shown that executive functions such as division of attention can be improved through training (Bomyea & Amir, 2011; Bomyea & Lang, 2012; Petersen, 2011). The current research, so far using only non-clinical participants, has also shown that short attentional control training can reduce the number of intrusive thoughts experienced during a thought suppression task (Bomyea & Amir, 2011; Petersen, 2011). Interestingly, pilot data suggests that attention modification training may be helpful in the treatment of PTSD symptoms (Bomyea & Lang, 2012). It is possible that eye-movements function as an attention training task, subsequently making distraction or disengagement from intrusive memories easier and improving suppression.

Suppression and attention training are two possible mechanisms for the effectiveness of eye-movements. Both seem to be promising suggestions and may allow eye-movement researchers to do away with the homunculus that the central executive is in danger of turning into. Of course it is important to state that this is a new and emerging area of research and further study is clearly required before confident conclusions can be drawn.

Eye-Movements in Clinical Practice

As mentioned above, generalising the current research to clinical practise is clearly premature. However, the issue of suppression in psychopathology and clinical treatment is highly contentious (see the letter by Holmes, Moulds, & Kavanagh (2007), and reply by Depue, Curran, & Banich for an example), and a brief discussion of how the current suppression research relates to clinical practise is required. Effective treatments for PTSD, such as trauma-focussed cognitive behavioural therapy, involve sustained focus on the traumatic memories, something ostensibly counter to suppression of memories. Additionally, research has found that cognitive avoidance is related to the maintenance of PTSD symptoms, although conversely, rumination is also associated with symptom maintenance (Ehlers, Mayou, & Bryant, 1998).

While it may, therefore, seem dangerous to allow a client to suppress a memory through eye-movements, research has found that avoidance techniques such as suppression have beneficial short-term effects through emotion regulation (Geraerts, Hauer, & Wessel, 2010). Such effects may make concentrating on and dealing with traumatic memories in a structured clinical environment easier for clients. Research also suggests that traumatic memories are not eliminated in treatment; rather, they are replaced with more positive representations (Shipherd & Salters-Pedneault, 2008). This suggests an important role for suppression of traumatic memories in order for the positive representations developed through treatment to be more easily recalled.

Researchers are beginning to take note of the importance of suppression in exposure therapy and the treatment of mental disorders. McNally (2007, pp. 753) states that “Most scientists now agree that extinction does not involve the unlearning of CS-US [Conditioned Stimulus – Unconditioned Stimulus] associations, but rather the establishment of new, inhibitory associations that compete with the original ones.” Other researchers agree, and suggest that enhancing executive functioning may improve the ability to suppress the fear originally paired with memories of traumatic events (Craske et al., 2008).

Research specific to EMDR has found that EMDR procedures result in clients being able to process traumatic memories in a more distant manner than in cognitive behavioural therapy (Lee, 2008). In EMDR clients are instructed just to notice what arises during therapy rather than remain focussed on specific traumatic material. Clients have control over their subjective experience and are free to focus on associated material rather than only the target stimuli. Research also shows that this distancing is produced by eye-movements, rather than by therapists' instructions, and that the degree of distancing during therapy is associated with improvement (Lee, Taylor, & Drummond, 2006; Lee, 2008). Hence, suppression may contribute to therapy by distancing clients from their traumatic memories, resulting in reduced distress and allowing for incorporation of associated material.

So there are many ways that thought suppression may be helpful in EMDR and other therapies (Bakker, 2009). The major problem with suppression has always been concerns regarding the rebound effect. The rebound effect refers to the finding that suppressed thoughts result in more subsequent intrusions than thoughts that are not suppressed (Wegner et al., 1987). In countering this argument it is first important to acknowledge that the current studies did not investigate whether suppression of negative memories was followed by a rebound effect. However, it is critical to note that the partial suppression of memories held in mind during eye-movements did not result in a rebound effect. If there had been a rebound effect, it would be expected that participants in the eye-movement conditions would have more intrusions than those in the no-eye-movement conditions.

Conclusion

Three hypotheses regarding the effect of eye-movements on negative memories were tested in the current research: eye-movements would lower self-ratings, eye-movements would lower the number of intrusive thoughts, and other tasks that tax central executive resources will also lower self-ratings and intrusive thoughts. Seven studies were conducted to test these hypotheses using various designs and methods. Results from these studies showed that eye-movements do not reliably lower self-ratings of both emotionality and vividness of memories. However, Eye-movements do lower the number of intrusive thoughts during suppression. In addition, other tasks that tax central executive resources also lower intrusive thoughts during suppression.

Findings from the current research suggest that the enhanced suppression of memories is due to eye-movements affecting central executive processes. While suppression has traditionally been thought of as a maintaining factor in PTSD, the short-term effects of suppression may be helpful in a therapeutic context. This is a young and complex area of research, drawing together many different and previously distinct methodologies and theories. However, it is hoped that such research may eventually help to explain and improve existing therapies for disorders such as PTSD.

References

Abramowitz, J. S., Tolin, D.F., & Street, G.P. (2001). Paradoxical effects of thought suppression: A meta-analysis of controlled studies. *Clinical Psychology Review, 21*, 683-703.

Adkins, J. W., Weathers, F.W., McDevitt-Murphy, M., & Daniels, J.B. (2008). Psychometric properties of seven self-report measures of posttraumatic stress disorder in college students with mixed civilian trauma exposure. *Journal of Anxiety Disorders, 22*, 1393-1402.

Aikins, D. E., Johnson, D.C., Borelli, J.L., Klemanski, D.H., Morrissey, P.M., Benham, T.L., Southwick, S.M., & Tolin, D.F. (2009). Thought suppression failures in combat PTSD: A cognitive load hypothesis. *Behaviour Research and Therapy*, *47*, 744-751.

Altink, A. J. A., van Terwisga, P., Helms, F.D.G., & Oostenbroek, S.H. (2012). A word tracking task as an alternative to horizontal eye movements in the reduction of vividness and emotionality of aversive memories in EMDR. *Social Cosmos, 3*(2), 185-199.

American Psychiatric Association. (2013). *Diagnostic and statistical manual of mental disorders* (5th ed.). Arlington, VA: Author.

Anderson, M. C., Bjork, R.A., & Bjork, E.L. (1994). Remembering can cause forgetting: Retrieval dynamics in long-term memory. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 20*(5), 1063-1087.

Anderson, M. C. (2003). Rethinking interference theory: Executive control and the mechanisms of forgetting. *Journal of Memory and Language, 49*, 415-445.

Anderson, M. C. (2005). The role of inhibitory control in forgetting unwanted memories: A consideration of three methods. In C. M. M. B. Uttl (Ed.), *Dynamic Cognitive Processes* (pp. 159-190). Tokyo: Springer-Verlag.

Anderson, M. C., & Levy, B.J. (2009). Suppressing unwanted memories. *Current Directions in Psychological Science, 18*(4), 189-194.

Antrobus, J. S., Antrobus, J.S., & Singer, J.L. (1964). Eye movements acompanying daydreaming, visual imagery, and thought suppression. *Journal of Abnormal and Social Psychology*, *69*(3), 244-252.

Aron, A. R. (2007). The neural basis of inhibition in cognitive control. *Neuroscientist, 13*, 214-228.

Baddeley, A. (1996). Exploring the central executive. *The Quarterly Journal of Experimental Psychology*, *49*, 5-28.

Baddeley, A. (2007). *Working Memory, Thought, and Action*. Oxford: Oxford University Press.

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

Bakker, G. M. (2009). In defence of thought stopping. *Clinical Psychologist, 13*, 59-68.

Barnier, A. J., Conway, M.A., Mayoh, L., Speyer, J., Avizmil, O., & Harris, C.B. (2007). Directed forgetting of recently recalled autobiographical memories. *Journal of Experimental Psychology: General, 136*(2), 301-322.

Barrowcliff, A. L., Gray, N.S., MacCulloch, S., Freeman, T.C.A., & MacCulloch, M.J. (2003). Horizontal rhythmical eye movements consistently diminish the arousal provoked by auditory stimuli. *The British Journal of Clinical Psychology, 42*, 289-302.

Barrowcliff, A. L., Gray, N.S., Freeman, T.C.A., & MacCulloch, M.J. (2004). Eye-movements reduce the vividness, emotional valence, and electrodermal arousal associated with negative autobiographical memories. *The Journal of Forensic Psychiatry & Psychology*, *15*, 325-345.

Beck, J. G., Grant, D.M., Read, J.P., Clapp, J.D., Coffey, S.F., Miller, L.M., & Palyo, S.A. (2008). The Impact of Event Scale - Revised: Psychometric properties in a sample of motor vehicle survivors. *Journal of Anxiety Disorders, 22*(2), 187-198.

Benish, S. G., Imel, Z.E., & Wampold, B.E. (2008). The relative efficacy of bona fide psychotherapies for treating post-traumatic stress disorder: A meta-analysis of direct comparisons. *Clinical Psychology Review, 28*, 746-758.

Bisson, J. I., Ehlers, A., Matthews, R., Pilling, S., Richards, D., & Turner, S. (2007). Psychological treatments for chronic post-traumatic stress disorder: Systematic review and meta-analysis. *British Journal of Psychiatry, 190*, 97-104.

Bjork, R. A. (1998). Intentional Forgetting in Perspective: Comments, Conjectures, and Some Directed Remembering. In J. M. Golding, & Macleod, C.M. (Ed.), *Intentional Forgetting: Interdisciplinary Approaches* (pp. 453-481). Mahwah, NJ: Lawrence Erlbaum Associates.

Bomyea, J., & Amir, N. (2011). The effect of an executive functioning training program on working memory capacity and intrusive thoughts. *Journal of Cognitive Theory and Research, 35*, 529-535.

Bomyea, J., & Lang, A.J. (2012). Emerging interventions for PTSD: Future directions for clinical care and research. *Neuropharmacology, 62*, 607-616.

Bradley, R., Greene, J., Russ, E., Dutra, L., & Westen, D. (2005). A multidimensional meta-analysis of psychotherapy for PTSD. *American Journal of Psychiatry, 162*, 214-227.

Bradley, M. M., & Lang, P.J. (1999). Affective norms for English words (ANEW): Instruction manual and affective ratings. (Vol. C-1). Gainesville, FL: University of Florida.

Breslau, N., Davis, G., Andreski, P., & Peterson, E. (1991). Traumatic events and posttraumatic stress disorder in an urban population of young adults. *Archives of General Psychiatry, 48*, 216-222.

Brewin, C. R., Andrews, B., & Valentine, J.D. (2000). Meta-analysis of risk factors for posttraumatic stress disorder in trauma-exposed adults. *Journal of Consulting and Clinical Psychology, 68*, 748-766.

Brewin, C. R., & Beaton, A. (2002). Thought suppression, intelligence, and working memory capacity. *Behaviour Research and Therapy, 40*, 923-930.

Brewin, C. R., Gregory, J.D., Lipton, M., & Burgess, N. (2010). Intrusive images in psychological disorders: Characteristics, neural mechanisms, and treatment implications. *Psychological Review, 117*, 210-232.

Brewin, C. R., & Saunders, J. (2001). The effect of dissociation at encoding on intrusive memories for a stressful film. *British Journal of Medical Psychology, 74*, 467-472.

Brewin, C. R., & Smart, L. (2005). Working memory capacity and suppression of intrusive thoughts. *Journal of Behaviour Therapy and Experimental Psychiatry, 36*, 61-68.

Cahill, S. P., Carrigan, M.H., & Frueh, B.C. (1999). Does EMDR work? And if so, why?: A critical review of controlled outcome and dismantling research. *Journal of Anxiety Disorders, 13*(1), 5-33.

Christman, S., & Garvey, K. (2001). *Bilateral eye movements reduce asymmetries in hemispheric activation*. Paper presented at the EMDR Internationl Association Conference.

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

Collette, F., Van der Linden, M., Laureys, S., Delfiore, G., Degueldre, C., Luxen, A., & Salmon, E. (2005). Exploring the unity and diversity of the neural substrates of executive functioning. *Human Brain Mapping, 25*, 409-423.

Collins Concise New Zealand Dictionary (7th ed.). (2008). London, England: Collins.

Conway, A. R. A., Kane, M.J., Bunting, M.F., Hambrick, D.Z., Wilhelm, O., & Engle, R.W. (2005). Working memory span tasks: A methodological review and user's guide. *Psychonomic Bulletin and Review, 12*(5).

Cottencin, O., Vaiva, G., Huron, C., Devos, P., Ducrocq, F., Jouvent, R., Goudemand, M., & Thomas, P. (2006). Directed forgetting in PTSD: A comparative study versus normal controls. *Journal of Psychiatric Research, 40*, 70-80.

Craske, M. G., Kircanski, K., Zelikowsky, M., Mystkowski, J., Chowdhury, N., & Baker, A. (2008). Optimizing inhibitory learning during exposure therapy. *Behaviour Research and Therapy, 46*, 5-27.

Creamer, M. C., Burgess, P., & McFarlane, A.C. (2001). Post-traumatic stress disorder: findings from the Australian National Survey of Mental Health and Well-being. *Psychological Medicine, 31*(7), 1237-1247.

Cukor, J., Olden, M., Lee, F., & Difede, J. (2010). Evidence-based treatments for PTSD, new directions, and special challenges. *Annals of the New York Academy of Sciences, 2108*, 82-89.

Cukor, J., Spitalnick, J., Difede, J., Rizzo, A., & Rothbaum, B.O. (2009). Emerging treatments for PTSD. *Clinical Psychology Review*, *29*, 715-726.

Darling, S., Della Sala, S., & Logie, R.H. (2007). Behavioural evidence for separating components within visuo-spatial working memory. *Cognitive Processing, 8*, 175-181.

Davidson, P. R., & Parker, K.C.H. (2001). Eye movement desensitization and reprocessing (EMDR): A meta-analysis. *Journal of Consulting and Clinical Psychology, 69*, 305-316.

Deeprose, C., Zhang, S., de Jong, H., Dalgleish, T., & Holmes, E.A. (2012). Imagery in the aftermath of viewing a traumatic film: Using cognitive tasks to modulate the development of involuntary memory. *Journal of Behaviour Therapy and Experimental Psychiatry, 43*, 758-764

de Jongh, A., Ernst, R., Marques, L., & Hornsveld, H. (2013). The impact of eye movements and tones on disturbing memories involving PTSD and other mental disorders. *Journal of Behaviour Therapy and Experimental Psychiatry, 44*, 477-483.

Denny, N. R. (1995). An orienting reflex/external inhibition model of EMDR and thought field therapy. *Traumatology, 1*(1), 6.

Depue, B. E., Curran, T., & Banich, M.T. (2007). Prefrontal regions orchestrate suppression of emotional memories via a two-phase process. *Science, 317*, 215-219.

Devilly, G. J. (2002). Eye Movement Desensitization and Reprocessing: A chronology of its development and scientific standing. *The Scientific Review of Mental Health Practice, 1*(2), 113-138.

Devilly, G. J., & Spence, S.H. (1999). The relative efficacy and treatment distress of EMDR and a cognitive behavioural trauma treatment protocol in the amelioration of post traumatic stress disorder. *Journal of Anxiety Disorders, 13*, 131-157.

Devilly, G. J., Spence, S.H., & Rapee, R.M. (1998). Statistical and reliable change with eye movement desensitization and reprocessing: Treating trauma within a veteran population. *Behaviour Therapy, 29*, 435-455.

Dunn, T. M., Schwartz, M., Hatfield, R.W., & Wiegele, M. (1996). Measuring effectiveness of Eye Movement Desensitization and Reprocessing (EMDR) in non-clinical anxiety:

A multi-subject, yoked-control design. *Journal of Behaviour Therapy and Experimental Psychiatry, 27,* 231-139.

Ehlers, A., Mayou, R.A., & Bryant, B. (1998). Psychological predictors of chronic Posttraumatic Stress Disorder after motor vehicle accidents. *Journal of Abnormal Psychology, 107*(3), 508-519.

Ehlers, A., Hackmann, A., & Michael, T. (2004). Intrusive re-experiencing in post-traumatic stress disorder: Phenomenology, theory, and therapy. *Memory, 12*, 403-415.

Elofsson, U. O. E., von Scheele, B., Theorell, T., & Sondergaard, H.P. (2008). Physiological correlates of eye movement desensitization and reprocessing. *Journal of Anxiety Disorders, 22*, 622-634.

Engelhard, I. M., van Uijen, S., van den Hout, M.A. (2010). The impact of taxing working memory on negative and positive memories. *European Journal of Psychotraumatology, 1*.

Engelhard, I. M., van den Hout, M.A., & Smeets, A.M. (2011). Taxing working memory reduces vividness and emotional intensity of images about the Queen's Day tragedy. *Journal of Behaviour Therapy and Experimental Psychiatry, 42*, 32-37.

Engle, R. W., Tuholski, S.W., Laughlin, J.E., & Conway, A.R.A. (1999). Working memory, short-term memory and general fluid intelligence: A latent-variable approach. *Journal of Experimental Psychology: General, 128*, 309-331.

Fisk, J. E., Sharp, C.A. (2004). Age-related impairment in executive functioning: Updating, inhibition, shifting, and access. *Journal of Clinical and Experimental Neuropsychology, 26*, 874-890.

Flett, R. A., Kazantzis, N., Long, N.R., MacDonald, C., & Milar, M. (2004). Gender and ethnicity differences in the prevalence of traumatic events: evidence from a New Zealand community sample. *Stress and Health, 20*, 149-157.

Foa, E. B., & Kozak, M.J. (1986). Emotional processing of fear: Exposure to corrective information. *Psychological Bulletin, 99*, 20-35.

Foa, E. B., Hembree, E., & Rothbaum, B. (2007). *Prolonged Exposure Therapy for PTSD: Emotional Processing of Traumatic Experiences, Therapist Guide.* New York: Oxford University Press.

Forbes, D., Creamer, M., Bisson, J.I., Cohen, J.A., Crow, B.E., Foa, E.B., Friedman, M.J., Keane, T.M., Kudler, H.S., & Ursano, R.J. (2010). A guide to guidelines for the treatment of PTSD and related conditions. *Journal of Traumatic Stress*, *23*(5), 537-552.

Friedman, N. P., & Miyake, A. (2005). Comparison of four scoring methods for the reading span test. *Behavoiur Research Methods*, *37*(4), 581-590.

Friedman, N. P., Miyake, A., Corley, R.P., Young, S.E., DeFries, J.C., & Hewitt, J.K. (2006). Not all executive functions are related to intelligence. *Psychological Science*, *17*, 172-179.

Geraerts, E., & McNally, R.J. (2008). Forgetting unwanted memories: Directing forgetting and thought suppression methods. *Acta Psychologica*, *127*, 614-622.

Geraerts, E., Hauer, B.J.A., & Wessel, I. (2010). Effects of suppressing negative memories on intrusions and autobiographical memory specificity. *Applied Cognitive Psychology, 24*, 387-398.

Gunter, R. W., & Bodner, G.E. (2008). How eye movements affect unpleasant memories: Support for a working-memory account. *Behaviour Research and Therapy, 46*, 913-931.

Gunter, R. W., & Bodner, G.E. (2009). EMDR works … But how? Recent progress in the search for treatment mechanisms. *Journal of EMDR Practise and Research*, *3*, 161-168.

Hall, M. N., & Berntsen, D. (2008). The effect of emotional stress on involuntary and voluntary conscious memories. *Memory, 16*, 48-57.

Harnishfeger, K. (1995). Development of Cognitive Inhibition. In F. Dempster, & Brainerd, C. (Ed.), *Interference and Inhibition in Cognition* (pp. 175-204). San Diego: Academic Press.

Harvey, A.G., & Bryant, R.A. (1998). The role of valence in attempted thought suppression. *Behaviour Research and Therapy, 36*, 757-763.

Herbert, J. D., Lilienfeld, S.O., Lohr, J.M., Montgomery, R.W., O'Donohue, W.T., Rosen, G.M., & Tolin, D.F. (2000). Science and pseudoscience in the development of eye movement desensitization and reprocessing: Implications for clinical psychology. *Clinical Psychology Review, 20*, 945-971.

Holmes, E. A., Moulds, M.L., & Kavanagh, D. (2007). Memory suppression in PTSD treatment? *Science, 318*, 1722.

Holmes, E. A., & Bourne, C. (2008). Inducing and modulating intrusive emotional memories: A review of the trauma film paradigm. *Acta Psychologica, 127*, 553-566.

Holmes, E. A., Brewin, C.R., & Hennessy, R.G. (2004). Trauma films, information processing, and intrusive memory development. *Journal of Experimental Psychology: General, 133*, 3-22.

Holmes, E. A., James, E.L., Coode-Bate, T., & Deeprose, C. (2009). Can playing the computer game “Tetris” reduce the build-up of flashbacks for trauma? A proposal from cognitive science. *PLoS ONE 4(1): e4153. doi:10.1371/journal.pone.0004153*.

Hornsveld, H. K., Houtveen, J.H., Vroomen, M., Kapteijn, I., Aalbers, D., & van den Hout, M.A. (2011). Evaluating the effect of eye movements on positive memories such as those used in resource development and installation. *Journal of EMDR Practise and Research, 5*(4), 146-155.

Ironson, G., Freund, B., Strauss, J.L., & Williams, J. (2002). Comparison of two treatments for traumatic stress: A community-based study of EMDR and prolonged exposure. *Journal of Clinical Psychology, 58*, 113-128.

Isaacs, J. S. (2004). Numerical distraction therapy: Initial assessment of a treatment for posttraumatic stress disorder. *Traumatology, 10*, 39-54.

Kavanagh, D. J., Freese, S., Andrade, J., & May, J. (2001). Effects of visuospatial tasks on desensitization to emotive memories. *British Journal of Clinical Psychology, 40*, 267-280.

Kemps, E., & Tiggemann, M. (2007). Reducing the vividness and emotional impact of distressing autobiographical memories: The importance of modality-specific interference. *Memory, 15*, 412-422.

Kerzel, D., & Ziegler, N.E. (2005). Visual short-term memory during smooth pursuit eye movements. *Journal of Experimental Psychology: Human Perception and Performance, 31*, 354-372.

Kessler, R. C., Sonnega, A., Bromet, E., Hughes, M., & Nelson, C.B. (1995). Posttraumatic stress disorder in the National Comorbidity Study. *Archives of General Psychiatry, 52*, 1048-1060.

King, D. W., Orazem, R.J., Lauterbach, D., King, L.A., Hebenstreit, C.L., & Shalev, A.Y. (2009). Factor structure of posttraumatic stress disorder as measured by the Impact of Event Scale-Revised: Stability across cultures and time. *Psychological Trauma: Theory, Research, Practice, and Policy, 1*, 173-187.

Klauer, K. C., & Zhao, Z. (2004). Double dissociations in visual and spatial short-term memory. *Journal of Experimental Psychology: General, 133*, 355-381.

Koppel, R. H. (2009). *Rapid eye movement effects on traumatic memories: A test of the working memory hypothesis.* The College of William and Mary, Williamsburg.

Krans, J., Langner, O., Reinecke, A., & Pearson, D.G. (2013). Intrusive images and voluntary memory for affective pictures: Contextualisation and dual-task performance. *Journal of Behaviour Therapy and Experimental Psychiatry, 44*, 418-425.

Krans, J., Naring, G., Holmes, E.A., & Becker, E.S. (2010). Motion effects on intrusion development. *Journal of Trauma and Dissociation, 11*, 73-82.

Kristjansdottir, K., & Lee, C. W. (2011). A comparison of visual versus auditory concurrent tasks on reducing the distress and vividness of aversive autobiographical memories. *Journal of EMDR Practise and Research, 5*(2), 34-41.

Kuiken, D., Bears, M., Miall, D., & Smith, L. (2002). Eye movement desensitization reprocessing facilitates attentional orienting. *Imagination, Cognition, and Personality, 21*(1), 3-20.

Lang, P. J., Bradley, M.M., & Cuthbert, B.N. (2008). International Affective Picture Systems (IAPS): Affective ratings of pictures and instruction manual. (Vol. 8). Gainesville, FL: University of Florida.

Lawrence, B. M., Myerson, J., Oonk, H.M., & Abrams, R.A. (2001). The effects of eye and limb movements on working memory. *Memory, 9*, 433-444.

Lawrence, B. M., Myerson, J., & Abrams, R.A. (2004). Interference with spatial working memory: An eye movement if more than a shift of attention. *Psychonomic Bulletin & Review, 11*, 488-494.

Lee, C. W. (2008). Crucial processes in EMDR: More than imaginal exposure. *Journal of EMDR practise and Research, 2*, 262-268.

Lee, C. W., & Cuijpers, P. (2013). A meta-analysis of the contribution of eye movements in processing emotional memories. *Journal of Behaviour Therapy and Experimental Psychiatry, 44*, 231-239

Lee, C. W., & Drummond, P.D. (2008). Effects of eye movement versus therapist instructions on the processing of distressing memories. *Journal of Anxiety Disorders, 22,* 801-808.

Lee, C. W., Gavriel, H., Drummond, P., Richards, J., & Greenwald, R. (2002). Treatment of PTSD: Stress inoculation training with prolonged exposure compared to EMDR. *Journal of Clinical Psychology, 58,* 1071-1089.

Lee, C. W., Taylor, G., & Drummond, P.D. (2006). The active ingredient in EMDR: Is it traditional exposure or dual focus of attention? *Clinical Psychology and Psychotherapy, 13,* 97-107.

Levy, B. J., & Anderson, M.C. (2002). Inhibitory processes and the control of memory retrieval. *Trends in Cognitive Sciences, 6*, 299-305.

Levy, B. J., & Anderson, M.C. (2008). Individual differences in the suppression of unwanted memories: The executive deficit hypothesis. *Acta Psychologica, 127*, 623-635.

Lilley, S. A., Andrade, J., Turpin, G., Sabin-Farrell, R., & Holmes, E.A. (2009). Visuospatial working memory interference with recollections of trauma. *British Journal of Clinical Psychology*, *48*, 309-321.

Lohr, J. M., Lilienfeld, S.O., Tolin, D.F., & Herbert, J.D. (1999). Eye movement desensitization and reprocessing: An analysis of specific versus nonspecific treatment factors. *Journal of Anxiety Disorders*, *13*(1), 185-207.

MacCulloch, M. J., & Feldman, P. (1996). Eye movement desensitization treatment utilises the positive visceral element of the investigatory reflex to inhibit the memories of post-traumatic stress disorder: A theoretical analysis. *British Journal of Psychiatry, 169*, 571-579.

MacLeod, C. M. (1998). Directed Forgetting. In J. M. Golding, & Macleod, C.M. (Ed.), *Intentional Forgetting: Interdisciplinary Approaches* (pp. 1-57). Mahwah, NJ: Lawrence Erlbaum Associates.

MacLeod, C. M., Dodd, M.D., Sheard, E.D., Wilson, D.E., & Bibi, U. (2003). In Opposition to Inhibition. In B. H. Ross (Ed.), *The Psychology of Learning and Motivation* (Vol. 43, pp. 163-206). San Diego: Academic Press.

MacLeod, C. M. (2007). The Concept of Inhibition in Cognition. In D. S. Gorfein, & MacLeod, C.M. (Ed.), *Inhibition in Cognition* (pp. 3-23). Washington, D.C.: American Psychological Association.

Maxfield, L., Melnyk, W.T., & Hayman, C.A.G. (2008). A working memory explanation for the effects of eye movements in EMDR. *Journal of EMDR Practise and Research, 2*, 247-261.

McNally, R. J. (2007). Mechanisms of exposure therapy: How neuroscience can improve psychological treatments for anxiety disorders. *Clinical Psychology Review, 27*, 750-759.

McNally, R. J., Metzger, L.J., Lasko, N.B., Clancy, S.A., & Pitman, R.K. (1998). Directed forgetting of trauma cues in adult survivors of childhood sexual abuse with and without posttraumatic stress disorder. *Journal of Abnormal Psychology, 107*(4), 596-601.

McNally, R. J., Lasko, N.B., Macklin, M.L., & Pitman, R.K. (1995). Autobiographical memory disturbance in combat-related posttraumatic stress disorder. *Behaviour Research and Therapy, 33*, 619-630.

Miyake, A., Friedman, N.P., Emerson, M.J., Witzki, A.H., Howerter, A., & Wager, T.D. (2000). The unity and diversity of executive functions and their contributions to complex “frontal lobe” tasks: A latent variable analysis. *Cognitive Psychology, 41*, 49-100.

Miyake, A., Friedman, N.P., Rettinger, D.A., Shah, P., & Hegarty, M. (2001). How are visuospatial working memory, executive functioning, and spatial abilities related? A latent-variable analysis. *Journal of Experimental Psychology: General, 130*, 621-640.

Mohr, H. M., & Linden, D.E.J. (2005). Separation of the systems for colour and spatial manipulation in working memory revealed by a dual-task procedure. *Journal of Cognitive Neuroscience, 17*, 355-366.

Muris, P., & Merckelbach, H. (1999). Traumatic memories, eye movements, phobia, and panic: A critical note on the proliferation of EMDR. *Journal of Anxiety Disorders, 13*(1), 209-223.

Muris, P., Merckelbach, H., & Horselenberg, R. (1996). Individual differences in thought suppression. The White Bear Suppression Inventory: Factor structure, reliability, validity, and correlates. *Journal of Behaviour Research and Therapy, 34*(5), 501-513.

Nixon, R., Menne, A., Kling, L., Steele, A., Barnes, J., Dohnt, H., Ball, S., & Tyler, H. (2008). Metacognition, working memory, and thought suppression in acute stress disorder. *Australian Journal of Psychology, 60*, 168-174.

Nixon, R. D. V., Flood, J., & Jackson, K. (2007). The generalizability of thought suppression ability to novel stimuli. *Personality and Individual Differences, 42*, 677-687.

Ozer, E. J., Best, S.R., Lipsey, T.L., & Weiss, D.S. . (2003). Predictors of posttraumatic stress disorder and symptoms in adults: A meta-analysis. *Psychological Bulletin, 129*, 52-73.

Pastotter, B., Kliegl, O., & Bauml, K. (2012). List-method directed forgetting: The forget cue improves both encoding and retrieval of postcue information. *Memory and Cognition*.

Pavlov, I. P. (1927). *Conditioned Reflexes: An Investigation of the Physiological Activity of the Cerebral Cortex.* New York: Dover.

Pearson, D. G., Ross, F.D.C., & Webster, V.L. (2012). The importance of context: Evidence that contextual representations increase intrusive memories. *Journal of Behaviour Therapy and Experimental Psychiatry, 43*, 573-580.

Pearson, D. G., & Sahraie, A. (2003). Oculomotor control and the maintenance of spatially and temporally disrupted events in visuo-spatial working memory. *The Quarterly Journal of Experimental Psychology, 56*, 1089-1111.

Pearson, D. G., & Sawyer, T. (2011). Effects of dual task interference on memory intrusions for affective images. *International Journal of Cognitive Therapy, 4*, 122-133.

Perkins, B. R., & Rouanzoin, C.C. (2002). A critical evaluation of current views regarding eye movement desensitization and reprocessing (EMDR): Clarifying points of confusion. *Journal of Clinical Psychology, 58*, 77-97.

Petersen, L. N. (2011). *Effectiveness of an Attentional Control Training on Decreasing Intrusive Thoughts.* Master of Arts, San Diego State University, San Diego.

Postle, B. R., Idzikowski, C., Della Sala, S., Logie, R.H., & Baddeley, A. (2006). The selective disruption of spatial working memory by eye movements. *The Quarterly Journal of Experimental Psychology, 59*, 100-120.

Power, K., McGoldrick, T., Brown, K., Buchanan, R., Sharp, D., Swanson, V., & Karatzias, A. (2002). A controlled comparison of eye movement desensitization and reprocessing versus exposure plus cognitive restructuring versus waiting list in the treatment of post-traumatic stress disorder. *Clinical Psychology and Psychotherapy, 9*, 299-318.

Propper, R. E., & Christman, S.D. (2008). Interhemispheric interaction and saccadic horizontal eye movements. *Journal of EMDR Practise and Research, 2*, 269-281.

Rassin, E., Merckelbach, H., & Muris, P. (2000). Paradoxical and less paradoxical effects of thought suppression: A critical review. *Clinical Psychology Review, 20*(8), 973-995.

Renfrey, G., & Spates, C.R. (1994). Eye movement desensitization: A partial dismantling study. *Journal of Behaviour Therapy and Experimental Psychiatry, 25*, 231-239.

Repovs, G., & Baddeley, A. (2006). The multi-component model of working memory: Explorations in experimental cognitive psychology. *Neuroscience, 139*, 5-21.

Ricci, R., Clayton, C.A., Foster, S., Jarero, I., Litt, B., Artigas, L., & Kamin, S. (2009). Special applications of EMDR: Treatment of performance anxiety, sex offenders, couples, families, and traumatised groups. *Journal of EMDR Practise and Research, 3*, 279-288.

Rothbaum, B. O. (1997). A controlled study of eye movement desensitization and reprocessing in the treatment of posttraumatic stress disordered sexual assault victims. *Bulletin of the Menninger Clinic, 61*(3), 317-334.

Rothbaum, B. O., Astin, M.C., & Marsteller, F. (2005). Prolonged exposure versus Eye Movement Desensitization and Reprocessing (EMDR) for PTSD rape victims. *Journal of Traumatic Stress, 18*(6), 607-616.

Rudkin, S. J., Pearson, D.G., & Logie, R.H. (2007). Executive processes in visual and spatial working memory tasks. *The Quarterly Journal of Experimental Psychology, 60*, 79-100.

Russell, M. C. (2008). Scientific resistance to research, training, and utilization of eye movement desensitization and reprocessing (EMDR) therapy in treating post-war disorders. *Social Science & Medicine, 67*, 1737-1746.

Sack, M., Lempa, W., Steinmetz, A., Lamprecht, F., & Hofmann, A. (2008). Alterations in autonomic tone during trauma exposure using eye movement desensitization and reprocesing (EMDR)-Results of a preliminary investigation. *Journal of Anxiety Disorders, 22*, 1264-1271.

Samara, Z., Elzinga, B. M., Slagter, H, A., & Nieuwenhius, S. (2011). Do horizontal saccadic eye movements increase interhemispheric coherence? Investigation of a hypothesized neural mechanism underlying EMDR. *Frontiers in Psychiatry, 2,* 1-9.

Schubert, S., & Lee, C.W. (2009). Adult PTSD and its treatment with EMDR: A review of controversies, evidence, and theoretical knowledge. *Journal of EMDR Practise and Research, 3,* 117-132.

Schubert, S. J., Lee, C.W., & Drummond, P.D. (2011). The efficacy and psychophysiological correlates of dual-attention tasks in eye movement desensitization and reprocessing (EMDR). *Journal of Anxiety Disorders, 25,* 1-11.

Seidler, G. H., & Wagner, F.E. (2006). Comparing the efficacy of EMDR and trauma-focused cognitive-behavioural therapy in the treatment of PTSD: A meta-analytic study. *Psychological Medicine, 36,* 1515-1522.

Servan-Schreiber, D. (2000). Eye Movement Desensitization and Reprocessing: Is psychiatry missing the point? *Psychiatric Times, 17*(7).

Servan-Schrieber, D., Schooler, J., Dew, M.A., Carter, C., & Bartone, P. (2006). Eye movement desensitization and reprocessing for posttraumatic stress disorder: A pilot blinded, randomized study of stimulation type. *Psychotherapy and Psychosomatics, 75*, 290-297.

Shapiro, F. (1989). Eye movement desensitization: A new treatment for post-traumatic stress disorder. *Journal of Behavioural Therapy and Experimentation, 20*, 211-217.

Shapiro, F. (2001). *Eye Movement Desensitization and Reprogramming (EMDR): Basic Principles, Protocols, and Procedures* (Second ed.). New York: The Guildford Press.

Shipherd, J. C., & Beck, J.G. (1999). The effects of suppressing trauma-related thoughts in women with rape-related posttraumatic stress disorder. *Behaviour Research and Therapy, 37*, 99-112.

Shipherd, J. C., & Salters-Pedneault, K. (2008). Attention, memory, intrusive thoughts, and acceptance in PTSD: An update on the empirical literature for clinicians. *Cognitive and Behavioural Practise, 15,* 349-363.

Smeets, M. A. M., Dijs, M.W., Pervan, I., Engelhard, I.M., & van den Hout, M.A. (2012). Time-course of eye movement-related decrease in vividness and emotionality of unpleasant autobiographical memories. *Memory, 20*(4), 346-357.

Sondergaard, H. P., & Elofsson, U. (2008). Psychophysiological studies of EMDR. *Journal of EMDR Practise and Research, 2*(4), 282-288.

Stickgold, R. (2002). EMDR: A putative neurobiological mechanism of action. *Journal of Clinical Psychology, 58*, 61-75.

Stuart, A. D. P., Holmes, E.A., & Brewin, C.R. (2006). The influence of a visuospatial grounding task on intrusive images of a traumatic film. *Behaviour Research and Therapy, 44*, 611-619.

Taylor, S., Thordarson, D.S., Maxfield, L., Fedoroff, I.C., Lovell, K., & Ogrodniczuk, J. (2003). Comparative efficacy, speed, and adverse effects of three PTSD treatments: Exposure therapy, EMDR, and relaxation training. *Journal of Consulting and Clinical Psychology, 71*, 330-338.

Tulving, E., Kapur, S., Craik, F.I.M., Moscovitch, M., & Houle, S. (1994). Hemispheric encoding/retrieval asymmetry in episodic memory: Positron emission tomography findings. *Proceeds of the National Academy of Science, 91*, 2016-2020.

Ursano, R. J., Zhang, L., Li, H., Johnson, L., Carlton, J., Fullerton, C.S., & Benedek. (2009). PTSD and traumatic stress: From gene to community and bench to bedside. *Brain Research, 1293,* 2-12.

van den Hout, M., Muris, P., Salemink, E., & Kindt, M. (2001). Autobiographical memories become less vivid and emotional after eye movements. *British Journal of Clinical Psychology, 40*, 121-130.

van den Hout, M. A., Engelhard, I.M., Smeets, M.A.M., Hornsveld, H., Hoogeveen, E., de Heer, E., Toffolo, M.B.J., & Rijkeboer, M. (2010). Counting during recall: Taxing of working memory and reduced vividness and emotionality of negative memories. *Applied Cognitive Psychology, 24*, 303-311.

van den Hout, M. A., Engelhard, I. M., Beetsma, D., Slofstra, C., Hornsveld, H., Houtveen, J., & Leer, A. (2011). EMDR and mindfulness. Eye movements and attentional breathing tax working memory and reduce vividness and emotionality of aversive ideation. *Journal of Behaviour Therapy and Experimental Psychiatry*.

van den Hout, M. A., Engelhard, I. M., Rijkeboer, M. M., Koekebakker, J., Hornsveld, H., Leer, A., Toffolo, M. B. J., & Akse, N. (2011). EMDR: Eye movements superior to beeps in taxing working memory and reducing vividness of recollections. *Behaviour Research and Therapy, 49*, 92-98.

van den Hout, M. A., Rijkeboer, M.M., Engelhard, I.M., Klugkist, I., Hornsveld, H., Toffolo, M.J.B., Cath, D.C. (2012). Tones inferior to eye movements in the EMDR treatment of PTSD. *Behaviour Research and Therapy, 50*, 275-279.

van Rood, Y. R., & de Roos, C. (2009). EMDR in the treatment of medically unexplained symptoms: A systematic review. *Journal of EMDR Practise and Research, 3*, 248-263.

Vink, S. K. (2011). *The effects of playing the computer game "Tetris" on intrusions for traumatic images.* Unpublished MSc Thesis, Utrecht University, Utrecht.

Wegner, D. M., Schneider, D.J., Carter, S.R.C., & White, T.L. (1987). Paradoxical effects of thought suppression. *Journal of Personality and Social Psychology, 53*, 5-13.

Wegner, D. M., & Zanakos, S. (1994). Chronic thought suppression. *Journal of Personality, 62*, 615-640.

Weiss, D. S. (2007). The Impact of Event Scale: Revised. In J. P. Wilson & C. S. Tang (Ed.), *Cross-Cultural Assessment of Psychological Trauma and PTSD* (pp. 219-238). New York: Springer.

Weiss, D. S., & Marmar, C.R. (1997). The Impact of Event Scale - Revised. In J. P. Wilson & T. M. Keane (Ed.), *Assessing Psychological Trauma and PTSD* (pp. 399-411). New York: Guildford Press.

Wells, A., & Davies, M.I. (1994). The Thought Control Questionnaire: A measure of individual differences in the control of unwanted thoughts. *Journal of Behaviour Research and Therapy, 32*(8), 871-878.

Wenzlaff, R. M., & Wegner, D.M. (2000). Thought suppression. *Annual Review of Psychology, 51*, 59-91.

Wilson, S. A., Becker, L.A., & Tinker, R.H. (1997). Fifteen-month follow-up of eye movement desensitization and reprocessing (EMDR) treatment for posttraumatic stress disorder and psychological trauma. *Journal of Consulting and Clinical Psychology, 65*, 1047-1056.

Zatzick, D. F., Marmar, C.R., Weiss, D.S., Browner, W.S., Metzler, T.J., Golding, J.M., Stewart, A., Schlenger, W.E., & Wells, K.B. (1997). Posttraumatic Stress Disorder and functioning and quality of life outcomes in a nationally representative sample of male Vietnam veterans. *American Journal of Psychiatry, 154*, 1690-1695.