A Working Memory Analysis of the Dual Attention Component of Eye Movement Desensitization and Reprocessing

Ph.D. Dissertation

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Abstract

This dissertation applied the concepts and predictions of working memory theory to a psychotherapeutic approach, Eye Movement Desensitization and Reprocessing (EMDR). The overview of EMDR included a description of the treatment, theoretical model, empirical studies, and possible mechanisms of action. The overview of working memory included a summary of concepts and theories, and a comprehensive research review. Seven studies that investigated the related effects of eye movements (EMs) were described in detail.

Two experiments were conducted to test predictions from working memory research about the effect of EMs on autobiographical memory. In both Experiments, participants identified 3 negative memories and focused on each for 2 minutes, while simultaneously engaging in 1 of 3 divided attention (DA) conditions: an easy EM task (Slow-EM), a difficult EM task (Fast-EM), and a task with no EM (Control). Measures were pre-post ratings of memory-related image vividness, thought clarity, and emotional intensity. In Experiment 2, participants were also randomly assigned to a focus on image-only or image-thought.

Memory recall during Control resulted in significant post-condition increases in all measures, except emotional intensity in Experiment 1. Compared to Control, recall during both Slow-EM and Fast-EM produced significantly smaller scores for image vividness and thought clarity, and, in Experiment 2, for emotional intensity. At post-condition, Fast-EM resulted in significantly lower scores than Slow-EM for image vividness in both Experiments and emotional intensity in Experiment 2. There were no differences in outcomes between focus on image-only and on image-thought.

Findings of the current experiments supported a working memory explanation for the effects on visual and thought clarity. The competition of resources during simultaneous EM and memory recall reduced memory quality. The greater degradation of memory components resulting from the more difficult condition, Fast-EM, may be attributed to demands made on visuospatial sketchpad resources. The components of each memory appeared to be linked and to show similar patterns of change, within conditions. Reported levels of pre-task emotional intensity did not predict change in thought clarity and image vividness. Finally, a theoretical application of working memory theory to EMDR was presented and recommendations were made for future research.

A WORKING MEMORY ANALYSIS OF THE DUAL ATTENTION COMPONENT OF EYE MOVEMENT DESENSITIZATION AND REPROCESSING

This dissertation investigated the application of the concepts and predictions of working memory theory to a psychotherapeutic approach, Eye Movement Desensitization and Reprocessing (EMDR) This intersection of two distinct areas of psychology, clinical psychotherapy and cognitive science, is highly appropriate for three reasons.

(1) EMDR is unusual in its direct treatment focus on memory. Most psychotherapies concentrate on the symptoms of the disorder and seek to alleviate these. For example, cognitive therapy focuses on cognitions, behavior therapy on behavior, interpersonal therapy on interpersonal relationships, etc. EMDR is unique in its primary focus on memory and its claim to work with, and to process in-session, the actual somatic, cognitive, affective, and sensory elements of memory. Consequently, working memory theories may be useful in explaining and predicting some of the mechanisms of action in EMDR.

(2) EMDR is a therapy that employs a dual task component; indeed, dual attention is unique to EMDR treatment and is considered an essential protocol element (Shapiro, 1989, 2001). Working memory research has primarily used dual task, or divided attention, designs to measure the activity and parameters of the various components of working memory. Because each working memory component is assumed to have limited resources, if two concurrent tasks use resources from the same working memory system, then performance on one or both concurrent tasks will be impaired. When two concurrent tasks require different memory system

resources, there is little or no interference from their simultaneous performance. If working memory research is relevant to an examination of the components of EMDR, then procedures and hypotheses about the effects of dual tasks should help to explain its possible mechanisms of action.

(3) In EMDR treatment, the dual attention process is administered in a series of 1-2 minute segments. The client focuses on a memory image while simultaneously engaging in eye movements for about 30 seconds. After this, the client is encouraged to identify a different image (or thought, emotion, or sensation) that is associated with the first memory image. The second image then becomes the focus of the next dual attention segment. After this, the client identifies a third image, and so on. The process is repeated many times throughout the session, and clients often attend to 20-30 different images throughout the session. These brief sequential attentional tasks are similar to those used in working memory research, as they allow for the immediate assessment of performance and resource utilization.

(4) Working memory research has primarily used laboratory investigations. As this immense body of research developed, there has been a corresponding recognition of the complexity of working memory. A few studies have examined the interaction of autobiographical memory and working memory, and this is an active area of research. This investigation of the components of EMDR with a working memory research design promises to illuminate some of the relationships between the verbal and emotional components of autobiographical long-term memory and working memory.

The first section of this introduction provides an overview of EMDR. A description of the treatment and the theoretical model is followed by a review of the outcome literature. The possible active components of EMDR are identified, with a summary of the dismantling research, highlighting the outstanding issues. The second section examines the concepts and theories of working memory. A thorough review of related research is provided, including evidence for the various components of working memory and findings from dual task studies. In addition, the role of working memory in visual imagery is summarized; studies assessing the effect of anxiety on working memory are also examined. The third section contains detailed descriptions of seven studies that have investigated the effects of EMs on working memory and cognitive processes. Four of these investigated the effect of EMs on retrieved autobiographical memories with indications that the effects could be attributed to the limited resources of the visuospatial sketchpad in processing visual and spatial information.

The final section of the introduction presents the rationale for the two experiments in this dissertation. The research was designed to investigate the hypothesis that EMs result in a deterioration of the quality of autobiographical memory components and that the effects can be explained by working memory theory. It was proposed that these effects contribute to EMDR therapy by making the painful memory less vivid and less distressing.

EMDR

Eye Movement Desensitization and Reprocessing (EMDR) is a psychotherapy treatment that was originally designed to alleviate the distress associated with traumatic memories (Shapiro, 1989a, 1989b). Numerous randomized clinical trials support its use for the elimination of symptoms of posttraumatic stress disorder (PTSD). Research reports a decrease in diagnostic status of 50%-90% after 3-8 sessions, and significant decreases in symptoms, with effects maintained at follow-up (Maxfield, 2002, in press). EMDR's probable efficacy in the treatment of PTSD has been recognized in Practice Guidelines published by the Clinical Psychology Division of the American Psychological Association (Chambless et al., 1996) and the International Society for Traumatic Stress Studies (ISTSS) (Chemtob, Tolin, van der Kolk, & Pitman, 2000). The latter gave EMDR an "A/B" rating, and recommended further research before EMDR could be afforded the highest level of confidence.

Although anecdotal reports and case studies suggest that EMDR may be effective in the treatment of other disorders, controlled research has not been forthcoming to support these claims scientifically. There has been much controversy related to EMDR's unusual eye movement component and the lack of supportive research for its contribution to outcome. However recent findings indicate that eye movements may contribute to process through the mechanisms of working memory (e.g., Kavanagh, Freese, Andrade, & May, 2001).

Description

Treatment Description

EMDR is a structured approach, that integrates components of many other psychotherapies (see Shapiro, 2002). These include psychodynamic therapy (free association), cognitive therapy (identification of dysfunctional beliefs, development of self-control techniques), experiential therapies (client-centered approach), and behavioral therapy (standardized protocols to attend to present stimuli and conditioned responses). EMDR also synthesizes conceptual or theoretical aspects of these psychotherapies. Its focus on the definitive influence of early childhood experiences has elements in common with psychoanalytic theories (Freud, 1900/1953; Jung, 1916; Wachtel, 2002); its use of the concept of positive and negative self-assessment cognitions is a basic element of cognitive therapy (Beck, 1967; Ellis, 1962; Meichenbaum, 1977; Young, 1990; Young, Zangwill, & Behary, 2002); its initial focus on the traumatic incident is similar to that of behavior therapy (e.g., Foa & Rothbaum, 1998) as is its attention to desensitization (Wolpe, 1958); and, its emphasis on the related physical responses are congruent with the approach taken by many PTSD researchers and theorists (e.g., van der Kolk, 1996).

The eye movements of EMDR are a distinctive element. These are used to engage the client's attention to an external stimulus, while simultaneously attending to internal distressing material. It is this dual focus, the client's attention to internal and external stimuli, that is unique to EMDR therapy. Shapiro (2001) describes eye movements as "dual attention stimuli" to describe their role in engaging clients in this dual attention task. Therapist directed eye movements are the most commonly used dual attention stimulus but a variety of other stimuli including hand-tapping and auditory stimulation are also used (Shapiro, 1991, 1995, 2001).

These other stimuli are anecdotally reported to produce effects similar to those of eye movements, but to date, no research has directly investigated this claim with diagnosed participants.

EMDR uses a standardized eight-phase treatment approach that is implemented within a comprehensive treatment plan (Shapiro, 2001). After a thorough assessment, the memory of the distressful event is targeted. The client is asked to focus on the event, with its associated distressing thoughts and feelings. S/he begins by identifying a visual image that represents the incident, and a related "negative cognition." The negative cognition is the client's current self-appraisal related to the incident (e.g., "I'm helpless"). A "positive cognition" is also obtained, in which patients express a desired self-attribution (e.g., "I'm competent"). The client's confidence in the positive cognition is assessed by instructing him/her to rate the felt validity of the statement on the Validity of Cognition Scale (VoC), (Shapiro, 1989) where one represents "not true" and seven "completely true." Following this, the patient is asked to identify the emotions that are elicited by the incident. The level of emotional distress is measured using the Subjective Units of Distress Scale (SUD, Wolpe, 1958) where zero represents "no distress" and 10 represents "the worst distress possible." Next, the patient is asked to identify the body location of the emotional distress.

The desensitization phase of EMDR follows the above assessment of the traumatic incident. The client engages in a series of brief (20-60 seconds) dual attention segments during which s/he focuses on the memory image while simultaneously engaging in eye movements. Then s/he is instructed to "let go" of the memory image and is asked, "what do you notice now?" This encourages the client to identify a different image, thought, emotion, or sensation. (It is assumed that the elicited material has some association with the targeted memory.) The second image then becomes the focus of the next dual attention segment. After this, the client identifies a third image, and so on. The process is repeated many times throughout the session, and clients typically attend to 20-30 different images (or related memory components) throughout the session.

As the process continues, the client begins to make associations to more adaptive material, which then becomes integrated with the traumatic memories. These new associations are thought to result in complete information processing, new learning, elimination of emotional distress, and development of cognitive insights (Shapiro & Maxfield, 2001). EMDR uses a three pronged protocol: (1) the past events that have laid the groundwork for dysfunction are processed, forging new associative links with adaptive information; (2) the current circumstances that elicit distress are targeted, and internal and external triggers are desensitized; (3) imaginal templates of future events are incorporated, to assist the client in acquiring the skills needed for adaptive functioning.

The Theoretical Basis for EMDR

Shapiro (1995) developed the Accelerated Information Processing model to describe and predict EMDR's effect. More recently, Shapiro (2001) expanded this into the Adaptive Information Processing model to broaden its applicability. She hypothesizes that humans have an inherent information processing system that generally processes the multiple elements of experiences to an adaptive state, where learning takes place. Information processing is defined as "the process by which new perceptual information is sorted, connected with associated memory networks, encoded, and stored in memory" (Shapiro & Maxfield, 2002b, p. 777). Shapiro conceptualizes memory as being stored in linked networks that are organized around the earliest related event, and its associated affect. Memory networks are understood to contain related thoughts, images, emotions, and sensations.

Shapiro's (2001) model hypothesizes that if the information related to a distressing or traumatic experience is not fully processed, the initial perceptions, emotions, and distorted thoughts will be stored as they were experienced at the time of the event. Shapiro argues that such unprocessed experiences become the basis of current dysfunctional reactions, and are the cause of many mental disorders. She proposes that EMDR successfully alleviates mental disorders by processing the components of the distressing memory. These effects are thought to occur when the targeted memory is linked with other more adaptive information. When this occurs, Shapiro posits that "learning takes place, information is stored with appropriate affect and is available to guide future action" (Shapiro & Maxfield, 2002b, p. 777).

There are numerous problems with Shapiro's model. Her assumption that mental disorders result from incomplete information processing does not have empirical support. Although there is evidence for the role of etiological events in the onset of *some* mental disorders, the evidence for causality is not straightforward (e.g., not everyone who experiences a trauma develops PTSD), and the possible role of information processing has not been determined. Furthermore, there are serious flaws with Shapiro's assumption that resolution of a distressing memory will eliminate the mental disorder that was supposedly caused by that memory. There is no evidence for the assertion that complete information processing of a distressing memory will eradicate pathology. These core assumptions underlie the grandiose claims that Shapiro has made about EMDR's supposedly rapid and thorough effects.

Shapiro's (1995, 2001) statements about "traumatic memory" are also problematic. She refers to unprocessed memories as being "stuck" in the nervous system and maintained in their raw original state. She wrote:

> When someone experiences a severe trauma, it appears that an imbalance may occur in the nervous system .... Due to this imbalance, the information acquired at the time of the event, including images, sounds, affect, and physical sensations is maintained neurologically in its distressing state. Therefore, the original material, which is held in this excitatory state-dependent form, continues to be triggered by a variety of internal and external stimuli ... (Shapiro, 1995, p. 30)

Although this position is held by some trauma researchers (e.g., van der Kolk, 2002), research has generally indicated that memories of trauma, like memories of other events, are subject to revisions and modifications over time (e.g., Southwick, Morgan, Nicolaou, & Charney, 1997). See pages 37-38 for more information on traumatic memories.

EMDR has been criticized as having no solid theoretical foundation (e.g., Lohr et al., 1998). Shapiro's original attempts to ground EMDR in a neurobiological framework were purely speculative and received with skepticism (e.g., Herbert et al., 2000). In addition, she (1995) provided multiple examples of potential mechanisms, ranging from behavioral to neurobiological. Although it is possible that eye movements have effects in multiple domains, the result of the uncertainty has been to depict EMDR as a treatment in search of a theory. One review stated, "a direct link between the theoretical basis of the therapy and observable psychological and neurobiological changes has yet to be established" (Spector & Read, 1999, p. 165). Another review concluded, "rationales provided for [EMDR] at this point tend to be largely untested post hoc hypotheses constructed to justify the methods" (Turner, McFarlane, & van der Kolk, 1996, p. 549).

Concerns about the theoretical basis of EMDR have been compounded by Shapiro's failure to build her model on the foundation of existing information processing models, and her premature rejection of existing and established behavior theory. Her early formulations ignored the contributions of theorists such as Rachman (1980), Foa and Kozak (1986), and Marks (1977). In her recent text, Shapiro (2001) claims that "the EMDR-based information-processing model is both generally compatible with them and distinct in its elements and applications" (p. 13). Although this statement gives cursory acknowledgement to these earlier models, Shapiro continues to emphasize her focus on EMDR's distinct application and argues that the effects of EMDR are not well predicted by behavioral models (Shapiro & Maxfield, 2002c).

The Efficacy of EMDR

Methodological Factors

There has been much controversy related to methodological factors in EMDR outcome studies. EMDR advocates have tended to dismiss negative findings and to attribute these to poor methodology, and in particular have complained about a lack of treatment fidelity. EMDR critics have tended to dismiss positive findings, and in particular have complained about inadequate assessments. In our meta-analysis (Maxfield & Hyer, 2002) methodological factors were rated, using a scale adapted from Foa and Meadows gold standards (1997) and the relationships between methodology and effect sizes were examined. Results indicated a positive significant correlation between gold standard scores and effect size, with more rigorous studies tending to have larger effect sizes. We concluded that rigor may reduce error measurement and allow for the more accurate detection of treatment effects.

In particular we examined the factor of adequate course of treatment. The number of sessions provided in the PTSD outcome studies varied from 2 sessions (Devilly, Spence, & Rapee, 1998) to 12 sessions (Carlson et al., 1998). Early studies tended to provide 2-4 sessions, probably based on Shapiro's claims of rapidity of treatment effects. Shapiro (2001) stated: "controlled studies have indicated that 77–90% of civilian PTSD has been eliminated within three 90-minute sessions" (p. 19). The average number of sessions provided in nine randomized civilian trials was 5.1 sessions, with six of the studies providing 5 or more sessions (Maxfield, in press). In our methodological meta-analysis (Maxfield & Hyer, 2002), we operationalized "adequate course of treatment" as 5 or more sessions for single trauma (civilian participants) and at 11 or more sessions for multiple traumas (combat veterans). There was a significant positive correlation between effect size and course of treatment, with adequate course of treatment associated with larger effects. In addition, we found that there was no significant relationship between the overall number of sessions and treatment effect. We concluded that the differentiation between multiple and single traumas was relevant, and that individuals with multiple traumas appear to require a longer course of treatment.

The potential need for multiply traumatized individuals to receive a lengthy course of treatment was noted in the ISTSS Practice Guidelines. They wrote: "EMDR dosage (i.e., number of sessions) should be consistent with the complexity of the trauma and the number of traumatic memories" (Chemtob et al., 2000, p. 151).

PTSD Treatment

Shapiro introduced EMDR in 1989 with the publication of a case study (1989b) and a randomized clinical trial (1989a). Since that time, independent researchers at multiple sites have conducted another 19 controlled outcome trials investigating EMDR treatment of posttraumatic stress disorder (PTSD). The efficacy of EMDR in the treatment of traumatic stress has been widely acknowledged. In 1997, independent reviewers (Chambless et al., 1998) for the APA Division of Clinical Psychology placed EMDR, exposure therapy, and stress inoculation therapy on a list of empirically supported treatments, as "probably efficacious for civilian PTSD;" no other therapies were judged to be empirically supported by controlled research for PTSD populations. In 2000, after the examination of additional published controlled studies, the ISTSS Practice Guidelines designated EMDR as efficacious for PTSD (Foa, Keane, & Friedman, 2001). The United Kingdom Department of Health (2001) also listed EMDR as an efficacious treatment for PTSD. Further, a 1998 meta-analysis of all published studies on psychological and drug treatments for PTSD reported: "The results of the present study suggest that EMDR is effective for PTSD, and that it is more efficient than other treatments" (Van Etten & Taylor, 1998, p. 140).

Studies using waitlist controls found EMDR superior to no treatment (e.g., Rothbaum, 1997; S. A. Wilson, Becker, & Tinker, 1995, 1997); six studies compared EMDR to treatments such as biofeedback relaxation (Carlson, Chemtob, Rusnak, Hedlund, & Muraoka, 1998), active listening (Scheck, Schaeffer, & Gillette, 1997), standard care (group therapy) in a VA hospital (Boudewyns & Hyer, 1996), and standard care (various forms of individual therapy) in a Kaiser HMO facility (Marcus, Marquis, & Sakai, 1997). These studies all found EMDR superior to the comparison condition on measures of posttraumatic stress.

Comparisons with CBT treatments.

EMDR advocates (e.g., Shapiro, 2002a) have implied that EMDR may be more efficient and more efficacious than CBT. They claim that studies investigating cognitive behavioral (CBT) treatments for PTSD reported a smaller decrease in PTSD diagnosis in more sessions (e.g., Foa et al., 1999; 50% reduction in 7 sessions), than studies investigating EMDR treatment (e.g., Rothbaum, 1997; 90% reduction in 3 sessions). However, in the last few years several PTSD researchers conducted direct comparisons of EMDR and CBT, and they reported only minor differences between the treatment effects. Seven randomized clinical trials compared EMDR to exposure therapies (Ironson, Freund, Strauss, & Williams, 2002; McFarlane, 2000; Rothbaum, 2001; Taylor et al., 2003 Vaughan et al., 1994) and to cognitive therapies plus exposure (Lee, Gavriel, Drummond, Richards, & Greenwald, 2002; Power et al., 2002). These studies found EMDR and the cognitive/behavioral (CBT) control to be relatively equivalent, with a superiority in two studies for EMDR on measures of PTSD intrusive symptoms, and for CBT in the Taylor et al. (2003) study on PTSD symptoms of intrusion and avoidance.

For example, we (Taylor et al., 2003) randomly assigned 60 civilians with severe chronic PTSD to eight sessions of EMDR, prolonged exposure, or relaxation training. All three treatments produced significant decreases in the four dimensions of PTSD symptoms (reexperiencing, avoidance, numbing, and hyperarousal). There were no differences between the treatments in reductions of numbing and hyperarousal symptoms. However, exposure was significantly superior to both EMDR and relaxation in reducing reexperiencing and avoidance symptoms. There were no differences between EMDR and relaxation training. At post-treatment, exposure was significantly better than relaxation in reducing PTSD diagnosis (87% vs. 40%), but not significantly different from EMDR (60%).

Similarly, Lee et al. (2002) randomly assigned 22 civilian subjects with PTSD to Stress Inoculation Training with Prolonged Exposure (SITPE) or EMDR. After serving as their own controls during a wait list period, participants were provided with seven 60-min treatment sessions. Measures were collected at pre and post-treatment and at three-month follow-up. Both EMDR and SITPE were found to be effective, with significant improvement on PTSD and depression measures. At follow-up 83% of the EMDR subjects and 75% of the SITPE subjects no longer met PTSD criteria. The only difference found between groups was on the Intrusion subscales of the PTSD measures with the EMDR group showing significantly greater improvement.

Foa, Riggs, Massie, and Yarczower (1995) suggested that exposure therapy may not be very effective with clients whose prominent affect is anger, guilt, or shame. In contrast to these claims, Taylor et al. (2003) reported equivalent and significant effects for exposure therapy and EMDR on reducing symptoms of anger and guilt for civilians with PTSD. Reports by clinicians treating combat veterans (e.g., Lipke, 1999; Silver & Rogers, 2002) indicated that EMDR may be effective with such PTSD presentations. A preliminary study found that EMDR reduced symptoms of guilt in combat-related PTSD (Cerone, 2000).

Efficiency.

From the beginning, Shapiro (1989a, 1989b) has maintained that EMDR is an exceptionally rapid treatment. She referred to it as an "Accelerated Information Processing" therapy (Shapiro, 1995) "because the rapid learning and transmutation of characteristics can take place without the time limitations accepted and imposed on the previous traditional therapies" (Shapiro, 2002b, p. 27). However, research support for the assertion of exceptional efficiency is limited. Two PTSD studies that compared treatment response on a session-by-session basis (Taylor et al., 2003) and at mid-point (Rothbaum, 2001), reported that EMDR did not result in more rapid treatment effects than exposure. Two other studies found EMDR to be more efficient than the CBT comparison condition. In the Ironson et al. study (2002), 70% symptom reduction was achieved by a significantly larger number of clients in the EMDR + in vivo exposure condition than clients in the imaginal + in vivo exposure condition. In the Power et al. (2002) study, EMDR clients used significantly fewer sessions (4.2 vs. 6.4 sessions) than clients receiving exposure plus cognitive restructuring.

EMDR advocates argue that even if EMDR and exposure therapy achieved the same results in the same number of sessions, EMDR is still more efficient than exposure because it does not require the client to perform homework assignments. Typically, exposure treatment sessions are supplemented with one hour of daily homework, while the EMDR condition is implemented without homework. The only study to control for the supplementary effects of homework (Ironson et al., 2002) provided both exposure and EMDR treatments with the same number of hours of exposure homework, and reported more rapid results with EMDR. Most studies have noted that because EMDR has minimal homework requirements the overall treatment time was much shorter for EMDR (e.g., Lee et al., 2002; Vaughan et al., 1994).

Maintenance of effects.

Twelve studies with PTSD populations assessed treatment maintenance by analyzing differences in outcome between post-treatment and follow-up. Follow-up times have varied and include periods of 3, 4, 9, 15 months, and 5 years after treatment. Treatment effects were maintained in eight of the nine studies with civilian participants; one study (Devilly & Spence,

1999) reported a non-significant trend for deterioration. Of the three studies with combat veteran participants only one (Carlson et al., 1998) provided a full course of treatment (12 sessions). (See above, Methodological Factors, p. 11-12, for a discussion of recommended number of sessions). The Carlson study found that treatment effects were maintained at 9 months.

The other two studies provided more limited treatment than is currently recommended by the ISTSS Practice Guidelines (Chemtob et al., 2000). Pitman et al. (1996) treated only two of multiple traumatic memories, and treatment effects were not maintained at 5-year follow-up (Macklin et al., 2000). The ISTSS review commented, "In this study, restricting the focus to two clearly delineated traumatic events may have reduced the impact of the treatment procedure on overall PTSD symptoms" (p. 150). Devilly et al. (1998) provided two sessions and moderate effects at post-test were not maintained at follow-up. It appears that the provision of limited treatment may be inadequate to fully treat the disorder in multiply traumatized veterans, resulting in remission of the partial effects originally achieved.

Treatment of Phobias, Panic Disorder, and Agoraphobia

There is much anecdotal information that EMDR is effective in the treatment of specific phobias. Unfortunately, the research that has investigated EMDR treatment of phobias, panic disorder, and agoraphobia has not found strong empirical support for such applications. Although these results are due in part to methodological limitations in the various studies, it is also possible that EMDR may not be consistently effective with these disorders. De Jongh, Ten Broeke, and Renssen (1999) suggest that since EMDR is a treatment for distressing memories and related pathologies, it may be most effective in treating anxiety disorders which follow a traumatic experience (e.g., dog phobia after a dog bite), and less effective for those of unknown onset (e.g., snake phobia). De Jongh and colleagues (De Jongh & Ten Broeke, 1998; De Jongh et al. 1999; De Jongh, van den Oord, & Ten Broeke, 2002) have published various single case studies in which EMDR successfully eliminated dental and choking phobias that followed a traumatic experience.

Muris and his colleagues (Muris & Merckelbach, 1997; Muris, Merckelbach, van Haaften, & Nayer, 1997; Muris, Merkelbach, Holdrinet, & Sijsenaar, 1998) have conducted a series of experiments evaluating EMDR treatment of spider phobia. EMDR did not produce results better than those achieved by imaginal exposure and participants in these two conditions showed greater improvement after in vivo exposure (Muris & Merckelbach, 1997). These results were replicated in the other studies, indicating that EMDR was less effective than in vivo exposure therapy in eliminating the spider phobia. The authors provided Shapiro's "phobia protocol" and their description of the application indicates treatment fidelity, although Shapiro (1999) has criticized the authors of failure to use the full protocol. Unfortunately, in one of the children's studies (Muris et al., 1998), the EMDR session lasted for 2.5 hours. Such a lengthy procedure is not advised (Shapiro, 1995); indeed it is recommended that children's sessions be shorter than those of adults because of their limited attention span. Nevertheless these results strongly indicate that EMDR is not as effective in the treatment of spider phobia as in vivo exposure.

There have been three studies that investigated EMDR treatment of panic disorder with/out agoraphobia. The first two studies were preliminary (Feske & Goldstein, 1997; Goldstein & Feske, 1994) and provided a short course (six sessions) of treatment for panic disorder. The results were promising, with EMDR patients showing significant improvement compared to waitlist. A third study (Goldstein et al., 2000) was conducted to assess the benefits of a longer treatment course. This study however changed the target population and treated agoraphobic patients. Participants suffering from Panic Disorder with Agoraphobia did not respond well to EMDR. Goldstein (quoted in Shapiro, 2001) suggests that these participants needed more extensive preparation, than was provided in the study, to develop anxiety tolerance. The authors suggest that EMDR may not be as effective as CBT in the treatment of panic disorder with/out agoraphobia; however no direct comparison studies have yet been conducted.

Treatment of Other Clinical Disorders

Shapiro (2001) states that EMDR should be helpful in reducing or eliminating other disorders that originate following a distressing experience. For example, Brown, McGoldrick, and Buchanan (1997) found successful remission in five of seven consecutive cases of Body Dysmorphic Disorder cases after 1-3 EMDR sessions that processed the etiological memory. Similarly there have been reports of elimination of phantom limb pain following EMDR treatment of the etiological memory and the pain sensations (Vanderlaan, 2000; Wilensky, 2000; S. A. Wilson, Tinker, Becker, Hofmann, & Cole, 2000). It is not anticipated that EMDR will be able to alleviate symptoms arising from physiologically based disorders, such as schizophrenia or bipolar disorder. However, there are anecdotal reports of persons with such disorders being treated successfully with EMDR for distress related to traumatic events. Furthermore, this implied distinction may be a false one, based on increasing evidence from neuroscience that all disorders have their biological underpinnings.

In addition to studies assessing the effectiveness of EMDR in the treatment of PTSD, phobias, and panic disorders (see above), some preliminary investigations have indicated that EMDR might be helpful with other disorders. These include dissociative disorders (e.g., Fine &

Berkowitz, 2001; Lazrove & Fine, 1996; Paulsen, 1995); performance anxiety (Foster & Lendl, 1996; Maxfield & Melnyk, 2000); body dysmorphic disorder (Brown et al., 1997); pain disorder (Grant & Threlfo, 2002); and personality disorders (e.g., Korn & Leeds, 2002; Manfield, 1998). These findings are preliminary and further research is required before any conclusions can be drawn. Applications of EMDR are described for complaints such as depression (Shapiro, 2002b), attachment disorder (Siegel, 2002), social phobia (Smyth & Poole, 2002), anger dyscontrol (Young, Zangwill, & Behary, 2002), generalized anxiety disorder (Lazarus & Lazarus, 2002), distress related to infertility (Bohart & Greenberg, 2002), body image disturbance (Brown, 2002), marital discord (Kaslow, Nurse, & Thompson, 2002), and existential angst (Krystal et al., 2002); all such applications should be considered in need of controlled research for comprehensive examination.

The Components of EMDR

EMDR is a complex therapeutic approach that integrates elements of many traditional psychological orientations and combines these in structured protocols. These include psychodynamic (Fensterheim, 1996; Solomon & Neborsky, 2001; Wachtel, 2002), cognitive behavioural (Smyth & Poole, 2002; Wolpe, 1990; Young, Zangwill, & Behary, 2002), experiential (e.g., Bohart & Greenberg, 2002), physiological (Siegel, 2002; van der Kolk, 2002), and interactional therapies (Kaslow, Nurse, &Thompson, 2002). Consequently EMDR contains many traditional components, all of which are thought (but not proven) to contribute to treatment outcome.

Marks, Lovell, Noshirvani, Livanou, & Thrasher (1998) proposed that emotion can be conceptualized as a "skein of responses," viewed as "loosely linked reactions of many physiological, behavioral, and cognitive kinds" (p. 324). They suggest that different types of treatment will weaken different strands within the skein of responses and that "some treatments may act on several strands simultaneously" (p. 324). EMDR is a multi-component approach that works with strands of imagery, cognition, affect, somatic sensation, and related memories.

Shapiro's (2001) Adaptive Information Processing model conceptualizes EMDR as working directly with cognitive, affective, and somatic components of memory to forge new associative links with more adaptive material. A number of treatment elements are formulated to enhance the processing and assimilation needed for adaptive resolution. These include: (1) *Linking of memory components.* The client's simultaneous focus on the image of the event, the associated negative belief, and the attendant physical sensations, may initiate information processing, by forging initial connections among various elements of the traumatic memory. (2) *Mindfulness.* Instructing clients to "just notice" and to "let whatever happens, happen", encourages mindfulness. This cultivation of a stabilized observer stance in EMDR appears similar to processes advocated by Teasdale (1999) as facilitating emotional processing. (3) *Free association.* During processing, clients are asked to report on any new insights, associations, emotions, sensations, images, that emerge into consciousness. This non-directive free association method may create associative links between the original targeted trauma and other related experiences and information, thus contributing to processing of the traumatic material (see Rogers & Silver, 2002). (4) *Repeated access and dismissal of traumatic imagery.* The brief exposures of EMDR may provide clients with repeated practice in controlling and dismissing disturbing internal stimuli, although it is difficult to demonstrate that instructions lead to this putative effect. This may provide clients with a sense of mastery, contributing to treatment effects by increasing their ability to reduce or manage negative interpretations and ruminations. (5) *Eye movements and other dual attention stimuli.* There are many theories about how and why eye movements may contribute to information processing, and these are discussed in detail below.

The Cognitive Component

When a specific memory is identified for processing with EMDR, several components of the memory are clearly identified. Among these are the associated cognitions: the client's present negative self-assessment and a desired positive belief. Identification and verbalization of the negative cognition may help the client recognize the irrationality of his/her cognitive interpretation of the event, and the impact that this continues to have on current self-concept ("e.g., "I'm unlovable"). Formulation of the desired positive cognition often involves reframing and restructuring. The therapist helps the client to identify a desired positive belief that expresses a sense of empowerment or value. The client's rating of confidence in this positive belief on the VOC scale provides both client and clinician with a baseline with which to assess the appropriateness of the chosen cognition and a given session's progress. It also serves to increase the client's awareness of his/her cognitive distortions.

Only one study has assessed the contribution of the cognitive element in EMDR. Cusack and Spates (1999) randomly assigned 27 participants to standard EMDR and to EMDR-without-cognitive-elements. All participants had experienced a traumatic incident; 67% met full criteria, and 33% partial criteria for the diagnosis of PTSD. Both conditions resulted in significant decreases on all measures. No difference was found between the two conditions, suggesting that for these participants the cognitive element of EMDR was not required for treatment effects. These results are similar to those found in PTSD outcome studies and depression dismantling studies. Although cognitive therapy is efficacious as a stand-alone treatment for PTSD (e.g., Resick, Nishith, Weaver, Astin, & Feuer, 2002), outcome was not improved when cognitive therapy was added to exposure therapy (Foa et al., 1999; Marks et al, 1998). Similarly, Jacobson et al. (1996) found no advantage for the addition of cognitive elements in the behavioral treatment of depression.

The Component of Exposure

A standard treatment for anxiety disorders involves exposing clients to anxiety eliciting stimuli (Craske, 1999). Many scientists posit that EMDR uses exposure in this traditional manner and that this accounts for EMDR's effectiveness. For example, some reviewers stated, "Had EMDR been put forth simply as another variant of extant treatments, we suspect that much of the controversy over its efficacy and mechanisms of action could have been avoided" (Lohr, Lilienfeld, Tolin, & Herbert, 1999, p. 201). In response, EMDR advocates (e.g., Rogers & Silver, 2002) argued that such a perspective ignores elements of the EMDR procedure that are antithetical to exposure theories; in other words, the theories predict that if these EMDR elements were used in exposure therapy, a diminished outcome would result.

These elements include frequent brief exposures, interrupted exposure, and free association. (1) Exposure theorists Foa and McNally (1996) wrote: "Because habituation is a gradual process, it is assumed that exposure must be prolonged to be effective. Prolonged exposure produces better outcome than does brief exposure, regardless of diagnosis" (p. 334). EMDR however uses extremely brief repeated exposures (i.e., 20-50 seconds). Nevertheless, EMDR's brief exposures, which occur repeatedly over a number of 60-90 minute sessions, can be considered to have a cumulative effect, and therefore may constitute prolonged exposure. (2)

Other theorists (Marks et al., 1998) stated that exposure should be continual and uninterrupted: "Continuous stimulation in neurons and immune and endocrine cells tends to dampen responses, and intermittent stimulation tends to increase them" (p 324). EMDR, on the other hand, interrupts the internal attention repeatedly to ask, "What do you get now?" Nevertheless, it could be said that this process does not interrupt exposure and that it actually deepens or extends exposure, by ensuring that the client is exposed to all aspects of the traumatic experience. (3) Exposure therapy is structured to inhibit avoidance (Lyons & Keane, 1989), and specifically prohibits the patient from reducing his/her "anxiety by changing the scene or moving it ahead quickly in time to skim over the most traumatic point" (p. 146) in order to achieve extinction of the anxiety. EMDR advocates point out that clients are encouraged to "change the scene" through the free association to whatever enters their consciousness. While this process may appear to divert attention from a focus on the actual experience, Shapiro's (2001) model posits that the elicited material is part of the traumatic memory network, and is integrally related to the core incident. Therefore association can be considered to enhance exposure.

It should be noted that EMDR and exposure therapy appear to differ in treatment process. During exposure therapy clients generally experience long periods of high anxiety (Foa & McNally, 1996; Jaycox, & Foa, 1996), while EMDR clients generally experience rapid reductions in SUD levels early in the session (Rogers et al., 1999). This difference suggests the possibility that EMDR's use of repeated short focused attention may invoke a different mechanism of action than that of exposure therapy with its continual long exposure. This speculation requires research investigation.

Eye Movements

In EMDR, eye movements (EMs) are used to engage the client's attention to an external stimulus, while the client is simultaneously focusing on internal distressing material. Shapiro (2001) describes EMs as "dual attention stimuli," to identify the process in which the client attends to both external and internal stimuli. Therapist directed EMs are the most commonly used dual attention stimulus but a variety of other stimuli including hand-tapping and auditory stimulation are often used. The use of such alternate stimuli has been an integral part of the EMDR protocol for more than 10 years (Shapiro 1991, 1993).

In 1989, Shapiro (1995) noticed that the emotional distress accompanying disturbing thoughts disappeared as her eyes moved spontaneously and rapidly. She began experimenting with this effect and determined that when others moved their eyes, their distressing emotions also dissipated. She conducted a case study (1989b) and controlled study (1989a), and reported support for her hypothesis that EMs were related to desensitization of traumatic memories. The role of eye movement had been previously documented in connection to cognitive processing mechanisms. A series of systematic experiments (Antrobus, 1973; Antrobus, Antrobus, & Singer, 1964) revealed that spontaneous EMs were associated with unpleasant emotions and cognitive changes.

Research Evaluating Eye Movements in EMDR

There have been about 20 published studies that investigated the role of EMs in EMDR. Studies have typically compared EMDR-with-EMs to a control condition in which the EM component was modified (e.g., EMDR-with-eyes-focused-and-unmoving). There have been four different types of studies: (1) single case experiments, (2) component studies using clinical participants (3) component studies using non-diagnosed participants, and (4) component action studies in which eye movements are examined in isolation. The four single case experiments are not reviewed in this dissertation, as they do not permit conclusions about underlying factors or causal mechanisms.

To further evaluate these studies, effect sizes were calculated for the component outcome studies that used diagnosed and non-diagnosed participants. The effect size is Cohen's *d*, which is the difference between pre and post means, divided by the pooled standard deviation. As can be seen in Table 1, there are many missing cells. A number of studies did not use outcome measures, and some did not report SUD ratings. Only a few studies investigated the use of alternate dual attention stimuli such as tapping or tones. This calculation of effect sizes clearly demonstrates the lack of difference between the EM condition and the no-EM comparison. The effect size for combined outcome measures was 0.98 for EM and 0.77 for the diagnosed participants; for the non-diagnosed participants the effect sizes were 0.61 for EM and 0.71 for no-EM. The SUD ratings also show no advantage for the EM conditions, with an effect size of 2.62 versus 2.79 for the diagnosed participants, and 1.53 versus 1.19 for non-diagnosed participants.

Clinical component studies with diagnosed participants.

There have been six controlled dismantling studies with diagnosed participants, four with PTSD participants and two studies where participants were diagnosed with other anxiety disorders. In these studies EMDR-with-EMs was compared to EMDR-without-EMs. Two (Feske & Goldstein, 1997; Wilson, Silver, Covi, & Foster, 1996) of the six studies found limited evidence that EMDR-with-EMs produced significantly superior outcomes compared to EMDR-without-EMs. The other studies found no advantage for the inclusion of EMs. As calculated in the current review, the mean Cohen's *d* effect size for combined outcome measures for the EM conditions in the six studies was 0.98, compared to 0.77 for the no-EM conditions (see Table 1). In their meta-analysis, Davidson and Parker (2001) reported that when EMDR-with-EMs was compared to EMDR-without-EMs, the effect size was "marginally significant if once examines only clinical populations satisfying [DSM] criteria" (p. 311). However, the aggregate finding indicates that EMs do not appear to contribute to outcome.

In the only EMDR dismantling study with civilian PTSD participants, Renfrey and Spates (1994) randomly assigned 23 PTSD participants to 3 treatment conditions: EMDR-with-EMs produced by tracking a clinician's finger; EMDR-with-EMs produced by tracking a light bar, and EMDR-with-fixed visual attention (EF). All three conditions produced significant improvement on multiple standardized measures. Although there was a decrease in PTSD diagnosis of 85% for EM conditions and 57% for the no-EM condition, there were no significant differences between conditions. There was no evidence that EMs contributed to outcome. EMDR advocates (e.g., Shapiro, 2001) have criticized this study for having inadequate statistical power, because there were only six or seven persons per condition. However, the effect sizes (See Table 1) are large enough (1.91-2.38) that a small sample can be considered adequate to assess significance.

The participants in the other three PTSD dismantling studies (Boudewyns & Hyer, 1996; Devilly et al., 1998; Pitman et al., 1996) were combat veterans, who received only two sessions or treatment of only one-two traumatic memories. The studies reported only small to moderate treatment effect sizes (0.15-0.67). (See Table 1). These studies did not find any advantage for the EM conditions over the no-EM comparison conditions Pitman et al. (1996) provided 17

Table 1

Summary of Effect Sizes Across EMDR Component Studies

Clinical Component Studies		**Mean Effect Size Outcome Measures**			**Effect Size of SUD Ratings**		
	Problem	EM	Tap/Tone	EC/EF	EM	Tap/Tone	EC/EF
Diagnosed Participants							
Boudewyns & Hyer, 1996	PTSD	0.67		0.48	n/a		n/a
Devilly et al. (1998)	PTSD	0.62		0.27	1.05		0.85
Pitman et al., 1996	PTSD	0.15	0.48		n/a	n/a	
Renfrey & Spates, 1995	PTSD	2.26		1.91	4.18		4.73
Feske & Goldstein, 1997	Phobia	1.22		0.41	n/a		n/a
Wilson et al., 1996	Mixed	n/a		n/a	n/a		n/a
Mean Effect Size		**0.98**		**.77**	**2.62**		**2.79**
Non-diagnosed Participants							
Bauman & Melnyk, 1994	Test Anxiety	n/a		n/a	2.22	1.51	
Carrigan & Levis, 1999	Speech Anxiety	n/a		n/a	0.00		0.02
Dunn et al., 1996	memories	0.41		0.47	1.34		1.11
Foley & Spates, 1995	Speech Anxiety	0.89	0.96	0.91	3.89	3.53	3.97
Gosselin & Matthews 1995	Test Anxiety	0.54		0.74	0.90		0.03
Sanderson & Carpenter, 1992	Fears	n/a		n/a	0.82		0.83
Mean ES Studies		**0.61**		**.71**	**1.53**	**2.52**	**1.19**

Note: Effect size is Cohen's *d*, which is the difference between pre and post means, divided by pooled standard deviation. The effect size for each study is the mean effect size of all measures used in that study.

chronic outpatient veterans with EMDR-with-EMs or EMDR-with-a combination of forced eye fixation, hand taps, plus therapist hand waving. Six sessions were administered for a single memory in each condition. Both conditions showed significant decreases in self-reported distress, intrusion, and avoidance symptoms. The tapping-fixed eye condition produced significantly greater improvement on a measure of intrusive symptoms than the EM condition. The effect sizes were small to moderate and effects were not maintained at 5-year follow-up (Macklin et al., 2000). This study has been criticized by EMDR advocates (e.g., Greenwald, 1996) for the small sample size, and for using an EMDR-variant (tapping) as a comparison condition. No advantage was found for participants in the EM condition and a slight advantage was found for participants in the fixed eye plus tapping condition.

The other two PTSD dismantling studies also did not find any advantage for the EM condition, and also had small-moderate effect sizes (see Table 1). In the Boudewyns and Hyer (1996) study, group therapy was supplemented with EMDR-with-EMs, EMDR-with-eyes-closed (EC), or no supplement. Participants who received the supplementary EMDR conditions showed superior improvement on mood and physiological measures compared to group therapy controls, and with no differences between EMDR-with-EMs and EMDR-with-EC. All participants improved significantly on a structured interview measuring PTSD symptoms, with no condition differences. The authors acknowledged that the chronicity and severity of the clients' PTSD, and variable treatment fidelity were limitations of the study. This study indicated that the addition of EMDR to group treatment may improve outcome, and that there was no advantage for the EM condition.

Devilly, Spence and Rapee (1998) assigned 51 combat veterans with PTSD to Standard Psychiatric Support (SPS), two sessions of EMDR-with-EM, or two sessions of EMDR-with-eyes fixed (EF) in which subjects concentrated on a stationary flashing light. At post treatment all groups showed significant improvement on measures of PTSD, depression, anxiety, and problem coping. Measures of reliable change indicated that 67% of the EM condition, 42% of the EF condition, and 10% of the SPS group were reliably improved. There were however no statistical differences between the three groups and the study did not find any significant advantage for the EM condition. This study had multiple methodological limitations including a lack of random assignment, an assessor who was not blind nor independent, treatment delivery that did not follow standard protocols, different assessment procedures at pre and post test, participants receiving concurrent mental health treatment, and provision of only 2 sessions to multiply traumatized veterans.

D. L. Wilson et al. (1996) compared EMDR-with-EMs to EMDR-with-taps and to EMDR-with eyes open. The 18 participants were a mixed group; 61% were diagnosed with PTSD and 39% with other anxiety disorders. Wilson et al. reported excellent results for the EM condition and concluded that it resulted in a "compelled relaxation response" (p. 227) that was not achieved in the other conditions. The only outcome measures used in this study were physiological measures (galvanic skin response, skin temperature, heart rate) and the reliability of these measures has been considered suspect by some critics. This study has many serious limitations, including inadequate statistical analysis, lack of a blind independent assessor, use of a mixed sample, lack of standardized measures, and no assessment of treatment fidelity. In their meta-analysis, Davidson & Parker (2001) argued that the Wilson et al. (1996) study was a "statistical outlier" because the exceptionally large effect size was very unusual (Rosenthal's r = .99). These concerns suggest that the results should be given little weight.

Feske and Goldstein (1997) assigned participants diagnosed with phobias to wait-list, EMDR-with-EMs and EMDR-without-EMs. Those in the EM condition showed significant improvement on multiple measures compared to wait-list. A minor significant advantage was reported for participants in the EM condition. These patients showed greater improvement on 2 of 5 measures assessing panic symptoms, compared to the no-EM condition. They also showed greater gains on measure of depression, social adjustment, and endstate functioning. The advantage for the EM condition, indicated by a combined effect size of 1.22 on the 5 measures, compared to 0.41 for the no-EM condition, disappeared at 3-month follow-up. This shift was reflected in a non-significant decrease in the EM effect size to 0.86, and a non-significant increase in the no-EM effect size to 0.62. The early advantage for the EM condition dissipated over time.

Clinical component studies with non-diagnosed participants.

There were six outcome studies with non-diagnosed participants (see Table 1). In these studies, participants with no diagnosed psychiatric disorders received treatment for complaints of public speaking anxiety, test anxiety, non-diagnosed phobias, and distressful memories. None of these studies found a significant effect for EMs as a contributor to outcome although they generally reported that the EM condition lowered SUD ratings more effectively than the no-EM condition. The outcome findings were well summarized by Lohr, Kleinknecht, Tolin, & Barrett, (1995) who wrote, "the evidence for the necessity of eye movements is meager" (p. 296).

Unfortunately, only two of the six studies (Foley & Spates, 1995; Gosselin & Matthews, 1994) mest basic methodological standards. Although confidence in the clinical findings of the other four studies is limited by numerous methodological problems, their reports that EMs do not contribute to outcome are consistent with the results of Foley and Spates (1995) and Gosselin and Matthews (1994). Two studies (Carrigan & Lewis, 1999; Sanderson & Carpenter, 1992) truncated the procedure and provided less than 3 or 5 minutes of EM, rather than the 40-70 minutes which is the standard application. Four of the six studies (Baumann & Melnyk, 1994; Carrigan & Lewis, 1999; Foley & Spates, 1995; Sanderson & Carpenter, 1992) provided EMD, the early version of EMDR which was not taught after 1991, and which lacks the EMDR components of free association, cognitive interweaves, and mindfulness. Although it has not been determined if EMD and EMDR produce different results, they use different treatment processes; the internal validity of these studies is unclear, because they did not use the standardized EMDR procedure. Three of the six studies did not use any pre-post outcome measures (Carrigan & Levis, 1999; Dunn, Schwartz, Hsatfield, & Wiegele, 1996; Sanderson & Carpenter, 1992), making it impossible to determine if the treatment had any effect. A fourth study (Bauman & Melnyk, 1994) confounded treatment conditions, making it impossible to determine pre-post effects.

The use of non-diagnosed participants makes it difficult to determine the nature of the complaint and its severity, and to assess whether treatment effects are generalizable to clients with more severe disorders. This problem can be alleviated to some extent through the use of standardized measures developed for the specific population. Three of the six studies (Baumann & Melnyk, 1994; Foley & Spates, 1995; Gosselin & Matthews, 1995) used standardized measures developed for their populations of test anxious and public speaking anxious individuals, which allowed the reader to assess the severity the disorder in that sample, and to evaluate the extent of the treatment effects. However the three other studies did not use any standardized measures at pre-test, making it impossible to evaluate the level of distress in the non-diagnosed sample. For example, the inclusion criteria for the Sanderson and Carpenter (1992) "phobic" study, was that individuals could "feel fear when imaging the feared stimulus" (p. 269). No diagnostic assessment was conducted and no standardized measures were used. It is not known whether the effects of the study can be generalized to individuals meeting DSM criteria for a phobia diagnosis.

Baumann and Melnyk (1994) provided EMD to participants with test anxiety, comparing an EM condition to a finger-tapping condition. One standardized measure, Test Anxiety Inventory, was used. Although the authors report no differences between tapping and EM conditions, the authors write, "Since nine of the (15) finger tapping S's received the eye movement condition as a delayed treatment it is not possible to separate the effects of the two conditions in these (post) scores" (p. 31). This study appears to have confounded conditions, making it impossible to separate the condition effects.

Gosselin and Matthews (1995) also treated participants with test anxiety. They investigated the effects of high and low expectancy and EM versus no-EM conditions, in a 2 x 2 design with 41 participants. One standardized measure, Test Anxiety Inventory, was used. Subjects received one 60-minute session of either EMDR or EMDR without eye movements (the therapist's fingers remained stationary and subjects looked at them for 25 seconds). In the high expectancy condition, subjects received introductory statements that said EMDR was a powerful new treatment. In the low expectancy condition, subjects were told that this was a new treatment with unknown effects. There was no effect found for expectancy. Scores on the Test Anxiety Inventory showed significant reduction for all treatment groups, there was no difference between EM and no-EM conditions on the TAI. The EM condition was more effective in reducing SUDS, than the no-EM condition.

Foley and Spates (1995) assigned 40 students with public-speaking anxiety to one of four groups: (1) EMD-with-EM, (2) EMD-with-moving audio stimulus (tone), (3)EMD-with-eyes focused on own hands (EF), and (4) no treatment. The participants received 1-2 treatment sessions. Outcome measures included three standardized objective inventories of speech anxiety and heart rate: The study demonstrated limited effectiveness for EMD with public-speaking anxiety, with significant effects for all conditions on one measure of public speaking anxiety. All three conditions also produced significant changes on SUD ratings. There was no benefit for the EM condition compared to tone or EF on either SUDs or outcome. This methodologically rigorous study appeared to support the hypothesis that EMs do not contribute to outcome.

Another EMD study on public speaking anxiety was conducted by Carrigan and Levis (1999). Unfortunately, this study lacks the methodological strengths of the Foley and Spates (1995) study. One standardized measure was used at pre-test, and a different standardized measure was used at post-test, making it impossible to assess any therapeutic progress. Only 10 minutes of treatment was provided; this included nine 15-second administrations of EMs and the comparison condition, no-EM. There were four conditions: EM and a focus on fear-relevant imagery; EM and a focus on relaxing imagery; no-EM and a focus on fear-relevant imagery; no-EM and a focus on relaxing imagery. An unexpected finding was an increase in physiological responding during the EM conditions, but it was not possible to determine the significance, if any, of this result. The post-test involved asking the participants to perform a short speech. Although participants in the no-EM conditions spoke for a significantly longer duration than those.in the EM condition, the lack of pre-tests on this measure limits the relevance of the finding.

Dunn et al. (1996) matched 14 pairs of participants for sex, age, level of stress, type of trauma). They provided one session of EMDR-with-EM or EMDR-without-EM, a fixed eye condition. The description of the treatment indicates a lack of conformity to the EMDR protocol, in that participants were repeatedly asked to focus on the target image. One member of the pair received EMDR-with-EM treatment for a distressing memory, until his/her SUD score reached 0 or 1, or for 45 minutes. Then the matched control participant received the same amount of treatment. No standardized outcome measures were used; physiological measures and SUD ratings were taken at pre and post treatment. The physiological measures reflected the decrease in SUD ratings that occurred at post-test. There were no differences between EM and no-EM conditions.

Sanderson and Carpenter (1992) investigated the effectiveness of EMD for clients with "phobias." No diagnostic assessment was conducted and the inclusion criteria were that the participant could "feel fear when imaging the feared stimulus" (p. 269). There were two treatment conditions, EMD-with-EM and EMD-without-EM. Each patient experienced both conditions; half with EMD-with-EM presented first, and half with EMD-without-EM presented first. Patients received seven 20-second administrations of each condition. The total treatment time was about 15 minutes. No standardized outcome measures were used. SUD ratings were taken before and after each condition. There were no significant differences between conditions and no advantage for the EM condition.

Component action studies.

Component action studies, or laboratory studies, test EMs in isolation. These studies typically provide brief sets of EMs (not EMDR) to examine their effects on memory, affect, cognition, or physiology. The purpose is to investigate the effects of moving the eyes (not EMDR), and EMs are compared to control conditions such as imaging and tapping. For example, a participant might be asked to visualize a memory image, then to move their eyes for a brief period, and then to rate the vividness of the image. This permits a pure test of the specific effects of EMs and non-EMs without the added effects of the active ingredients of the other EMDR procedures.

Findings from these studies suggest that EMs may have an effect on physiology, decreasing arousal (e.g., Barrowcliff, MacCulloch, & Gray, 2001; D. Wilson et al., 1996) and on memory processes, enhancing semantic recall (Christman & Garvey, 2000; Christman, Garvey, Propper, & Phaneuf, in press). Four studies (Andrade, Kavanagh, & Baddeley, 1997; Kavanagh et al., 2001; Sharpley, Montgomery, & Scalzo, 1996; van den Hout, Muris, Salemink, & Kindt, 2001) have demonstrated that EMs decrease the vividness of memory images and the associated emotion. No (or minimal) effect has been found for tapping conditions. These studies suggest that EMs may make a contribution to treatment by decreasing the salience of the memory and its associated affect. These studies are discussed in more detail in the section "*Related Studies Investigating Eye Movements*" on page 65.

The working memory studies (e.g., Kavanagh et al., 2001) have used non-clinical participants. Although research is needed to determine if similar results are achieved with diagnosed participants, it is anticipated that the results should be generalizable. These studies are not studying a treatment process; instead they are investigating basic memory functions which are thought to transcend mental disorders. For example, all individuals have long-term, short-term, and working memory (see p. 41 for a more detailed analysis). All individuals use the basic memory mechanisms of encoding, storage and retrieval (Schacter, 1996). The memory dysfunctions that can result from some mental disorders, such as poor short-term memory, are usually explainable in terms of basic memory mechanisms. For example, lack of concentration is related to impaired working memory.

Although the area of traumatic memory has been somewhat controversial, most scientists now agree that traumatic memories do not have special properties and that common memory mechanisms are adequate in explaining memories of traumatic experiences (Shobe & Kihlstrom, 1997). Even dissociative memory problems can be (partly) described by processes (identified in experimental laboratory studies) such as diminished rehearsal, intentional forgetting, encoding specificity, and implicit memory (Spinhoven, Nijenhuis, & Van Dyck, 1999). The elements of storing and remembering emotional and traumatic memories have been well documented in numerous research studies (LeDoux, 1996).

Nevertheless, being able to conceptualize the memory mechanisms involved does not necessarily change the intractability of some traumatic memories. Indeed, "the core pathology of PTSD is that certain sensations or emotions related to traumatic experiences keep returning in unbidden ways, and do not fade with time" (van der Kolk, 2002). It is not yet known whether the intense vivid intrusive memories of PTSD are subject to the same deterioration of image and emotion when a dual attention task is presented. Research is needed to investigate this critical question.

The Contribution of Eye Movements to Outcome in EMDR

. Various reviews of the related EM research have provided a range of conclusions. Some reviewers (e.g., Lohr, Lilienfeld, Tolin, & Herbert, 1999; Lohr, Tolin, & Lilienfeld, 1998) stated that there is no compelling evidence that eye movements contribute to outcome in EMDR treatment and the lack of unequivocal findings has led some reviewers to dismiss EMs altogether (e.g., McNally, 1999). Other reviewers (e.g., Chemtob et al., 2000; Feske, 1998; Perkins & Rouanzoin, 2002) identified methodological failings (e.g., lack of statistical power, floor effects) and called for more rigorous study.

Nevertheless, it is apparent that the research to date has found no evidence for the contribution of EMs to outcome. A more interesting question is if EMs contribute to treatment process. Although some studies have found that EMs reduce SUD ratings more than the no-EM comparison condition, this has not been a consistent finding (see Table 1).

Some Hypothesized Mechanisms of Action for Eye Movements in EMDR

There are several different models seeking to explain the mechanism of dual attention stimulation in EMDR in terms of an orienting or investigatory response. The orienting response is a natural response of interest and attention that is elicited when attention is drawn to a new stimulus; it is thought to interfere with the activation of the conditioned response (Armstrong & Vaughan, 1994). Sleep researcher, Stickgold (2002) has suggested that the orienting response in EMDR induces neurobiological mechanisms, which facilitate the activation of episodic memories and their integration into cortical semantic memory. He speculated that such mechanisms are similar to those involved in the learning processes active during sleep. Recent research by Kuiken, Bears, Miall and Smith (2001-2002) has provided preliminary support for the attentional orienting effects of EM, finding similar outcomes to that achieved in studies of orienting response subsequent to REM sleep.

MacCulloch and Feldman (1996) and Barrowcliff et al. (2001) posited that the orienting in EMDR is actually an "investigatory reflex." This reflex is said to result in a reassessment of the environment; with the perception that there is no threat, a basic relaxation response is elicited. These effects are thought to contribute to outcome through a process of reciprocal inhibition. This model fails to explain some of the observed effects of EMDR processing, including a range of affective states, increases in arousal, and elicitation of other related distressing memories (Welch & Beere, 2002).

These various models are purely speculative, and research is needed to test their hypotheses. In addition, it should be noted that the orienting response does not explain the effects of Shapiro's (1995) original spontaneous eye movements in the park, as she was not focusing on an external stimulus.

There are several research studies (e.g., Andrade et al., 1997; Kavanagh et al., 2001; van den Hout et al., 2001) indicating that EMs and other stimuli have an effect on perceptions of the targeted memory, decreasing image vividness and associated affect. Two possible mechanisms have been proposed to explain how this effect may contribute to EMDR treatment. Kavanagh et al. (2001) hypothesize that this effect occurs when EMs disrupt working memory, decreasing vividness, and that this results in decreased emotionality. They further suggest that this effect may contribute to treatment as a "response aid for imaginal exposure" (p. 278), by titrating exposure for those clients who are distressed by memory images and/or affect. Van den Hout et al. (2001) hypothesize that EMs change the somatic perceptions accompanying retrieval, leading to decreased affect, and therefore decreasing vividness. They propose that this effect "may be to temporarily assist patients in recollecting memories that may otherwise appear to be unbearable" (p. 129). This explanation has many similarities to reciprocal inhibition.

These theories and related studies are described in detail in the section *Related Studies Investigating Eye Movements*, beginning on page 65.

Working Memory

Memory

Memory is a complicated system with multiple components. Storage duration ranges from nanoseconds to the span of a lifetime, with storage capacity varying from a few items held in short-term memory to the vast body of information stored in long-term memory (Baddeley, 1998). There are many theories of memory; these vary in their elements of structure (e.g., single-system, multiple component), process (e.g., encoding, storage, retrieval), and/or content (e.g., episodic, semantic). Memory is most commonly conceptualized as a multi-component framework, consisting of sensory stores, short-term memory store, working memory, and long-term memory (Eysenck, 2001).

Sensory stores and short-term memory.

Sensory stores hold memory very briefly and are modality specific. This type of memory allows us to retrieve what we have just seen (iconic store) or heard (echoic store). Short-term memory is understood to have primarily a storage function. Traditional verbal span and digit span tasks are considered assessment measures of short-term memory.

Working memory.

Working memory is transient and has limited resources. Its capacity is restricted by the amount of material that can be held, the length of time the material can be maintained, and processing demands. In addition to information storage, working memory has computational, prospective, and inhibitory functions. It is conceptualized as a "limited capacity system allowing the temporary storage and manipulation of information necessary for such complex tasks as learning, comprehension, and reasoning" (Baddeley, 2000, p. 418). Complex span measures such as operation span or reading span are considered assessment measures of working memory.

The model of working memory primarily referred to in this paper is Baddeley's multi-component model (Baddeley & Hitch, 1974; Baddeley, 1986; Baddeley, 1998; Baddeley, 2000). It is the most cited, researched, and empirically supported model. Other models include the single storage system of Cowan (1988) with its various levels of activation; the resource sharing model (Daneman & Carpenter, 1980; Hitch et al., 2001) which posits a trade-off between storage and processing demands; the controlled attention model (Engle, Kane, & Tuholski, 1999) which hypothesizes that performance on working memory span tasks depends on short-term memory capacity and controlled attention; and numerous other conceptual frameworks.

Baddeley's multi-component model (Baddeley & Hitch, 1974; Baddeley, 1986, 1996, 1998, 2000) includes four basic components: the central executive, phonological loop, visuospatial sketchpad, and episodic buffer (see Table 1). It is assumed that bi-directional links connect and communicate information between all elements of this model.

Long-term memory.

Long-term memory holds a vast amount of information. There are various types of long-term memory (see Schacter, 1996), including procedural memory, which contains non-declarative knowledge of skills and habits; and implicit memory, in which past experiences unconsciously influence perceptions, thoughts, and actions. Tulving (1972) posited that memory can be understood as either semantic or episodic. Episodic memory is the storage and retrieval of specific events; it contains autobiographical records, information about experiences that

Table 1

Baddeley's Multi-Component Model of Working Memory

The central executive

- provides administrative functions, including:
    - allocation of attention and division of attention between concurrent tasks
    - choice and use of memory retrieval strategies
    - temporary activation of long-term memory
    - inhibition of interference from environmental stimuli and events stored in long-term memory.

The phonological loop

- stores, rehearses, and processes auditory and verbal information.
- plays an important role in the learning of language
- implicated in subvocalization; e.g., repetition of cues for a task, internal dialogue.

The visuospatial sketchpad

- stores, rehearses, and processes visual and spatial information.
- stores information about form and color
- works with spatial and movement information
- maintains this information in an active state.

The episodic buffer

- integrates information from long-term memory and the phonological and visuospatial subsystems
- information is integrated across space and time, and across modalities
- consolidates information by chunking it into episodes
- serves the function of temporary storage
- has limited capacity

occurred in specific spatial and temporal contexts. Semantic memory is conceptual and factual knowledge of the world. Tulving and colleagues (Wheeler, Stuss, & Tulving, 1997) have asserted that these concepts are not solely distinguished by the content of the memory: A key component is subjective experience during recall. Episodic memory is characterized by "the type of awareness experienced when one thinks back to a specific moment in one's personal past and consciously recollects some prior incident or state as it was previously experienced" (p. 333). In contrast, semantic memory is objective knowledge; the information is not dependent on, or linked to, any specific experience. This may be understood as the felt difference between remembering and knowing (e.g., Gardiner & Richardson-Klavehn, 2000).

The Relationships between Short-term, Working, and Long-term Memory

Verbal tasks.

Tulving and Colotla (1970) stated that memory for a word can be attributed to short-term memory if no more than 7 other "events" (e.g., words) have intervened between its presentation and recall. If more than 8 words have intervened, memory is attributed to long-term memory. Research using verbal tasks has distinguished between short-term memory and working memory. Verbal working memory span tasks, that have a processing component, appear to better predict reading comprehension than short-term memory span tasks (e.g., Daneman & Carpenter, 1980; Daneman & Merikle, 1996).

Engle, Tuholski, Laughlin, and Conway (1999) conducted a latent-variable analysis to determine the extent to which short-term memory and working memory are separate constructs. Using verbal tasks, they found that although short-term memory and working memory span scores correlated with each other (r = .68) at the latent variable level, working memory span tasks predicted performance on general fluid intelligence tests, even after the short-term memory variance was partialled out. When the working memory variance was partialled out, the short-term memory span tasks no longer correlated with general fluid intelligence. These findings appear to support the concept that working memory span tasks measure an element that is not assessed by short-term memory tasks. The authors explained this effect by proposing that the working memory task differs from the short-term memory task in that it requires controlled attention. Using the terms of Baddeley's (1986) model, Miyake, Friedman, Rettinger, Shah, and Hegarty (2001), suggest that short-term memory capacity is equivalent to the capacity of the phonological loop, and that working memory capacity is determined by the capacity of the phonological loop and the efficiency of the central executive, so that "working memory = short-term memory + controlled attention" (p. 622). However, such a formulation appears to ignore the processing functions of working memory.

Visual tasks.

Spatial span tasks measuring short-term memory and working memory appear to equally predict performance on spatial ability tests (Shah & Miyake, 1996). In a latent-variable analysis, using spatial tasks, Miyake et al. (2001) determined that both short-term memory and working memory had a strong relationship to executive function and could not be discriminated. This finding is very different from that in the verbal domain (Engle, Tuholski, et al., 1999) where short-term memory and working memory are separable constructs, and suggests that the phonological loop and the visuospatial sketchpad are dissimilar. Miyake et al. (2001) posit that this asymmetry may reflect differences in short-term memory for verbal and spatial material. While the rehearsal of verbal material is a well-practiced and familiar behavior, committing a spatial design to memory is a poorly practiced skill. There is no identified rehearsal mechanism for visuospatial items and maintenance of spatial items may make strong demands on the executive control (Baddeley, 1996b). Another possibility is that the visuospatial sketchpad has such a limited capacity that any processing requires involvement of the central executive.

Baddeley and Andrade (2000) propose that long-term memory contributes to visual imagery by providing sensory information to construct the image. To some extent, vividness of imagery depends upon the amount of information available for retrieval during the allotted time. They further postulate that working memory enhances the imaging process by producing a continuous image through the processes of storage and rehearsal, and by allowing the manipulation of the image and/or its recombination with other material.

Visual and verbal tasks.

Research has consistently determined the separability of verbal and visual working memory systems. Friedman and Miyake (2000) assert that each have their own processing function, and are independently developed and maintained. However, at the level of long-term memory, visual and verbal memories appear to be integrated. A number of studies have found that when participants studied maps, they were better able to retrieve other nonspatial information about sites on the maps (e.g., McNamara, Halpin, & Hardy, 1992). Long-term memory contains coherent multidimensional representations.

Baddeley's Multi-Component Model of Working Memory

The concept of working memory was initially developed by Baddeley & Hitch (1974, 1994). They proposed a tri-partite model, containing an executive control, and two specific slave systems, the phonological loop (to store and process auditory and verbal information) and visuospatial sketchpad (to store and process spatial and visual information). Recently, Baddeley (2000) proposed bi-directional links to account for apparent connections between each slave system and long-term memory. He also added a new component, the episodic buffer. The buffer serves an integrative function, integrating information from long-term memory and the phonological and visuospatial subsystems.

Baddeley (1998) has proposed that working memory underlies the phenomenon of consciousness by allowing the individual to simultaneously consider several modes of information and to integrate these into mental models that allow prediction and planning. These systems are said to interact with each other and long-term memory. A large body of research has supported the idea of the separable and independent functions of the various components of this model. Many studies (e.g., Friedman & Miyake, 2000) have determined that visuospatial and verbal dimensions are independently developed and maintained, and that this separability is evident at the level of complex cognitive processes such as spatial thinking and language processing (Shah & Miyake 1996). Interference with one modality does not impair the function of the other system, indicating that these working memory subsystems are separable and function independently.

Baddeley and Logie (1999) defined working memory in the following way:

> Working memory comprises multiple specialized components of cognition that allow humans to comprehend and mentally represent their immediate environment, to retain

> information about their past experience, to support the acquisition of new knowledge, to solve problems, and to formulate, relate, and act on current goals. (p. 28).

Baddeley and Logie (1999) asserted that this model could account for complex cognitive activities in a variety of domains. These include "language comprehension, counting and mental arithmetic, syllogistic reasoning, and dynamic perceptuomotor control" (p. 31). The components of this model are described below, with summaries of the research that has helped to define and clarify the functions of each element.

Phonological Loop

The phonological loop stores and rehearses auditory and verbal information. The capacity of the phonological loop has been estimated as the amount of verbal material that can be articulated within 1.5 or 2 s (Baddeley, Lewis, & Vallar, 1984). Memory span is greater for short words than long words; this effect is attributed to the fact that more short words can be spoken in 1.5 s. The role of the phonological store has been demonstrated by research that showed that immediate memory for letters, or words, is impaired if the letters, or words, are phonologically similar. This effect is not found for letters, or words, that are visually or semantically similar, and is attributed to the articulatory coding of the letters and words. Operation of the phonological loop is impaired by concurrent articulation, the concurrent recitation of a single word (e.g., "the") or well-learned sequence (e.g., 1, 2, 3, 4). Concurrent recitation interferes with phonological short-term memory (Baddeley et al., 1984); this process is referred to as "articulatory suppression." Suppression removes the word length effect, but does not diminish the phonological similarity effect.

It is thought that the basic components of the phonological loop include a phonological store and an articulatory control process. This distinction is based on findings from many studies (see Baddeley, 1998), and has been supported by research using positron-emission tomography (PET) scans (Awh et al., 1996; Paulesu, Frith, & Frackowiak, 1993). Factor analysis (Waters & Caplan, 1996) revealed separate verbal working memory factors: digit-related tasks, sentence processing, and recall. These findings suggest a multi-functioning system, containing a pool of resources.

Recent research has suggested that the phonological loop may have a more complex role than previously thought. In a study investigating the effects of suppression and task switching, Baddeley, Chincotta, and Adlam (2001) had participants engage in a simple arithmetic task (adding or subtracting the number "1" from a single digit number) while engaging in a secondary dual attention task (e.g., naming months). They concluded that the phonological loop maintained memory of the switching instructions when the operational signs (+ or -) were missing, and that participants cued themselves verbally (plus, minus, plus). This verbal cuing became more difficult when participants were required to engage in secondary verbal tasks but performance was impaired only when the person was required to switch between tasks (e.g., add, subtract, add, subtract) while simultaneously engaging in the secondary task. When the secondary task involved a greater retrieval load, performance was slowed, suggesting an effect on attentional demand. Baddeley et al. concluded that their results support a more complex view of the phonological loop, and argued for a more active and executive role. This has also been suggested by Miyake and Shah (1999), who proposed that the phonological loop be understood as more than a "temporary memory or rehearsal device" (p. 446).

Baddeley et al. (2001) also pointed out the role of self-talk in behavior control. The effect of subvocalization has been demonstrated in performance of a reasoning task (Farmer, Berman, & Flatcher, 1986) and the Wisconsin Card Sorting Test (Dunbar & Sussman, 1995). Subvocalization is apparently used for rehearsal. It may also play a role in worry cognitions and performance anxiety (see below *Anxiety and Working Memory*).

Visuospatial Sketchpad

The visuospatial sketchpad stores and rehearses visual and spatial information. A distinction has been made between visual and spatial components, with evidence from various studies (see Logie, 1995) and PET scans. Performance has been disrupted by secondary tasks that load the visuospatial system. Such tasks (e.g., tapping a predetermined pattern, eye movements, presentation of visual noise) typically do not demand much attentional control so as to minimize the demand on the central executive.

It has been assumed that active rehearsal is an essential function for the maintenance of working memory. However, the task of maintaining a visual image is not a commonly practiced skill, and Miyake et al. (2001) suggested that the storage of visual images may require involvement of the central executive. They conducted a latent-variable analysis to determine the relationship between visuospatial working memory, short-term memory, and executive control, by using tasks assessing spatial visualization, spatial relations, and perceptual speed. They determined that working memory and short-term memory could not be discriminated and that both had a strong relationship with the central executive. Miyake et al. proposed that the visuospatial sketchpad may have a very limited storage capacity. Support for this premise is found in research showing that temporary storage may be limited to one item (e.g., Ballard, Hayhoe, & Pelz, 1995); Miyake et al. suggest that storage of visual items may require involvement of the central executive.

There appear to be different pools of visuospatial resources. Logie (Baddeley & Logie, 1999; Logie, 1995) proposes two subcomponents: the *visual cache,* which stores information about form and color; and the *inner scribe,* which works with spatial and movement information, rehearses information in the visual cache, and transfers information to the central executive. Dual task paradigms have shown that the maintenance of spatial information in working memory is disrupted by a concurrent spatial task, but not by a visual task, and that the maintenance of visual information is disrupted by a concurrent visual task, but not by a spatial task. Shah and Miyake (1996) point out that this separability may exist primarily at the level of peripheral subsystems, as integration of visual and spatial information is required for the performance of complex visuospatial tasks. Nevertheless, this separability is congruent with information from brain-imaging studies (see Nyburg & Cabeza, 2000) that show that visual and spatial information is handled at different locations in the brain.

Three spatial ability factors, spatial visualization, spatial relations, and perceptual speed, identified in various factor analytic studies, were assessed by Miyake et al. (2001) to determine their relationship with working memory. They found that each factor had differing relationships with the central executive, indicating differing requirements for controlled attention. All ability factors had strong relationships with the central executive: Spatial visualization had the greatest executive involvement (r = .91), and perceptual speed the least (r = .43). Miyake et al. concluded that these three functions were dependent on both controlled attention and maintenance of the visual image (visuospatial storage).

Visual imagery has an inherently phenomenological quality. Almost all research on visual imagery has removed its phenomenological aspects (Marks, 1977, cited in Baddeley & Andrade, 2000). A critical question is how to measure the visual images generated by individuals. The use of absolute scales assumes the psychometric ability to compare one person's subjective imagery with that of a population, an impossible task. However, the use of within-subject ratings tends to produce coherent and consistent data (e.g., Guisberti, Cornoldi, de Beni, & Massironi, 1992). Furthermore, participants have been asked to make comparisons of imagery across situations, by providing complex descriptions of imagery; this type of task is also subject to numerous phenomenological variations. Baddeley & Andrade (2001), using an analogy from Neisser, compare this to asking someone to describe the shifting cloud formations of a stormy sky. A simpler task is to ask participants to rate the extent of the cloud cover. This is accomplished by asking participants to rate the vividness of imagery and by using within-subject comparisons. As a result of six experiments, Baddeley and Andrade (2000) concluded that ratings of vividness "reflect the richness of representation in working memory" (p. 137).

Central Executive

It is thought that the Central Executive has several critical functions (Baddeley, 1996). These include the ability to divide attention between two concurrent tasks (Bourke, Duncan, & Nimmo-Smith, 1996; D'Esposito et al., 1995); the capacity to control attention and switch it when necessary (Baddeley, Chincotta, & Adlam, 2001); the ability to choose and switch retrieval plans.(Baddeley, 1996); and the temporary activation of long-term memory.

The central executive appears to use controlled attention to prevent environmental distraction and to inhibit interference from events stored in long-term memory. Baddeley et al.

(2001) have suggested that the central executive is similar in concept to the Supervisory Attentional System (SAS) of Shallice and Burgess. The SAS has several functions including the resolution of interference between environmental triggers and action schemas. The authors provide an example describing the selection of a socially desirable response instead of the immediate reaction prompted by the environment. This selection is said to occur when the SAS biases the action-selection process by attending to less active information and inhibiting the initial reaction.

An experiment conducted by Duff (2000) found that performance decreased on dual tasks with dual modalities (verbal and spatial). He concluded that shared central executive resources, related to processing, were required for both tasks, and that increased demand limited performance. This study did not rule out the possibility that the function was that of controlled attention.

The Episodic Buffer

Constraints are placed on problem-solving, decision-making, and concept formation by the limitations of the capacities and operational characteristics of working memory. To be able to process information, it must be held in an active state. Complex processing requires the ability to have multiple chunks of information simultaneously available. The episodic buffer (Baddeley, 2000; Baddeley et al., 2001) is proposed as serving an integrative function, integrating information from long-term memory and the phonological and visuospatial subsystems. It has limited capacity and consolidates information by chunking it into episodes. It may be similar to the concept of long-term working memory proposed by Ericcson and Kintsch (1995). It is thought to be accessible to conscious awareness thus providing access to long-term memory retrieval processes, a process identified by Tulving (1989) as requiring further investigation. The role of the episodic buffer is apparent in research on the phenomology of imagery (Baddeley & Andrade, 2000), where long-term memory, the visuospatial sketchpad, and the phonological verbal systems were each seen as making separate contributions to imagery vividness.

The buffer is "episodic" in that multi-dimensional material is chunked in coherent packages, and information is integrated across space and time. Baddeley (2000) reflects that it is similar in this respect to Tulving's (1989) concept of episodic memory, but different in that the buffer is conceptualized as a temporary store, one that is available to amnesic patients. It is conceptualized as a "buffer" because it combines material from the slave systems and long-term memory. It forges novel connections, a "cross-modal binding" (Baddeley et al., 2001, p. 653) and may also function as an intermediate storage system.

Bi-directional Links

The proposal for bi-directional links between the phonological and visuospatial subsystems and long-term memory derived from research on the phonological loop. Baddeley, Gathercole, and Papagno (1998) demonstrated the critical role of the phonological loop in helping novel phonological sequences become registered as words. These findings provided evidence that the phonological loop is involved in the development of long-term phonological memory and that it is essential in the acquisition of language. Other research has demonstrated the role of long-term memory in influencing immediate phonological memory through language habits. Gathercole (1995) found that the immediate recall of nonwords that are structured like words is better than that of pronouncable but less word-like sequences.

There appear to be bi-directional links between long-term memory, the visuospatial sketchpad, and the phonological loop. Baddeley and Andrade (2000) demonstrated that these three systems all contribute independently to the vividness of both auditory and visual imagery. Visual vividness was reduced by concurrent visual tasks, and auditory vividness by concurrent verbal tasks. Although these effects were most specific to modality, cross-modality effects were also observed (e.g., counting reduced visual vividness). Long-term memory was found to support vividness in a series of experiments which indicated that meaningful pictures or phrases were more vivid than nonsense items; static items were more vivid than dynamic; ordinary scenes and sounds were more vivid than bizarre ones; and, items related to semantic knowledge were more vivid than novel items.

Baddeley and Andrade (2000) propose that long-term memory contributes to visual imagery by providing sensory information to construct the image. To some extent, vividness of imagery depends upon the amount of information available for retrieval during the allotted time. They further postulate that working memory enhances the imaging process by producing a continuous image through the processes of storage and rehearsal, and by allowing the manipulation of the image and/or its recombination with other material.

Anatomical Locations

A number of studies have been performed to determine the neuropsychological basis for the various components of working memory. Brain scan studies (see Nyburg & Cabeza, 2000) have been useful in confirming that the phonological loop and visuospatial sketchpad are distinct and independent and/or in identifying the distinction between processing and storage functions.

Research using individuals with brain lesions, amnesia, or Alzheimer's Disease has also been helpful in mapping out the anatomical correlates for the working memory subsystems.

The sketchpad has been found to be primarily associated with right-brain functions, in areas 6, 19, 40, and 47 (Baddeley, 2000), and to be linked with the right posterior parietal lobe (Baddeley & Logie, 1999). There appear to be two dissociable systems, with object information linked to occipital-temporal and inferior pre-frontal regions, and spatial information associated with the occipital-parietal and superior-prefrontal regions (see Nyburg & Cabeza, 2000). Also, object information tends to be left-lateralized, and spatial information right-lateralized.

The phonological loop has been found to be related primarily to Brodmann areas 44 and 46 (Baddeley, 2000), and to be linked with the right posterior parietal lobe (Baddeley & Logie, 1999). There appear to be two dissociable systems, with the phonological store associated with parietal regions, and the rehearsal process linked to activations in Broca's area (see Nyburg & Cabeza, 2000).

Nevertheless, as Baddeley (1996) points out, the working memory model is a functional model that does not derive its meaning from precise mapping onto neuroanatomical features. Baddeley expresses concern that neuroanatomical models of working memory would limit exploration of the working memory system, because certain functional elements could have a range of anatomical locations. In addition, different laboratories have produced a wide range of findings. Although it may be possible to define the central executive as a system residing in the frontal lobes, Eichenbaum and Cohen (2001) argue that "it is currently impossible to reach a conclusion about the nature of division of functions across the prefrontal cortex" (p. 502).

Dual Attention Tasks

Humans often engage in dual tasks. Some combinations are efficient (e.g., walking and talking; reading and listening to music); some are nonproductive (e.g., reading and talking; problem-solving and listening) (Wickens, 1984). The extent to which tasks share the same working memory resources is thought to influence the extent to which the performance of one task impairs another. For example, Robbins et al. (1996) rated the quality of chess moves, while chess players engaged in one of several tasks: repetitive tapping (which makes no demands on working memory), random number generation (involving the central executive), tapping keys in a clockwise fashion (involving the visuospatial sketchpad), and rapid repetition of the word see-saw (involving the phonological loop). Robbins et al. found that both complex tapping and random number generation decreased performance, while the other tasks had no effect. This implies that selection of chess moves involves both the central executive and the visuospatial sketchpad, and not the phonological loop. Because the effects were the same for skilled and unskilled chess players, it can be concluded that both types of players use the same processes.

Researchers have primarily used dual attention tasks to investigate the components of working memory. Because each component has limited capacity, and because each is conceptualized as relatively independent, concurrent dual tasks allow the investigation of working memory components. When two concurrent tasks use the resources of the same component, performance will be impaired; when two concurrent tasks use independent components, performance will be unaffected. It is assumed that concurrent tasks will compete for storage capacity or rehearsal processes, thereby disrupting representations and decreasing performance. Many studies have substantiated these effects.

Modality

Research using situational model construction (Friedman & Miyake, 2000) suggests that verbal and visual working memory systems each have their own processing function. The authors determined that visuospatial and verbal (causal) dimensions were independently developed and maintained. Interference with one modality did not impair the function of the other system, indicating that these working memory subsystems are separable and function independently.

Baddeley and Andrade (2000) looked at the specific effects of visual and auditory interference on visual and auditory images. They found that rated vividness of auditory images was reduced most by a secondary articulatory task (counting aloud) and somewhat by a spatial task (complex tapping), while vividness of the visual image was reduced most by the spatial task, and somewhat by the verbal task. Bourke et al. (1996) experimented with the use of cross-modality dual tasks. They used 12 dual task combinations of four tasks: tone discrimination, random letter generation, a manual-tactile manipulation, and image recognition. Tones created the most interference on other concurrent tasks, and manual the least. Participants were instructed to focus on the primary task, while also engaging in the secondary task, and ratings were collected for performance on all tasks. Performance decrements were found in almost all dual task conditions, with performance impaired most on the secondary task. More complex tasks created greater interference. Bourke et al. concluded that these effects were the result of a general factor, rather than factors specific to each task. It is possible that this factor is related to the function of the Central Executive, in its allocation of attention and resources.

Dual Tasks at Encoding and Retrieval

Most research has found interference effects of a concurrent task to be less at retrieval than at encoding (e.g., Craik, Govoni, Naveh-Benjamin, & Anderson, 1996). For example, Fernandes and Moscovitch (2000) found that divided attention at encoding consistently interfered with subsequent recall regardless of the modality of the secondary task. Divided attention during retrieval caused less interference and interfered with free recall of words from long-term memory only when the secondary task was verbal. The magnitude of interference was directly related to the similarity of the content. A secondary task requiring digit monitoring did not interfere to the same extent as a task requiring word monitoring. The authors concluded that interference occurs during encoding because of competition for general resources, and that during retrieval it occurs when there is competition for resources of the specific representational system.

Working Memory Span Tasks

Working memory span tasks are measures that require participants to manage both storage and processing, to maintain target items in memory, while simultaneously performing concurrent cognitive processing. These are dual tasks that require both processing and storage, and thus differ from traditional short-term memory tasks such as digit span. Content of the tasks vary (e.g., reading span, counting span, operation span). All require that the person retain target items (e.g., numbers, words, spatial orientation) in memory while engaging in a concurrent processing task (counting, reading, math calculation, mental rotation). For example, in reading span, participants read a series of sentences with instructions to remember the last word in each sentence. The score reflects how many sentences can be read while maintaining accurate recall of sentence-final words. Similarly, counting span involves counting an array of visual images and maintaining memory for the count totals, and operation span involves mathematical calculations.

Working memory span tasks are popular as assessment tools. It is thought that they measure the capacity for complex cognitive processing, as they appear to be a good predictor of performance on complex cognitive tasks. A meta-analysis (Daneman & Merickle, 1996) based on 77 published studies, found that reading span (an assessment of working memory) had a larger correlation with reading comprehension than digit span or word span, which are tests of short-term memory storage. Scores on working memory span tasks appear to be positively correlated with general fluid intelligence (Engle et al., 1999). However, working memory span measures may have low reliability. While some research has shown high internal reliability (split-half reliability or Cronbach's alpha), test-retest reliability may not be high (Waters & Kaplan, 1996; c.f., Klein & Fiss, 1999). Because working memory span tasks are highly complex, participants may use very different strategies and still attain the same scores. This variability in task approach may be one reason for poor reliability.

Working Memory and Anxiety

There is a substantial body of research suggesting that anxiety interferes with performance. Working memory theories suggest that this occurs when anxiety competes for resources from working memory systems, thus impairing performance.

Anxiety and performance. Individuals low in performance anxiety appear to focus effectively on situational demands (Wine, 1980). In their study on successful table tennis players, Krohne and Hindel (cited in Sarason & Sarason, 1990) found that superior players reported relatively few self-evaluative thoughts while performing, and that they were able to remain focused and immersed in the task. It is assumed that it is the diversion of attention to evaluative concerns which results in performance impairment for the highly test anxious. High anxiety may also be related to memory deficits. Research (see Leary & Kowalski, 1995) has shown that anxiety interferes with tasks requiring deeper levels of cognitive processing. The memory performance of socially anxious individuals decreases when tasks become more complex and unstructured, and demand focused attention. Working memory theory suggests that the internal dialogue of anxious persons competes for the verbal resources of the phonological loop, and attentive resources of the central executive.

Anxiety and working memory.

Persons with high and low trait anxiety participated on word span and reading span tasks after being exposed to either stressful or nonstressful environments (Sorg & Whitney, 1992). Performance on the word span task (a measure of short-term storage capacity) was not affected. However, performance on the reading span task (a measure of storage and manipulation capacity) indicated an interaction between trait anxiety and situational stress: Persons with low anxiety outperformed those with high anxiety in the stress condition, but in the nonstress condition, persons with high anxiety had the better performance. This study provided evidence that the interactive effects of trait anxiety and situational stress influence working memory. This study is also interesting in that the tasks were not concurrent; the stress condition preceded the span tasks, and influenced the subsequent working memory performance.

Derakshan and Eysenck (1998) determined that high anxious participants had greater response latencies than low anxious persons, and that this deficit increased as the verbal task became more demanding. Similar effects were reported by Ikeda, Iwanga, & Seiwa (1996) who found longer reaction times for high anxious participants on the verbal span task. These researchers found no difference between groups in performance on the spatial memory task. They concluded that anxiety symptoms of worry and cognitive self-concern might impair information processing through their competition for resources of the articulatory loop of the working memory system. Similar findings were also reported by Markham and Darke (1991) who found no effect for anxiety on short-term verbal and visual tasks, or on a visual reasoning task. However performance was impaired for high anxious participants on a verbal reasoning task. These findings further support the hypothesis that anxiety acts through the articulatory loop.

Other researchers have proposed that anxiety may also make demands on the central executive. MacLeod and Donnellan (1993) compared the performance of students with high and low anxiety on a grammatical reasoning task with a concurrent memory task. Not only did the high anxiety group show longer decision latencies on the reasoning task, but their performance was further impaired when the simultaneous memory task was more difficult. The authors argue that this impairment may not just result from the competition for working memory resources; they think that high anxious individuals have impaired attentive processes, due to a tendency to "selectively process task irrelevant threat cues" (p. 171). Interestingly, they also found no correlation between depression scores and slowing of response during the high memory task.

The efficiency of persons with anxiety on a verbal task was examined by Elliman, Green, Rogers, and Finch (1997) who found that persons with high anxiety took a longer period to achieve results comparable to those of persons with medium and low anxiety. The task placed demands on the central executive and the phonological loop. Similarly, the speed and accuracy of math anxious participants deteriorated when the execution of a simple arithmetic problem made demands on central executive function (Ashcraft & Kirk, 2001). Ashcraft and Kirk propose that anxious arousal functions as a dual task condition, with degraded performance on the primary task (simple math); they assert that these effects can be attributed to a failure to inhibit attention to distracting thoughts. Ashcraft and Kirk recommend empirical investigation of the role of affect in cognitive processes.

In an experiment to evaluate the effect of concurrent tasks on worrying, Rapee (1993) found that only random letter generation interfered with the ability to worry. This task is thought to use the resources of both the central executive and the phonological loop. A task (articulatory suppression) that used the phonological loop alone had a mild effect on worrying; tasks that used the visuospatial sketchpad (complex tapping) and the sketchpad and central executive (random letter tapping) had no effect on worrying.

Memory and Mood

There is a substantial body of research documenting the effects of mood on memory (see Baddeley, 1998), although not specifically on working memory. These effects appear to derive from the effect of mood on perception and recall, and appear to be related to mood congruency. An example given by Williams (cited in Baddeley, 1998) described two different descriptions of the same experience by the same woman: When depressed, she remembered the event as humiliating and stressful; when in a happier mood, she recalled positive aspects of the incident. The reported memories varied according to, and were congruent with, mood at recall.

Depression seems to result in a bias to perceive and recall events consistent with the depressed mood. Depressed individuals are often preoccupied with prior negative events, or negative aspects of character. Studies that examined the effect of depression on performance (e.g., Dunbar & Lishman, 1984; Zuroff, Colussy, & Weilgus, 1983) have reported impaired performance of depressed participants, related to reduced processing and input. Learning and recall was biased through the mood congruency effect, with depressed persons perceiving and recalling more items consistent with their mood. Anxiety appears to affect performance in a very different way, through an impact on attention. Anxious individuals attend selectively to threats, showing a related bias of perception (e.g., Eysenck, MacLeod, & Mathews, 1986).

Related Studies Investigating Eye Movements

This section examines in detail seven studies that investigated the effect of EMs on memory and cognitive processes. The first is a study that examined the effects of EMs on working memory during encoding. The next four are the studies that investigated EMs and their effect on retrieved autobiographical memories. The final two studies examined the effects of prior administration of EMs on subsequent tasks testing retrieval of episodic memories and working memory flexibility.

Lawrence et al. 2001

Lawrence, Myerson, Oonk, and Abrams (2001) examined the effects of EMs on working memory, during memory encoding. Participants were presented with a sequence of letters (e.g., "p," "x"), and instructed to remember the name of each letter, and its location. Material was presented in a manner requiring EMs or no EMs. Lawrence et al. found that EMs interfered with memory for spatial locations but not memory for letter identity. That is, although the participants in the EM condition could remember what letter they had seen, they had difficulty recalling the location of the letter. In a subsequent experiment, Lawrence et al. determined that there was no difference in the effects of various types of EMs (reflexive saccades, pro-saccades, anti-saccades). They found that these all interfered with working memory to the same extent, with spatial working memory more degraded than verbal working memory. To further test their hypothesis that EMs interfere with spatial working memory by disrupting the visuospatial sketchpad, they replaced the EMs with limb movements. This produced the same interference as the EMs, suggesting that the interference produced by EMs is not the result of their visual consequences. Lawrence et al. concluded that "all spatially directed movements appear to have similar effects on visuospatial working memory." It should be noted however that Lawrence et al. did not test the effects of EM on visual memory; outcome was assessed in terms of spatial and verbal memory only. Consequently their conclusions may be premature. EMs and movements may have similar effects on spatial memory, but dissimilar effects on visual memory.

Sharpley et al., 1996

Sharpley et al. conducted the first study to assess the effects of concurrent EMs on the vividness of retrieved autobiographical memory images. Twenty-four volunteers identified one "important event," with a related image for which they provided a vividness rating. The participants were instructed to visualize the image and concentrate on physical sensations while engaging in one of three dual attention tasks. These were presented in a counter-balanced order for 60 s each: (1) EMs, which were presented in six 10 s sets, and which were induced by having the participants track the researcher's moving hand as it moved across their visual field; (2) eyes fixed (rolled up), on a point between the eyebrows; and, (3) relaxation, keeping the mind blank. The memory was discussed between each intervention for 3 minutes and vividness ratings were provided.

Sharpley et al. (1996) found that both EMs and eyes fixed (rolled up) resulted in a significant decrease in vividness, and that EMs were significantly more effective than the other conditions. Although this study provides useful preliminary information about the effect of interventions on memory vividness, it has a number of serious methodological problems. These include the use of a single memory, the discussion of the memory between interventions, and the lack of distinction between positive and negative memories. This study did not use a working memory paradigm.

Andrade et al., 1997

The first study to examine the effects of EMDR-type EMs, using a working memory perspective, was conducted by Andrade et al. (1997) with a series of four experiments. A within-subjects design was used to control for individual differences in rating, and data were analyzed with a repeated measures analysis of variance (ANOVA). The first experiment, used the following sequence: (1) participants viewed and rated the vividness of 12 negative and 12 neutral photographs; (2) they viewed a single image for 5 s; (3) they participated in a visual task (EM or eyes fixed) for 8 s; (4) they rated the image. This was repeated for each of the 24 images. EMs were induced by having the participant monitor letters (of 4 mm in height) that flashed for 200 ms on alternate sides of a computer screen, with a 200 ms inter-display interval. The computer screen was situated 45 cm in front of the participant, the presentations were 25 cm apart, and subtended an angle of approximately 30^{o}. In the control condition (eyes fixed), the letters were presented in the middle of the screen. On 95% of the presentations, the letter "p" appeared; the participants identified when the alternate letter, "q" appeared.

The researchers found that vividness was significantly less in the EM condition. In the second experiment, participants rated the vividness and emotiveness of these 24 images under three conditions, EM, eyes fixed, and counting. The EM condition resulted in less vivid ratings than either of the two controls (with no difference between them) and lower ratings of emotiveness than counting. The third experiment which looked at the effects of complex tapping, simple tapping, and fixed eyes, found the largest decrease for complex tapping. In the fourth experiment, the 24 images were presented with three conditions, EMs, complex tapping, and fixed eyes. The EM condition resulted in significantly less vividness than the two controls, and, for negative emotion, EMs and complex tapping were less emotional than fixed eyes.

In addition to using the 24 presented pictures, the 24 participants in the fourth experiment identified six memories (3 positive, 3 negative) and rated each related memory image in terms of its vividness and emotiveness. For each memory, the image was held in awareness for 20 s, then the participant engaged in one of three conditions (EMs, complex tapping, fixed eyes) for 8 s, after which they rated the vividness and emotiveness of the image. The complex tapping was a spatial dual task, and involved tapping a specific pattern. The EM condition resulted in less vivid and emotional images, for positive and negative memories, than either control; the complex tapping resulted in less emotiveness than fixed eyes. The decrease in emotiveness was much larger for the autobiographical images than for the photographs.

Andrade et al. (1997) concluded that all effects were attributable to the demands made by EMs on the visuospatial sketchpad, and the competition for resources with the mental image. The tapping task had a smaller effect than EMs, "suggesting that there is something special about eye movements" (p. 220). The authors provided a possible explanation: tapping requires only spatial processing, whereas EMs require both spatial and visual processing, with extraneous visual material competing with the autobiographical image for processing resources. The decrease in emotiveness was assumed to be a result of the decrease in image vividness although there was no supportive empirical evidence for this assumption.

Kavanagh et al., 2001

A second study by these authors (Kavanagh et al., 2001) further examined the effects of dual task manipulations on retrieved autobiographical memories, using a similar design. Eighteen participants identified three positive and three negative memories and rated these with regard to emotionality and vividness. Participants focused on the mental image of each memory while engaging in one of the three conditions: EMs, visual noise (a flickering pattern on the computer screen, observed passively), and eyes fixed ("exposure alone"). The EM and eyes fixed conditions used the same procedure as Andrade et al. (1997). Participants engaged in eight sets (trials) of imaging for each memory image; these sets lasted for 8 s; in the EM condition, participants conducted 10 EMs (left-right-left) in each set. After each set, vividness and emotionality were rated. This process was followed for each of the six memories. After one week (post-test), participants again rated each memory.

The data were analyzed using a repeated measures ANOVA that had three conditions (exposure alone, visual noise, EM) x 10 occasions of measurement (pre, eight trials, 1-week post) x 2 memory valences (positive, negative), with repeated measures on all factors. The sum of square variance was partialled into three orthogonal contrasts: a comparison of pre and post measures with those during the dual task; linearity during the eight trials; and, pre versus post ratings.

EM resulted in a significantly greater decrease in vividness than exposure alone during the eight trials, with EM showing a greater within-session decrease in vividness than exposure alone, in relation to negative images. There was a significant decrease between pre- and post-ratings of vividness, with no difference between conditions. The ratings of positive emotion were stronger than those of negative emotion at pretest, and showed a larger decrease in intensity during the dual task than the negative emotion. There was a significant decrease in emotionality over the dual task trials, and this effect was significantly greater for EM compared to exposure alone. There was a significant difference between pre and post ratings of emotionality, with no difference between conditions. The effects of the visual noise condition were mid-way between those of EM and exposure alone, and not significantly different from either.

Kavanagh et al. (2001) concluded that EM may function in EMDR as a therapeutic "response aid" to assist clients to access painful and distressing memories. The authors also pointed out the greater effects of EMs compared to visual noise may occur because EMs utilize both the visual and spatial resources of the sketchpad, whereas visual noise utilizes only the visual resources. The effect of EM was primarily on within-session vividness and distress; all conditions resulted in a significant decrease at one week post-test. Kavanagh et al. concluded that the desensitization effects (i.e., from pretest to one week post-test) of EM on vividness and emotionality were no different than that of exposure alone and visual noise, and asserted that these findings are in line with those treatment studies reporting no difference in outcome between exposure and EMDR.

Although EMs resulted in larger in-session reductions than the other dual tasks, this difference had disappeared at post-test, indicating no differences in desensitization at one week. This was a weak manipulation, the ability to detect effects after one week was not optimal, and dissipation of effects was predictable. The failure to show an effect after one week does not imply that a stronger manipulation would not have a larger effect.

van den Hout et al., 2001

A similar study was conducted by van den Hout et al. (2001) who also examined the effects of EMs on the vividness and emotionality of autobiographical images. Thirty participants worked with three positive memories, and thirty with three negative memories; each memory was imaged under three task conditions: EMs, rhythmic tapping, and imagery (exposure alone). EMs were induced by having the participants track the experimenter's hand as it moved across their visual field at the rate of one left-right-left movement per second. In the tapping condition, participants tapped the table top with index and middle finger together; this was a control for the movement involved in EMs. In the exposure condition, the participants "visualized" (p. 124) the image.

Participants visualized each specific memory for 20 s and provided the initial ratings of emotion and vividness. They then engaged in four sets (trials) of concurrently focusing on the memory image while engaging in one of the task conditions; these sets lasted for 24 s, with a 10 s rest between sets. After the final set, vividness and emotionality were rated. This process was followed for each of the three memories.

A three-way ANOVA was carried out; within-subject factors were Condition (EMs/tapping/imagery) and Time (pre/post); the between-subjects factor was order of administration (each of the six different orders of the three conditions). This ANOVA was carried out for both positive and negative memories. The vividness of both positive and negative memory images was significantly decreased in the EM condition. The other manipulations had no effect on the vividness of the negative images; for the positive images, the manipulation of imagery produced a significant increase in vividness, and tapping had no effect. The emotionality of both positive and negative memory images was decreased by EMs. The other conditions had no effect on the emotionality of the negative images; for positive images, both imagery and tapping resulted in some decrease in emotionality. This was not as large as the decrease in the EM condition, and EMs resulted in a significantly larger decrease than imagery.

Van den Hout et al. (2001) asserted that the effects of divided attention should occur only during the concurrent tasks, not after the EMs stop. In all studies, rating was done after the dual task was completed, demonstrating that the effects continued after the termination of the EMs. These effects are predictable, as it is normal for most affective states to persist for a short period. Although the authors did not specify the timeframe, the best interpretation is that the ratings were done within 2 m of task completion. It appears that during the dual attention task, anxiety was decreased due to limited capacity, and that this effect continued after the cessation of the EMs for a period of time.

Christman et al., in press

Two hundred and eighty students were instructed to pay attention to 36 words presented sequentially for 5 seconds each. After a 30 minute filler task, participants engaged in one of four EM tasks or a no-EM task for a duration of 30 seconds. They then completed tests of either episodic or implicit memory. (Note that EM and non-EM were not conducted as dual tasks, but preceded the other tasks.) In the episodic task, participants were asked to circle words that they remembered from the original list; in the implicit task, participants were asked to complete word fragments, half of which were based on words on the original list. Horizontal (not vertical) saccadic (not smooth pursuit) EMs produced an increase in discriminability between old and new items for the recognition (not fragment completion) task. They also found that EMs resulted in a more conservative response bias in that errors were more likely to be misses than false alarms.

In a second experiment Christman et al. (in press) had 40 students keep a journal for 10 days in which they recorded 10 unusual events. Two weeks later they were tested for memory of journal contents, after they completed a visual noise condition (non-moving circle with changing colors) or an EM condition. In this task, a black circle appeared sequentially on the left and right portions of the computer screen, changing positions every 500 msec, with a visual angle of approximately 27°. The EM condition resulted in significantly greater retrieval of episodic memories than the visual noise (no-EM) procedure. The authors based their interpretations on cortical activation research and concluded that saccadic horizontal EMs were superior because they induce simultaneous activation of both hemispheres. They argued that EMs enhance interhemispheric interaction, thereby producing the improvement in episodic memory.

Kuiken et al., 2001-2002

This study examined the hypothesis that EM effects can be explained in terms of attentional orienting, with related shifts in working memory. Kuiken et al. (2001-2002) hypothesized that the carry-over effect from REM sleep, in which a persistent spontaneous activation of the orienting response occurs for about 6 minutes after waking, would also be found after the induction of rapid EMs during wakefulness. They also investigated the possibility that attentional redirection facilitates "transformation of the contents of working memory" (p. 6). Twenty-five students completed a 20 second EM or non-EM procedure and then participated in covert visual attention tasks and sentence rating tasks. (Note that EM and non-EM were not conducted as dual tasks, but preceded the other tasks.) The EMs were induced by alternate blinking oval stimuli on a computer screen, with a visual angle of 20°, at 3 saccades per second.

The non-EM task consisted of counting backwards from 100 with eyes fixed on a non-moving oval stimulus.

In the covert attention task, participants were required to identify the location of the stimulus. There were three sets, each preceded by the EM (or non-EM) task, of 26 trials. Of these 78 trials, 60 had valid locator cues, and 18 invalid cues. Participants in the EM condition accurately identified significantly more locations with invalid cues, indicating that the EM task facilitated orienting to stimuli in unexpected locations. The EM task in this study resulted in similar outcomes as those found in REM research (cited in Kuiken et al., 2001-2002; see also Stickgold, 2002), which have indicated that REM sleep is characterized by activation of the orienting response.

In the Kuiken et al. (2001-2002) study, 20 sentences had metaphorical or non-metaphorical endings and the participants rated them for "strikingness" after experiencing EM or non-EM. Participants in the non-EM task rated metaphoric sentences less striking as the sequence continued while those in the EM group consistently rated them as striking. Kuiken et al. concluded that EMs influenced attentional control and "facilitated shifts in working memory that allowed rapid response to unexpected stimuli" (p. 14). They suggested that EMs arouse the participant's interest in presented material with increased appreciation for abstract or metaphorical concepts. They argued that EMs "facilitate spontaneous shifts in working memory" (p. 15) enhancing the participant's willingness to consider novel material. Kuiken et al. suggested that this cognitive flexibility might contribute to EMDR's therapeutic efficacy.

The Two Experiments

Introduction

The purpose of the current research was to determine if working memory theory (Baddeley, 1998, 2000) could predict the effects of EMs on the components of memory. It was expected that the findings could be generalized to the EM component of EMDR (Shapiro, 2001), and provide some understanding of EMDR's treatment process. There was no assumption that the identification of such working memory effects would provide evidence for EM's contribution to outcome. The research tested the predictions derived from working memory theory regarding the effects of the dual attention tasks on the cognitive, affective, and imagery components of autobiographical memory.

Research has yet to determine the actual mechanism, if any, by which divided attention may contribute to treatment outcome in EMDR (Lohr et al., 1999). Indeed many critics have suggested that eye movements are superfluous (e.g., McNally, 1999) and that no further research is required. Other reviewers (e.g., Chemtob et al., 2000; Feske, 1998; Perkins & Rouanzoin, 2002) have cited methodological failings in most of the clinical dismantling studies, and have argued that more rigorous study is needed. It is however apparent that the research to date has found no evidence for the contribution of EMs to outcome. A more interesting question is if EMs contribute to treatment process. The current research sought to investigate the effects of EMs on memory components, with a consideration of the possibility that the effects might be applicable to EMDR treatment process.

EMDR is a psychotherapeutic intervention that uses a dual task approach to facilitate the processing, in-session, of the cognitive, affective, and sensory elements of a recalled disturbing event (Shapiro, 1995, 2001). Clients attend internally to these memory components while concurrently attending to an external stimulus. Such stimuli are referred to as dual attention stimuli (Shapiro, 2001) and include EMs, tapping, and auditory tones (Shapiro, 1991). At the end of the session, clients typically report positive changes in the cognitive, affective, and imagery components of the memory (Shapiro & Maxfield, 2001a). Shapiro's (2001) Adaptive Information Processing model posits that these changes result from information processing that is facilitated by the client's participation in the dual attention task. These claims are not supported by current research findings.

Working memory research provides a possible explanation for the mechanism of the dual attention stimuli in EMDR treatment process. Studies have consistently confirmed that performance is degraded when two simultaneous tasks make demands on the attentional capacity of the central executive (Baddeley, Chincotta et al., 2001), and/or common resources of the slave systems (Baddeley & Andrade, 2000). The two slave systems, the visuospatial sketchpad and articulatory loop, are separable and independent. Demands on the resources of one subsystem do not impair the simple function of the other system. Based on working memory findings, it could be hypothesized that EM task in EMDR may act by reducing the vividness, and related salience, of the autobiographical image. Working memory theory would also predict that EMs should have little direct effect on a verbal component of autobiographical memories. Working memory research has demonstrated that as the dual task becomes more difficult, with additional resources required from the central executive as well as slave systems, there is a decrease in performance on the primary task. Therefore it is possible that a more difficult EM divided attention task may result in a larger decrease in vividness and emotiveness of the targeted memory image, than an easy EM task, due to greater demands on both the visuospatial sketchpad and the central executive.

Four other studies (Andrade et al., 1997; Kavanagh et al., 2001; Sharpley et al., 1996; van den Hout et al., 2001) have investigated the effects of EMs and other divided attention conditions on the vividness and emotiveness of autobiographical images. These studies are reviewed in detail in the section *Related Studies Investigating Eye Movements* beginning on page 65. Each study found that concurrent EMs significantly reduced the reported vividness and emotionality of the images, and that EMs were more effective in reducing such clarity than comparison conditions that used other divided attention tasks. Two studies (Andrade et al., 1997; Kavanagh et al., 2001) used EMs induced by stimuli appearing alternately on opposite sides of a computer screen; the other two studies (Sharpley et al., 1996; van den Hout et al., 2001) used smooth pursuit EMs induced by having participants track the researcher's hand as it moved back and forth across the visual field.

Other dual attention conditions produced smaller effects than the EM task in these studies and included complex tapping - a spatial task (Andrade et al., 1997), visual noise – a visual task (Kavanagh et al., 2001), eyes rolled up – a spatial task perhaps (Sharpley et al., 1996), and rhythmic tapping – an attention task (van den Hout et al., 2001). Imagery was the control condition used in all experiments except the Sharpley et al. study, which used relaxation as the control. No study has yet looked at the effects of an auditory dual attention task on verbal autobiographical memory.

The outcome measures, or dependent variables, used in the four studies that examined the effects of EMs on memory images were vividness, which is clearly related to the visuospatial sketchpad, and emotiveness. Andrade et al. (1997) and Kavanagh et al. (2001) posited that the decrease in image vividness was the primary result of competition for working memory resources, and that the decrease in emotiveness was a secondary result of working memory, subsequent to the image degradation. Van den Hout et al. (2001) explained the results in accordance with their model of "emotional reasoning," rather than working memory. They maintained that there is something about EMs that decreases emotion, and that the decrease in emotionality was the primary result, with a decrease in image vividness following as a secondary result. Examining the effect sizes of the dependent variables might assess these two explanations. One would expect the primary outcome to have a larger effect than the secondary result, or that in the absence of a primary effect, there would be no secondary effects.

The current research tested predictions derived from Baddeley's (1998, 2000) working memory model to determine if it can explain the possible mechanisms of action of EMs in EMDR. It evaluated the effects of divided attention (DA) conditions on the cognitive, affective, and imagery components of autobiographical memory, and examined whether speed and complexity of presentation impacted these effects. EMs were provided in a slow and simple format (Slow-EM) and in a faster more complex format (Fast-EM). These two conditions were compared to a control condition (No-EM) with the same memory tasks, but requiring minimal divided attention. The effects of the conditions were independently assessed on three memory components: image vividness, clarity of the related thought, and emotional intensity.

Several hypotheses, derived from working memory theory were tested in Experiment 1.

(1) It was hypothesized that Slow-EM and Fast-EM would result in decreased ratings of image vividness, emotional intensity, and thought clarity compared to the No-EM condition.

(2) It was hypothesized that the more difficult Fast-EM would result in larger decreases in ratings of image vividness, emotional intensity, and thought clarity than the easier Slow-EM.

(3) It was hypothesized that the effects of Slow-EM and Fast-EM would be specific to the visual modality as opposed to the verbal modality, and larger for image vividness than for thought clarity.

No hypotheses were made regarding the relationships among the three memory components, image vividness, emotional intensity, and thought clarity. It was not clear from prior research (Kavanagh et al., 2001; van den Hout et al., 2001) whether decreases in emotional intensity are related to working memory effects on image vividness or whether they occur independently. An exploration was conducted to analyze the relationships.

No hypothesis was made regarding the effect of emotional intensity at pre-task because it is difficult to make predictions from the inconsistent extant research. Findings from anxiety research have shown that anxiety has a deleterious effect on working memory function (e.g., MacLeod & Donnellan, 1993). This suggests that high emotional intensity at pre-test would result in high demands on working memory resources, with resultant large decreases in the reported quality of the memory components. However, Ikeda, Iwanga, and Seiwa (1996) found that anxiety impaired performance on a verbal span task but not on a spatial memory task. This research suggests that the impact of emotional intensity on image vividness would be minimal, and that the impact on thought clarity would be larger.

In addition, there is disagreement in the traumatic memory field concerning the intractability of traumatic memories, and their susceptibility to change. Scientists such as Shobe and Kihlstrom (1997) have posited that traumatic memories show the same types of changes as non-traumatic memories, while scientists such as van der Kolk (2002) have argued that the high emotional intensity of a memory inhibits change. An exploration was conducted to analyze the effects of reported emotional intensity on degradation of memory qualities.

Experiment 1

Method

Participants

Participants were 25 university students, enrolled in a first year Introductory Psychology course. They received course credit for participation. All completed informed consent forms (See Appendix A). One female participant did not engage in the dual attention task, and she was dropped from all analyses and replaced. Of the remaining 24 participants, 9 were male and 15 female. Participants ranged in age from 17 to 44 years; 45.8% of the participants were 17-19 years, 33.3% were in their twenties, and 20.8% were 30 and above. The ethnic background of the participants reflected the ethnicity of the student body, with 83.3% Caucasian, 8.3% First Nations, 4.2% Black American, and 4.2% Asian participants.

Procedure

Each participant read a written description of the study (see Appendix B) which stated that they were participating in a study on dual tasks and memory and that the purpose of this study was to look at the effects of a secondary task on the components (image, feeling, thought) of memories. Participants also received a verbal rationale, telling them that the research would test a conceptual model called "working memory," and examine the effects of divided attention on the various aspects of autobiographical memory.

Each participant was asked to identify memories of three negative experiences (e.g., illness or death of relative, parental divorce, threats from animals, argument with a friend, horror movies). They were instructed not to choose memories about the worst events in their lives. The participant was then asked to rate the memories in terms of their negativity, indicating the most and least negative memories. Each memory was randomly assigned to one of the three task conditions, and the order of presentation was also randomly determined.

For the first memory, the participant identified a visual image, a related thought (e.g., "its all my fault"), and associated emotion. S/he then focused on the memory and its components for 20 seconds, after which s/he provided pre-condition ratings of image vividness, thought clarity, and emotional intensity. After this, the participant was seated in front of the computer screen at a distance of approximately 45 cm. S/he was instructed to think of the memory, with its image, thought, and feelings, at the same time that s/he engaged in the dual attention task. There were 10 trials of each task, each trial lasting 8 seconds, with a 4 second interval between trials. This was a replication of the Kavanagh et al. (2001) procedure. During 4 of the 9 between-trial intervals, the experimenter reminded the participant to focus on the memory and its components. After the 10th trial, the participant was asked to provide post-condition ratings of image vividness, thought clarity, and emotional intensity. This was followed by a 2-minute distracter activity, in which the participant completed the Famous People test (see description below, and Appendix C).

This entire process was repeated with the second memory, pairing it with a different dual attention task. After completion of the post-condition ratings and a second administration of the Famous People test, the process was repeated with the third memory and the other dual attention task.

Divided Attention Conditions

There were three divided attention (DA) conditions. Each was randomly paired with one of the three memories, and presented in a counter-balanced order. In each condition, participants focused on one of the memories while concurrently engaging in a second task. In the two EM tasks, participants moved their eyes back and forth, following a moving stimulus on a computer screen. In the No-EM condition, participants stared at a blank computer screen. In short, the conditions differed in movement complexity. Fast-EM was a difficult EM task. It was expected to place demands on the resources of the visuo-spatial sketchpad and the central executive. Slow-EM was a moderately difficult EM task, and was expected to require fewer resources. No-EM was easy, and was expected to require minimal resources.

For the Slow-EM and Fast-EM conditions, participants were asked to attend to the selected memory while simultaneously moving their eyes back and forth. The cue for eye movement was the repeated appearance of letter "p" on one side of the computer screen, systematically followed by its appearance on the alternate side of the screen. Once during each trial, the letter "q" randomly replaced the letter "p". The letters were 4 mm in height. For the Slow-EM condition, participants engaged in 8 cycles of left-right-left horizontal eye movements, conducted at a consistent speed of 1 cycle per second. Each cycle consisted of a 300 ms left stimulus presentation, followed by a 200 ms inter-display interval (with no stimulus), then a 300 ms right stimulus presentation, followed by a 200 ms inter-display interval (with no stimulus). The angle of vision was approximately 16°. There were 10 trials of each task, each trial lasting 8 seconds, with a 4 second interval between trials.

For the Fast-EM condition, participants engaged in 10 cycles of left-right-left eye movements, conducted at an inconsistent speed, averaging 0.8 cycles per second. Each cycle consisted approximately of a 200 ms left stimulus presentation, a 200 ms inter-display, a 200 ms right stimulus presentation, and a 200 ms inter-display interval. The angle of vision was approximately 31°. In both Slow-EM and Fast-EM, the participants were instructed to move their eyes from side to side, attending to the stimulus presentation and to alert the researcher when they saw the letter "q" by raising their hand. On 50% of the trials, the researcher acknowledged "q"-recognition by saying "good" or "mm-hmm" after the participant raised his/her hand.

The No-EM task consisted of participants staring at the blank computer screen for the same length of time. It controlled for the effects on the memory of rehearsal and extended attention. Although there was no stimulus presentation, the researcher said the words "good" or "mm-hmm" during 50% of the trials, to control for the effects of reinforcement.

Famous People Test

The Famous People Test (see Appendix C) consists of eleven pages of names, each with a list of about 40 persons who have recently been in the news. Between each of the tasks, participants were presented with 2 pages of names and instructed to write a few words that would identify that individual, on the blank line beside each name. For example, for the name of Bruce Willis, the participant could write, "movie actor" or some other descriptor. The task was used solely as a distracter activity, and the response sheets were not scored. Most participants could only identify a few of the "famous" people.

Measures

A rating scale was used to evaluate three components of the recollected memory: image, thought, and (negative) emotion. Each component was measured using an eleven point Likert scale. Image vividness was rated from 0 "no image at all," to 10 "perfectly clear, as vivid as normal vision." Emotional intensity was rated from 0 "neutral, no emotion," to 10 "extremely negative." (See Andrade et al., 1997; Kavanagh et al., 2001; van den Hout et al., 2001). Thought clarity was rated from 0 "no thoughts at all," to 10, "perfectly clear, as clear as normal thought." A copy of the rating scale (see Appendix D) was placed beside the computer and participants indicated the score by pointing to and stating the number. All scores were rounded to the higher whole number. For example, if a participant said "7.5" the score was recorded as "8."

Experiment 1 Results

Preliminary Analyses

Preliminary analyses were conducted to examine the formative features of the data. See Table 3 for means and their 95% confidence intervals. The variables were normally distributed and without skew. Three multivariate outliers were identified through the use of box plots and standardized scores. In the first case, two scores were in excess of $z = 3.19$ and two scores were in excess of $z = 2.47$. An examination of scores for this case revealed that the Fast EM pre-scores were very low, with very large change scores; it may be that the pre-scores were inaccurately reported. The second case contained four scores in excess of $z = 2.5$ and an examination suggested irregular responding. The third case contained four scores in excess of $z = 2.5$ and an examination showed very low scores at post-condition for the Fast EM condition. No adjustment was made for these outliers, as it is possible that these cases belong to the population being studied.

Preliminary analyses showed no effect for sex [F (3,20) = 1.094, $p > .10$] or age, [F (6, 40) = 0.910, $p > .10$], and no effect for the order of condition presentation [F (15, 54) = 1.020, $p > .10$].

Table 3

Experiment 1: Means (with Lower and Upper 95% Confidence Intervals) for Memory Components at Pre and Post-Condition.

DA Condition	Image Vividness		Thought Clarity		Emotional Intensity	
	Pre	Post	Pre	Post	Pre	Post
Slow-EM	8.33 (7.73, 8.94)	8.21 (7.57, 8.84)	7.96 (7.35, 8.56)	7.50 (6.69, 8.31)	7.46 (6.63, 8.28)	7.42 (6.49, 8.35)
Fast-EM	7.79 (7.00, 8.58)	6.88 (5.76, 7.99)	8.04 (7.28, 8.80)	6.58 (5.66, 7.51)	7.08 (6.16, 8.01)	6.58 (5.56, 7.61)
No-EM	7.75 (6.92, 8.58)	8.96 (8.52, 9.40)	7.88 (7.16, 8.59)	8.67 (8.09, 9.25)	7.13 (6.17, 8.08)	7.33 (6.37, 8.30)
Mean	7.96 (7.48, 8.44)	8.01 (7.40, 8.62)	7.96 (7.46, 8.46)	7.58 (7.07, 8.10)	7.22 (6.65, 7.79)	7.11 (6.44, 7.78)

Note: N = 24.

Memories

Although participants were instructed not to choose memories of great distress, many selected very negative experiences. For example, 19% of participants chose a memory related to the death of a loved one. At the beginning of the experiment, participants rated the negativity of the memories. The most negative memories were related to situations of severe stress (e.g., assault, being arrested). The most frequent type of negative memory (chosen by 25% of participants) was a negative interpersonal incident. See Table 4 for details about the targeted memories.

All memory components were rated on an eleven point Likert scale. At pre-condition, the mean score across participants for image vividness was 7.96, for thought clarity, 7.96, and, for emotional intensity, 7.22. (See Table 3). The mean score of emotional intensity was significantly smaller than mean scores of both image vividness [t (23) = 3.688, p. = .001] and thought clarity [t (23) = 3.068, p. = .005]. There were no differences, between divided attention conditions, for pre-condition scores on any measure.

Post-condition Comparisons

Post-condition scores were compared to assess differences in performance and to evaluate apparent reductions in memory quality resulting from the dual task conditions. The No-EM condition required minimal divided attention, and consequently was considered the comparison baseline for performance. Figure 1 shows the post-condition ratings of memory

Table 4

Experiment 1: Frequency of Types of Memories Selected by Participants, with Rated Level of Negativity.

	Total Memories		Negativity Rating			
Memory Type	N	Frequency	High	Medium	Low	Mean
Relationship Difficulty	18	25%	5	8	5	2.00
Death of family member, or pet	14	19%	7	3	4	2.21
Situations of Severe Stress	10	14%	4	5	1	2.30
Accident	10	14%	3	4	3	2.00
School Failure	9	13%	2	2	5	1.67
Personal Illness	5	7%	2	0	3	1.80
Other	6	8%	1	2	3	1.67

Note: Participants rated the memory as high, medium, or low negativity. The "mean" was calculated by scoring high negativity= 3, medium = 2, low = 1.

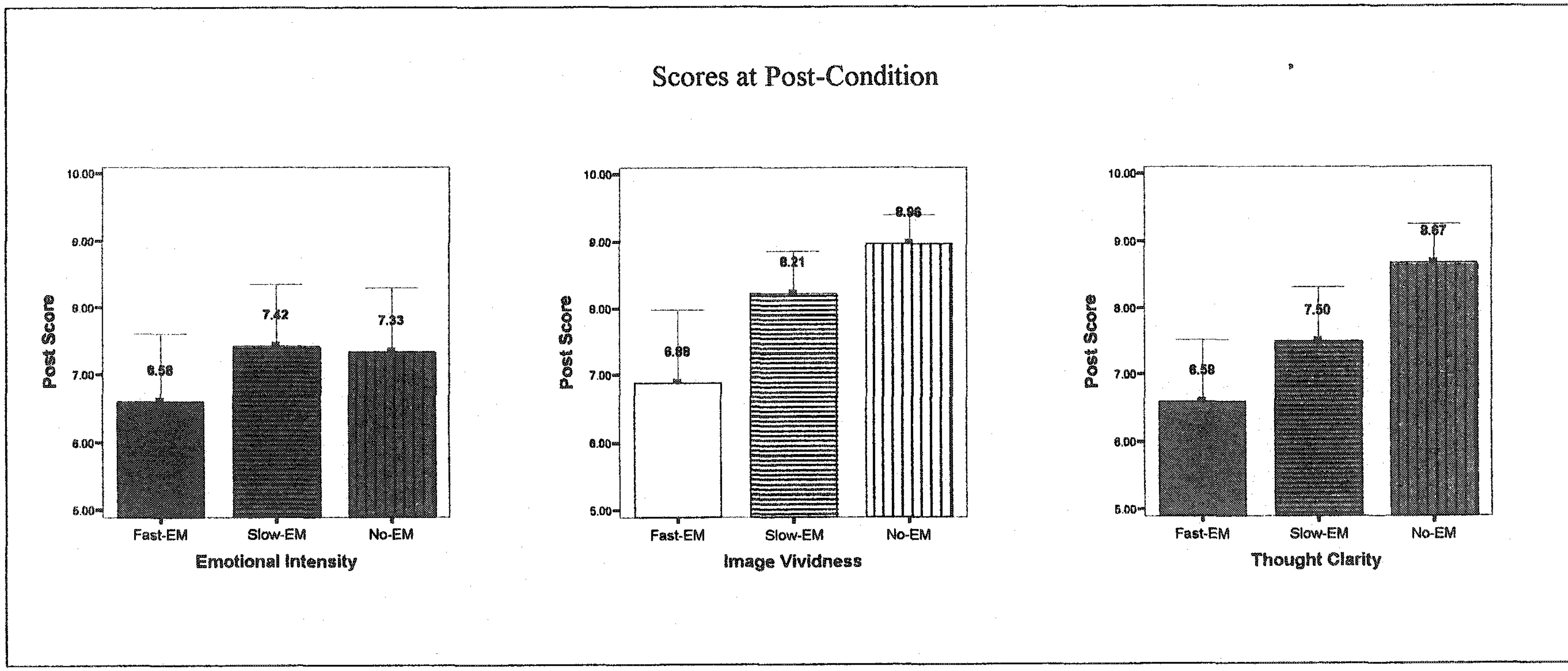

Figure 1

Experiment 1: Means for scores of memory quality at post-condition. Error bars indicate 95% confidence interval.

quality and Figure 2 illustrates the apparent reduction in performance resulting from divided attention. A MANOVA was conducted on the 3 measures using the 3 conditions as a repeated measures factor. See Table 5. There were significant differences between EM conditions.

For image vividness, one-tailed tests of within-subjects contrasts indicated significantly lower scores for Slow-EM and Fast-EM compared to No-EM, and significantly lower scores for Fast-EM compared to Slow-EM. For thought clarity, one-tailed tests of within-subjects contrasts indicated significantly lower scores for Slow-EM and Fast-EM compared to No-EM, and a non-significant trend for Fast-EM to produce lower scores than Slow-EM. For emotional intensity, no difference between No-EM, Slow-EMs, and Fast-EM was significant, although the same pattern of Fast-EM resulting in smaller scores was observed.

Comparison of Pre-Post Changes

To evaluate pre-post changes a MANOVA was conducted on the 3 measures with the 3 DA conditions and 2 occasions as repeated measures factors. See Table 6. Multivariate tests showed a significant interaction between DA conditions and pre-post, indicating that the different DA conditions resulted in different amounts of change on the combined measures. See Figure 3.

Simple effects contrasts indicated that both the Slow-EM and Fast-EM conditions resulted in significantly greater pre-post reductions in image vividness compared to the No-EM condition. (See Table 6). Similarly, the Slow-EM and Fast-EM conditions resulted in significantly greater pre-post reductions in thought clarity compared to the No-EM condition. The pre-post differences between Fast-EM and Slow-EM failed to reach significance.

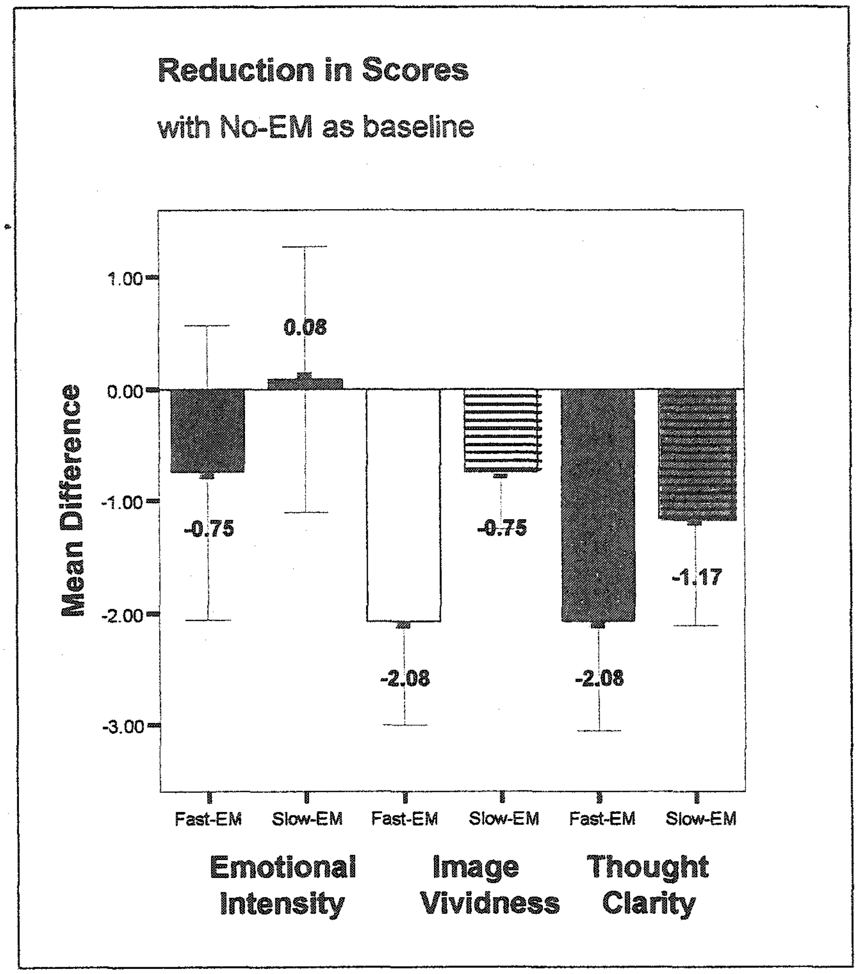

Figure 2

Experiment 1: Mean difference between No-EM post-condition scores and those of Fast-EM and Slow-EM, with No-EM scores as baseline. Error bars indicate 95% confidence interval.

Table 5

Experiment 1: Analysis of Variance for Post Scores

Multivariate Tests

Within Subjects

Source	*df*	*F*	*p*	η^2
Condition	6, 18	5.997	.001	.667

One-Tailed Tests of Within Subjects Contrasts

Source	Condition Comparison	Mean Square	*df*	*F*	*p*	η^2
Condition						
Image Vividness	Slow-EM vs. No-EM	13.500	1, 23	9.554	.003	.293
	Fast-EM vs. No-EM	104.167	1, 23	22.638	<.001	.496
	Slow-EM vs. Fast-EM	42.667	1, 23	6.847	.008	.229
Thought Clarity	Slow-EM vs. No-EM	32.667	1, 23	6.403	.010	.218
	Fast-EM vs. No-EM	104.167	1, 23	19.665	<.001	.461
	Slow-EM vs. Fast-EM	20.167	1, 23	2.797	.054	.108
Emotional Intensity	Slow-EM vs. No-EM	0.167	1, 23	0.21	.443	.001
	Fast-EM vs. No-EM	13.500	1, 23	1.396	.125	.057
	Slow-EM vs. Fast-EM	16.667	1, 23	2.237	.74	.089

Table 6

Experiment 1: Analysis of Variance of Pre-Post Changes

Multivariate Analysis

Within subjects

Source	*Df*	*F*	*p*	η^2
Interaction between pre-post and condition	6, 18	5.921	.001	.664

Tests of within subjects contrasts

Source	Condition Comparison	Mean Square	*Df*	*F*	*p*	η^2
Interaction between pre-post and condition						
Image Vividness	Slow-EM vs. No-EM	42.667	1, 23	12.066	.002	.344
	Fast-EM vs. No-EM	108.375	1, 23	10.624	.003	.316
	Slow-EM vs. Fast-EM	15.042	1, 23	2.277	.145	.090
Thought Clarity	Slow-EM vs. No-EM	37.500	1, 23	9.127	.006	.284
	Fast-EM vs. No-EM	121.500	1, 23	27.263	<.001	.542
	Slow-EM vs. Fast-EM	24.000	1, 23	3.877	.061	.145
Emotional Intensity	Slow-EM vs. No-EM	1.500	1, 23	0.381	.543	.016
	Fast-EM vs. No-EM	12.042	1, 23	1.351	.257	.055
	Slow-EM vs. Fast-EM	5.042	1, 23	.547	.467	.023

Pre-Post Changes

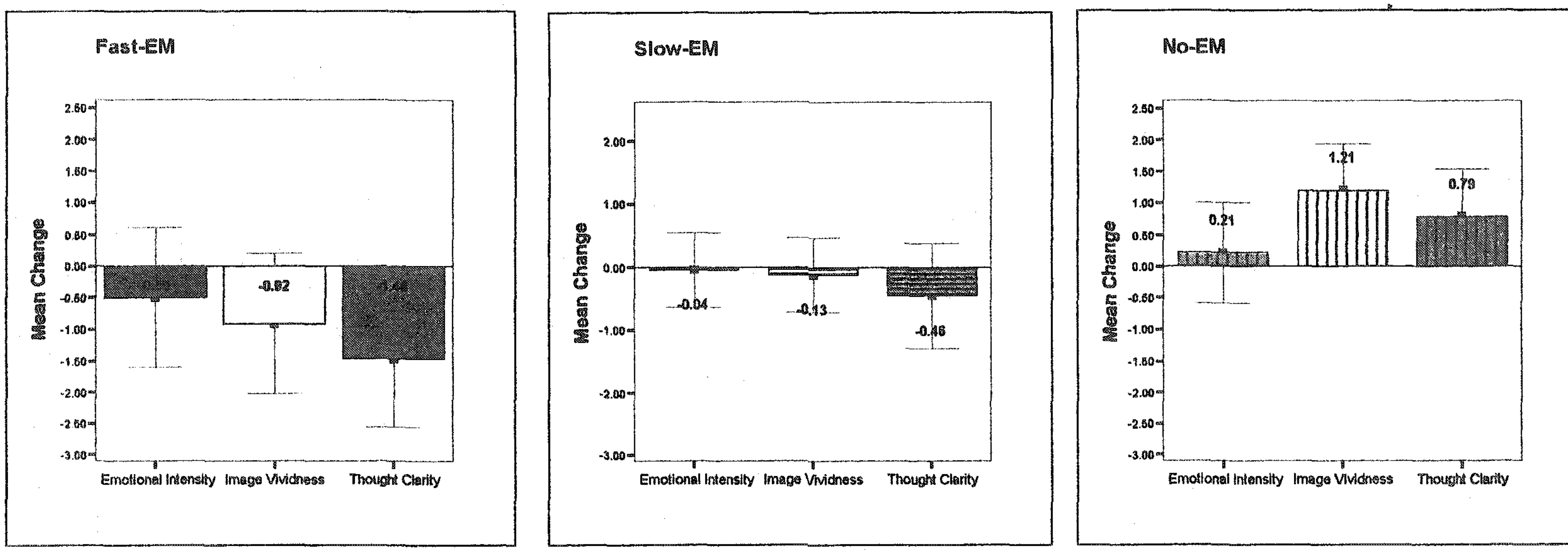

Figure 3

Experiment 1: Comparison of pre-post changes across measures, for each divided attention condition. Error bars indicate 95% confidence intervals.

Paired t-tests were used to determine if Fast-EM or No-EM resulted in significant pre-post changes. Fast-EM resulted in a significant pre-post decrease in thought clarity [t (23) = -2.761, $p.$ = .011] while No-EM resulted in significant pre-post increases in image vividness [t (23) = -3.444, $p.$ = .002] and thought clarity, [t (23) = -2.193, $p.$ = .039].

Relationship Among Memory Components

Bivariate correlations for change scores were conducted to examine the relationship among the memory components. There were significant positive Pearson correlations between changes in image vividness and changes in thought clarity for Slow-EM (r = .632, $p.$ = .001), Fast-EM (r = .720, $p.$ < .001), and No-EM (r = .630, $p.$ = .001), indicating that these memory components all showed the same patterns of change within tasks. Changes in emotional intensity were correlated with changes in image vividness (r = .780, $p.$ < .001) and thought clarity (r = .792, $p.$ < .001) only in the Fast-EM task.

Effect of Emotional Intensity at Pre-Task

Two analyses were conducted to examine the effect of emotional intensity at pre-task. Correlational analyses were done to assess the relationship between pre-task emotional intensity and change scores on the memory components. There was no relationship between pre-task emotional intensity and changes in image vividness or changes in thought clarity after any of the three EM conditions. These findings indicate that reported levels of emotion at pre-task did not predict patterns of change in the related memory components.

The emotional intensity ratings at pre-task had a significant negative correlation with emotional intensity change scores for the Fast-EM and No-EM conditions (see Table 7). There tended to be a reversal in scores, with high scores becoming lower, and low scores higher. The overall tendency at post-task (see Table 6 and Figure 3) was a non-significant increase in emotionality ratings for the No-EM group (mean change = 0.83) and a non-significant decrease in emotionality scores for the Fast-EM group (mean change = -0.67). In the Slow-EM condition, pre-task emotional intensity scores were not associated with changes at post-task.

Table 7

Correlations of Pre-Task Emotional Intensity with Change Scores for Each Condition.

Condition	Correlation with Change Score in Image Vividness	Correlation with Change Score in Thought Clarity	Correlation with Change Score in Emotional Intensity
Fast-EM	$R = -.243$	$R = -.247$	$R = -.405$*
Slow-EM	$R = -.106$	$R = .000$	$R = -.168$
No-EM	$R = -.222$	$R = -.288$	$R = -.501$*

Note: * indicates $p. < .05$

A second analysis was conducted to evaluate individual differences and to determine if there was a difference in responding for participants whose mean emotional ratings at pre-test were high or low. A between-subjects variable was developed with three groups. Participants whose mean emotional intensity pre-task score was in the lower quartile were in the low group, those with a mean score in the upper quartile, were in the high group, and those in the middle

50% were in the mid-group. No effect was found for mean level of emotional intensity at pre-task [F (6,40) = 1.369, $p > .10$]. These findings indicate that reported levels of emotion at pre-task did not predict patterns of change on the three memory components for individuals whose initial ratings of emotion were high, medium, or low.

Summary of Findings in Experiment 1

There were significant positive correlations between changes in image vividness and thought clarity, suggesting similar patterns of change for these related memory components. Changes in emotional intensity were only correlated with changes in the other components in the Fast-EM task. An analysis of the effect of pre-task emotional intensity indicated that initial emotion did not predict changes in the other memory components, although it was related to changes in emotional intensity in the Fast-EM and No-EM conditions.

When participants focused on the memory with a minimal divided attention task (No-EM), there was a significant increase in their ratings of image vividness and thought clarity at post-task. A number of participants commented, "The more I think about it, the stronger it gets." When participants engaged in Fast-EM or Slow-EM, the tendency for the memory to become stronger was inhibited; there was no increase in vividness and clarity, and scores were significantly smaller than those of the No-EM condition. Post-condition comparisons indicated that both EM conditions resulted in significant reductions compared to No-EM in image vividness and thought clarity, and that Fast-EM resulted in significantly lower scores in image vividness than Slow-EM. Although emotional intensity showed the same pattern and directions of change, the analyses failed to reach significance. When participants engaged in Fast-EM, there was a significant pre-post decrease in thought clarity.

The finding that Fast-EM and Slow-EM resulted in significant reductions in image vividness compared to the No-EM task replicates the findings of previous studies (Andrade et al., 1997; Kavanagh et al., 2001; Sharpley et al., 1996; van den Hout et al., 2001). However these studies also reported that the EM condition significantly reduced emotionality compared to the control condition, and, in the current study, the effect on emotional intensity failed to reach significance. It was unclear whether this lack of effect on emotion could be related to the inclusion of the new variable, thought clarity. Perhaps asking clients to attend to the cognitive component of the memory interfered with the affective component. A second experiment was designed to investigate the effects of including a cognitive focus in this working memory study. Working memory theory predicts that a focus on thought during a visual dual attention task should have no effect on ratings of image vividness. It was not clear what the effect on emotional intensity would be.

Experiment 2

Method

Participants

Participants were 36 university students, enrolled in a first year Introductory Psychology course. There were 25 female and 11 male participants. They ranged in age from 18 to 42 years; 52.8% of the participants were 18-19 years, 27.8% were in their twenties, and 19.4% were 30 and above. The ethnic background of the participants reflected the ethnicity of the student body, with 88.9% Caucasian, 8.3% First Nations, and 2.8% Asian participants.

Procedure

The preliminary procedures were identical to those used in Experiment 1. Participants received course credit for participation and completed informed consent forms (see Appendix A). The written description of the study (see Appendix B) read by participants and the verbal rationale were the same as that used in Experiment 1. Participants were told that the purpose of this study was to look at the effects of a secondary task on the components (image, feeling, thought) of memory and that the research would test a conceptual model called "working memory." Each participant identified memories of three negative experiences and rated these in terms of their negativity, indicating the most and least negative memories. Ranked memories were randomly assigned to one of the three DA conditions, and the order of presentation was also randomly determined.

Participants were randomly assigned to one of two groups, "focus on image only" and "focus on image-thought." Participants in the "focus on image-thought" group identified a visual image, a related thought (e.g., "its all my fault"), and associated emotion for each memory. In the "focus on image only" group, participants identified visual images and associated emotions, but no related thoughts.

The participant focused on the memory and its components for 20 seconds, after which s/he provided pre-condition ratings of image vividness and emotional intensity. The experimental procedure was identical to that used in Experiment 1, with two exceptions. (1) In the current experiment, only two memory components were measured: image vividness and emotional clarity. (2) In the "focus on image-thought" group, participants were instructed to focus on the memory, with its image, thought, and emotions. In the "focus on image-only" group, participants were instructed to focus on the memory, with its image and emotions. The participant was reminded of the focus during 4 of the 9 between-trial intervals. After the 10th trial, the participant was asked to provide post-condition ratings of image vividness and emotional intensity. This was followed by a 2-minute distracter activity, in which the participant completed the Famous People test. The entire process was repeated with the second memory, pairing it with a different DA condition. After completion of the post-condition ratings and a second administration of the Famous People test, the process was repeated with the third memory and the third DA condition.

Divided Attention Conditions

The DA conditions, Slow-EM, Fast–EM, and No-EM, were identical to those used in Experiment 1. No-EM involved a minimal level of divided attention, Slow-EM a moderate level, and Fast-EM a high level.

Famous People Test

The administration of the Famous People Test was identical to that employed in Experiment 1. See Appendix C.

Measures

Two measures were used, image vividness and emotional intensity. These were measured and scored as in Experiment 1. See Appendix E.

Experiment 2 Results

Preliminary Analysis

Preliminary analyses were conducted to examine the data. See Table 8 for means and their 95% confidence intervals. The variables were normally distributed and without skew. There was no effect for sex [$F(2,31) = .104, p. > .10$] or age [$F(4,60) = .137, p. > .10$], and no effect for order of condition presentation [$F(10,48) = .666, p. > .10$].

Memories

Although participants were instructed not to choose memories of great distress, many selected very negative experiences. Disturbing interpersonal incidents constituted 33% of the memories, death of a loved one 21%, and situations of severe stress (e.g., assault, being arrested) 17% (see Table 9). All memory components were rated on an eleven point Likert scale. At pre-task, the mean score across participants for image vividness was 7.53 (S.D. = 1.34) and for

Table 8

Experiment 2: Means (with Lower and Upper 95% Confidence Intervals) for Memory Components at Pre and Post-Condition.

DA Condition	Image Vividness				Emotional Intensity			
	Pre		Post		Pre		Post	
	I-O	I-T	I-O	I-T	I-O	I-T	I-O	I-T
Slow-EM	7.61 (6.86, 8.36)	8.06 (6.96, 9.15)	7.22 (6.34, 8.10)	7.56 (6.60, 8.51)	6.22 (5.05, 7.40)	7.00 (5.93, 8.07)	5.72 (4.54, 6.90)	7.11 (6.19, 8.03)
Fast-EM	7.72 (6.62, 8.83)	7.06 (6.05, 8.06)	7.00 (6.08, 7.92)	6.00 (5.05, 6.95)	5.78 (4.67, 6.89)	6.44 (5.43, 7.46)	5.22 (3.91, 6.54)	5.67 (4.72, 6.62)
No-EM	7.56 (6.77, 8.34)	7.17 (6.26, 8.07)	8.83 (8.21, 9.45)	7.50 (6.68, 8.32)	6.39 (5.38, 7.40)	6.56 (5.45, 7.66)	7.67 (6.57, 8.76)	6.94 (5.83, 8.06)
Mean	7.52 (7.07, 7.98)		7.35 (6.95, 7.75)		6.40 (5.96, 6.85)		6.39 (5.90, 6.88)	

Note: I-O = focus on image-only (N = 18); I-T = focus on image-thought (N = 18).

Table 9

Experiment 2: Frequency of Types of Memories Selected by Participants, with Rated Levels of Negativity.

Memory Type	Total Memories		Negativity Ratings			
	N	Frequency	High	Medium	Low	Mean
Relationship Difficulty	36	33%	12	12	12	2.00
Death of family member, or pet	23	21%	10	10	3	2.30
Situations of Severe Stress	18	17%	5	5	8	1.83
Accident	15	14%	5	5	5	2.00
School Failure	7	6%	1	1	5	1.43
Personal Illness	1	1%	0	1	0	2.00
Other	8	7%	3	2	3	2.00

Note: Participants rated the memory as high, medium, or low negativity. The "mean" was calculated by scoring high negativity= 3, medium = 2, low = 1.

emotional intensity, 6.40 (S.D. = 1.32). The mean score of emotional intensity was significantly smaller than that of image vividness [t (35) = 4.184, p. < .001]. There were no differences, between divided attention conditions, for pre-condition scores on either measure.

Post-Condition Comparisons

Because the No-EM condition was considered the comparison baseline, a post-condition comparison was conducted to directly evaluate apparent reductions in memory quality resulting from the DA conditions. Figure 4 shows the post-condition ratings of memory quality and Figure 5 illustrates the apparent reduction in scores resulting from Fast-EM and Slow-EM. A multivariate analysis of variance was conducted on the 2 measures, using the 3 DA conditions as a repeated measures factor, and with one between-subjects variable (2 foci). See Table 10. There was a significant effect for condition, indicating that different conditions resulted in different post-condition scores. The effect for the between-subject variable, focus, was not significant [p. = .08]. As can be seen from the effect size [η^2 = .142], focus accounted for a small percentage of the variance. The interaction between condition and focus was also not significant [η^2 = .180].

For image vividness, one-tailed tests of within subjects contrasts indicated that Slow-EM and Fast-EM resulted in significantly lower post-condition scores compared to No-EM. For emotional intensity, one-tailed tests of within subjects contrasts indicated that Slow-EM and Fast-EM resulted in significantly lower post-condition scores compared to No-EM. Compared to Slow-EM, Fast-EM resulted in significantly larger reductions in image vividness and emotional intensity. (See Table 10 and Figure 5).

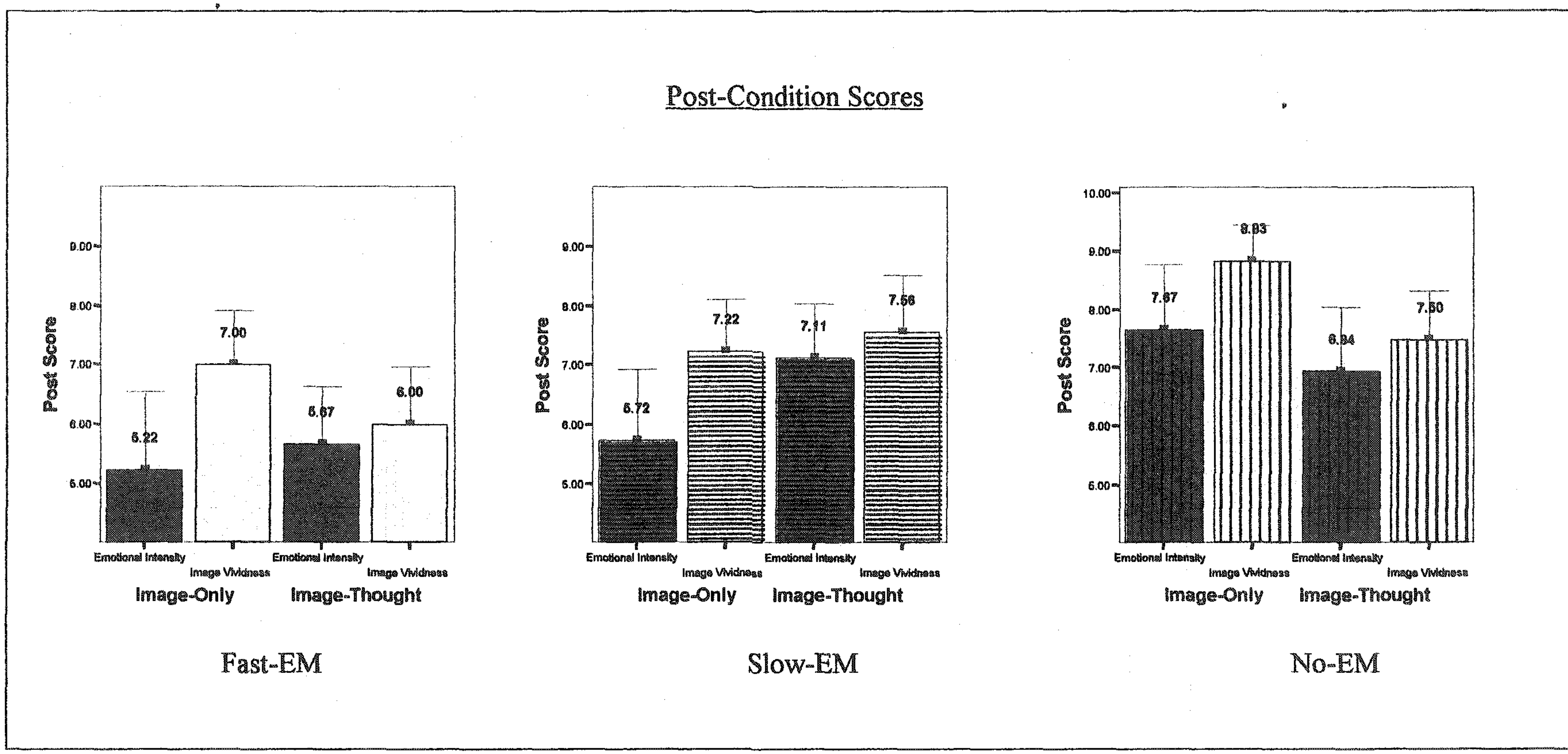

Figure 4

Experiment 2: Scores at post-condition for image vividness and emotional intensity, showing differences for image-only and image-thought groups. Error bars indicate 95% confidence interval.

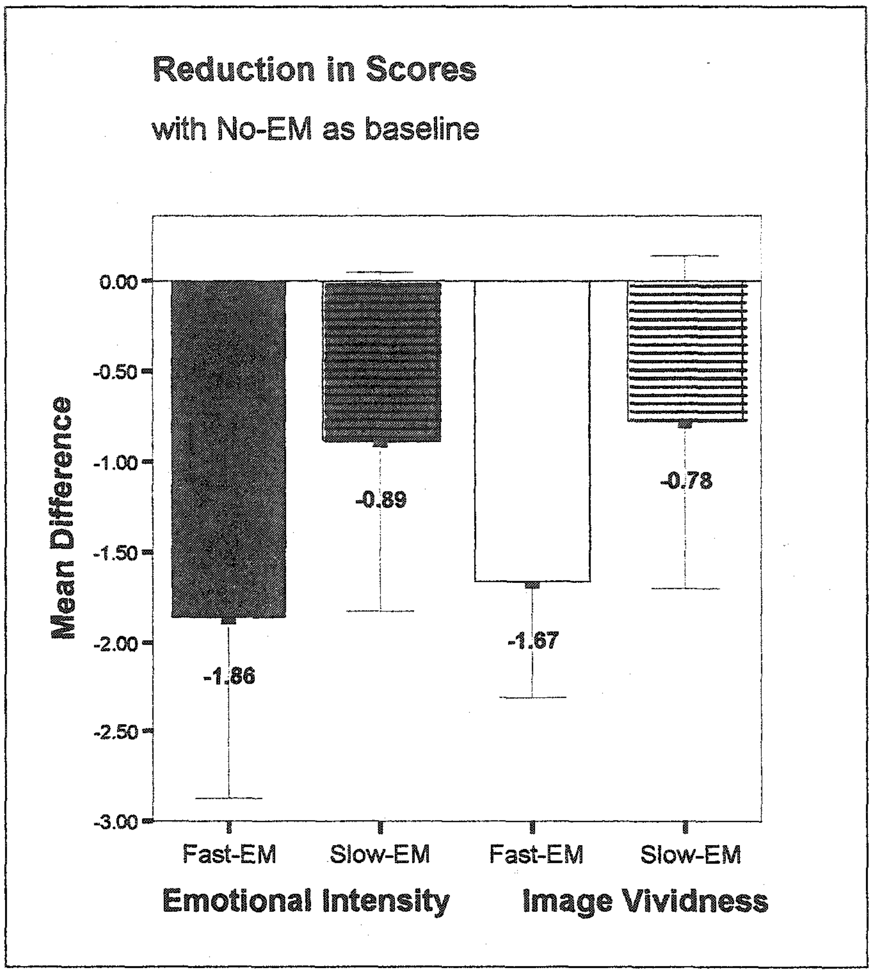

Figure 5

Experiment 2: Mean difference between No-EM post-condition scores and those of Fast-EM and Slow-EM for image vividness and emotional intensity, with No-EM scores as baseline. Error bars indicate 95% confidence intervals.

Table 10

Experiment 2: Analysis of Variance of Post Scores

Multivariate Tests

Source	*df*	*F*	*p*	η^2
Between-subjects				
Focus	2, 33	2.27	.080	.142
Within-subjects				
Condition	4, 31	6.929	<.001	.472
Interaction between Focus and Condition	4, 31	1.707	.174	.180

One-Tailed Tests of Within-Subjects Contrasts

Source	Condition Comparison	Mean Square	*df*	*F*	*p*	η^2
Condition						
Image Vividness	Slow EM vs. No-EM	21.778	1, 34	3.175	.042	.085
	Fast EM vs. No-EM	100.000	1, 34	27.200	<.001	.444
	Slow EM vs. Fast EM	28.444	1, 34	6.061	.010	.151
Emotional Intensity	Slow EM vs. No-EM	28.444	1, 34	4.215	.024	.110
	Fast EM vs. No-EM	124.694	1, 34	14.129	<.001	.294
	Slow EM vs. Fast EM	34.028	1, 34	3.517	.035	.094

Comparison of Pre-Post Effect Changes

To assess the pre-post effect of condition, a multivariate analysis was conducted on the 2 measures with the 3 DA conditions and 2 occasions as repeated measures factors, and with one between-subject variable (2 foci). Eighteen participants were assigned to the image-thought focus group, and eighteen were assigned to the image-only focus group. Each participant was tested on two occasions, on three tasks, with measures taken on two dependent variables.

Multivariate tests showed a significant interaction between occasion and task, indicating that the different tasks resulted in different amounts of change. (See Table11 and Figure 6.) There was no significant effect for the between-subject variable, focus, and the interaction between condition, pre-post, and focus was not significant [$\eta^2 = .150$]. For image vividness, simple effects contrasts showed that the Slow-EM and Fast-EM conditions resulted in significantly different pre-post changes compared to the No-EM condition. There were no significant differences between the pre-post scores of Fast EM and Slow EM. For emotional intensity, simple effect contrasts showed that both the Slow-EM task and the Fast-EM task differed significantly from the No-EM task. There were no significant pre-post differences between Fast-EM and Slow-EM.

Paired t-tests were used to examine pre-post differences for each task. The No-EM task showed significant increases in scores of image vividness [t (35) = -3.477, p. = .001] and emotional intensity [t (35) = -2.860, p. = .007]. Fast EM resulted in a significant decrease in scores of image vividness [t (35) = 2.498, p. = .017]. There were no significant pre-post differences for Slow EM.

Table 11

Experiment #2: Analysis of Variance of Pre-Post Scores

Multivariate Tests

Source	*df*	*F*	*p*	η^2
Between-subjects				
Focus	2, 33	1.649	.209	.091
Within-subjects				
Interaction between Condition and Pre-Post	4, 31	5.177	.003	.400
Interaction between Condition, Pre-Post, and Focus	4, 31	1.365	.269	.150

Tests of Within-Subjects Contrasts

Source	Condition Comparison	Mean Square	*df*	*F*	*p*	η^2
Interaction between Condition and PrePost						
Image Vividness	Slow-EM vs. No-EM	28.125	1, 34	15.612	<.001	.315
	Fast-EM vs. No-EM	51.681	1, 34	19.071	<.001	.359
	Slow-EM vs. Fast-EM	3.556	1, 34	1.975	.169	.055
Emotional Intensity	Slow-EM vs. No-EM	19.014	1, 34	10.044	.003	.228
	Fast-EM vs. No-EM	40.500	1, 34	7.423	.010	.179
	Slow-EM vs. Fast-EM	4.014	1, 34	1.031	.317	.029

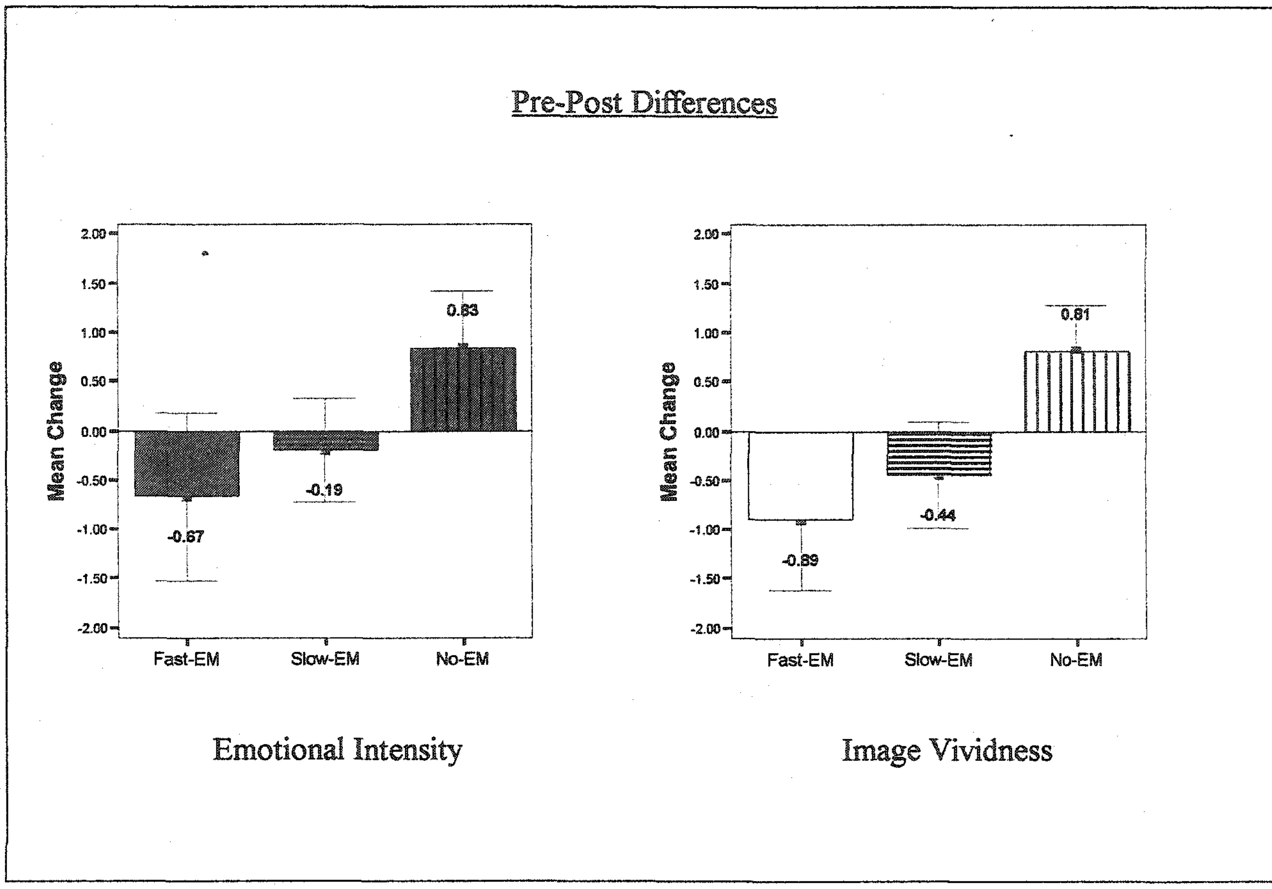

Figure 6

Experiment 2: Pre-post changes for emotional intensity and image vividness, for each DA condition. Error bars indicate 95% confidence intervals.

Relationship Among Memory Components

Bivariate correlations for change scores were conducted to examine the relationship among the memory components. There were significant positive correlations between changes in image vividness and changes in emotional intensity for Slow-EM ($r = .356$, $p. = .033$), Fast-EM ($r = .838$, $p. <= .001$), and No-EM ($r = .480$, $p. = .003$), indicating that the memory components all showed the same patterns of change within tasks.

Effect of Emotional Intensity at Pre-Task

Two analyses were conducted to examine the effect of emotional intensity at pre-task. Correlational analyses were done to assess the relationship between pre-task emotional intensity and change scores on memory components (see Table 12). There was no relationship between the emotional intensity of a memory at pre-task and the change in image vividness after the Slow-EM and No-EM conditions, suggesting that the pre-task emotional level of the memory was unrelated to changes in image vividness in these conditions. However in the Fast-EM condition, there was a significant negative relationship between pre-task emotional intensity and image vividness change scores. High ratings of emotion at pre-task were associated with larger decreases in image vividness (mean change = -0.89) after Fast-EM.

The emotional intensity ratings at pre-task had significant negative correlations with emotional intensity change scores for all conditions. There tended to be a reversal in scores, with high scores becoming lower, and low scores higher. The overall tendency at post-task (see Table 11 and Figure 6) was a significant increase in emotionality ratings for the No-EM group (mean change = 0.83), and non-significant decreases in emotionality scores for the Fast-EM group (mean change = -0.67) and Slow-EM conditions (mean change = -0.19).

Table 12

Correlations of Pre-Task Emotional Intensity with Change Scores for Each Condition.

Condition	Correlation with Change Score in Image Vividness	Correlation with Change Score in Emotional Intensity
Fast-EM	$R = -.416$*	$R = -.528$*
Slow-EM	$R = -.161$	$R = -.374$*
No-EM	$R = .071$	$R = -.351$*

Note: * indicates $p. < .05$.

A second analysis was conducted to evaluate individual differences and to determine if there was a difference in responding for participants whose mean emotional ratings at pre-test were high or low. A between-subjects variable was developed with three groups. Participants whose mean emotional intensity pre-task score was in the lower quartile were in the low group, those with a mean score in the upper quartile, were in the high group, and those in the middle 50% were in the mid-group. No effect was found for mean level of emotional intensity at pre-task [$F\,(4,66) = 0.209, p > .10$]. These findings indicate that there were no differences in patterns of change for individuals whose ratings of emotion were high, medium, and low.

Summary of Findings in Experiment 2

There were significant positive correlations between changes in image vividness and changes in emotional intensity, suggesting similar patterns of change for these related memory components. An analysis of the effect of pre-task emotional intensity indicated that initial emotion predicted changes in image vividness only in the Fast-EM condition. Initial emotion was significantly related to changes in emotional intensity in all conditions.

When participants engaged in Fast-EM or Slow-EM, scores of memory quality were significantly smaller than those following a No-EM condition, where participants focused on the memory with minimal divided attention. The No-EM condition resulted in significant pre-post increases in ratings of image vividness and emotional intensity and Fast-EM resulted in a significant decrease in image vividness. There were no significant pre-post differences between Fast EM and Slow EM. No significant differences were found between the focus on image-only and the focus on image-thought. Post-condition comparisons indicated that, compared to No-EM, both EM conditions resulted in significant reductions in image vividness and thought clarity, and that Fast-EM resulted in significantly lower scores in image vividness and emotional intensity than Slow- EM.

Discussion

The purpose of the current research was to determine if working memory theory (Baddeley, 1998, 2000) could predict the effects of EMs on the components of memory. It was expected that the findings could be generalized to the dual attention component of EMDR, and that they might help to explain the mechanisms of action of EMDR's dual attention stimuli (Shapiro, 2001).

Limitations

Before evaluating the results of the study, and their possible applicability to EMDR, the limitations of the conceptualization and implementation of the study must be considered.

Findings of the extant dismantling studies.

Current research has not found that EMs contribute to outcome (e.g., Renfrey & Spates, 1994), and many would argue that EMs do not contain any active mechanism (e.g., Lohr et al., 1999). While there may be some disagreement with these conclusions (e.g., Feske, 1998), the findings that EMs do not contribute to treatment outcome are not particularly relevant to the current research. The current research sought to investigate the effects of EMs on memory components, with a consideration of the possibility that the effects might be applicable to EMDR treatment process, rather than outcome. There is no assumption or intention that the identification of such working memory effects will provide evidence for EM's contribution to outcome. On the contrary, identification of working memory effects provides evidence only for a possible mechanism related to treatment process.

Brief duration of conditions in current study.

The interventions tested in the current research were of 2 minutes in duration. It could be argued that the applicability to EMDR is limited by this very short duration, and that the findings apply only to the first 2 minutes of EMDR. However, EMDR is a treatment that is administered in sequential 2-minute segments; in each segment the client is encouraged to focus on a different image. Each new image is then subjected to the same DA process, with probable resulting degradation of image vividness. It is hypothesized that the structure of EMDR maximizes working memory effects by sequentially desensitizing progressive images of an incident. Nevertheless research is needed to examine the effects of longer presentations of EM and No-EM on the components of memory.

Use of university students as participants.

The participants used in this study were university students and the results may not generalize to a clinical population. Research is needed to replicate this study with a clinical population before definitive conclusions can be made. However, working memory research has indicated that anxiety tends to limit working memory resources, with resultant impaired performance (e.g., Leary & Kowalski, 1995). (See pp. 60-64 in this document for a detailed discussion). It is consistent with working memory theory to expect that participants with anxiety disorders would show greater deterioration of performance than normal individuals, on tasks involving competition for working memory resources. If so, then EMs might result in an even larger degradation of memory quality for participants with anxiety disorders, than was produced in the current study with university students. Nevertheless, caution should be used when generalizing from these laboratory findings to the clinical setting.

Ordinary memory, not traumatic memory.

Another concern related to a non-clinical population is the generalizability of types of memory. It may be that only ordinary memories degrade when there is competition for working memory resources, and that traumatic memories do not show the same effect. Some researchers maintain that trauma memories are intractable (e.g., Shapiro, 2001; van der Kolk, 2002) and others insist that traumatic memories are no different than ordinary memories (e.g., Shobe & Kihlstrom, 1997). Research is required to investigate this specific question. However, in the current research, many participants chose traumatic events as one of their remembered incidents. These included events such as death of a loved one, almost dying in a car accident, accidents resulting in severe injuries, being assaulted, being raped, etc. Fifty-four percent (Experiment 1) and twenty-nine percent of the memories were rated as having high (8-10) negative emotional intensity at pre-task. The current research found that the intensity of the initial emotion was generally not associated with changes to thought clarity or image vividness. Therefore, it might be possible that the same type of results would be produced with traumatic memories. However research to examine this issue is required before any conclusions can be reached.

Combined Findings from Experiments 1 and 2

Experiments 1 and 2 used the same design elements, with two exceptions: (1) In Experiment 2, participants were also randomly assigned to a focus on image-only, or a focus on image-thought. (2) In Experiment 2, the variable of thought clarity was removed.

Both experiments demonstrated that Fast-EM and Slow-EM resulted in diminished quality of the memory components compared to a No-EM control condition. When compared to No-EM, both Slow-EM and Fast-EM produced significantly smaller scores of image vividness

(Experiments 1, 2), thought clarity (Experiment 1), and emotional intensity (Experiment 2, not 1). At post-condition, Fast-EM resulted in significantly lower scores than Slow-EM for image vividness (Experiments 1, 2) and emotional intensity (Experiment 2, not 1).

The No-EM task resulted in significant pre-post increases in image vividness (Experiment 1, 2), thought clarity (Experiment 1), and emotional intensity (Experiment 2, not 1). Fast-EM resulted in significant pre-post decreases in image vividness (Experiment 2) and thought clarity (Experiment 1). In Experiment 1, no condition had a significant effect on emotional intensity, although similar patterns were observed. In Experiment 2, no effect was found for the between-subjects variable of focus, and the focus groups did not differ in change scores for emotional intensity or image vividness. Since the focus on thought in Experiment 2 did not inhibit the responsiveness of emotional intensity to the various tasks, it does not appear that focus on thought in Experiment 1was responsible for the lack of significant change for emotional intensity in that study.

An examination of the relationship among memory components found that changes in image vividness and changes in thought clarity had significant positive correlations in all conditions (Experiment 1). Changes in emotional intensity and image vividness also had significant positive correlations in the Fast-EM (Experiments 1, 2), and Slow-EM and No-EM conditions (Experiment 2, not 1). These findings suggest that the components of each memory are linked and that they tend to change together.

Emotional intensity at pre-test was found to have a minimal association with processing of image and thought components. Correlations between pre-task emotional intensity and changes in image vividness (Experiments 1,2) and changes in thought clarity (Experiment 1) were insignificant with one exception. These findings appear to indicate that reported levels of emotion at pre-task generally did not predict patterns of change in related memory components. However, after the Fast-EM condition (Experiment 2), there was a significant negative relationship between pre-task emotional intensity and image vividness change scores, indicating that intense emotions at pre-task were associated with decreases in image vividness at post-task in the Fast-EM condition.

The reported level of emotional intensity at pre-task had significant negative correlations with emotional intensity change scores for all conditions in both experiments except Slow-EM in Experiment 1. In all conditions, low emotional intensity scores tended to increase, and high scores to decrease. Although this might be a regression to the mean, there were significant differences among conditions in Experiment 2: In the No-EM condition, emotional intensity showed a significant increase at post-task and scores were significantly larger than scores in the EM conditions.

Hypotheses

Working memory studies have consistently confirmed that performance is degraded when two simultaneous tasks make demands on the attentional capacity of the central executive (Baddeley, Chincotta et al., 2001), and/or common resources of the slave systems (Baddeley & Andrade, 2000). Working memory research has also demonstrated that as the DA condition becomes more complex, with additional resources required from the central executive and slave systems, there are greater detriments in performance (Baddeley et al., 2000). The effects of tasks tend to be modal specific (Friedman & Miyake, 2000). When concurrent dual tasks make demands on the resources of a single subsystem, (i.e., the visuospatial sketchpad or articulatory loop), the simple function of the other system is not usually impaired. A focus that activates the phonological loop will have very little effect on tasks requiring the resources of the visuospatial sketchpad. Although a minor effect on the second subsystem has also been demonstrated (Baddeley & Andrade, 2000), cross-modality effects appear to be relatively small.

Predictions regarding the effects of the DA conditions on the cognitive, affective, and imagery components of autobiographical memory were tested to evaluate the effects of EM on the components of memory. The possible applicability of working memory theory to EMDR's dual attention procedures is discussed in a later section. The following hypotheses were tested:

(1) that Slow-EM and Fast-EM would result in decreased ratings of memory quality compared to the No-EM condition` which was expected to make minimal demands on working memory systems.

(2) that the more difficult DA condition(Fast-EM) would result in larger decreases in ratings of memory quality than the easier DA condition (Slow-EM).

(3) that, in Experiment 1, the effects of Slow-EM and Fast-EM would be specific to the visual modality as opposed to verbal, and larger for image vividness than for thought clarity and emotional intensity.

(4) that, in Experiment 2, a focus on image-thought would not result in a reduction of memory quality, compared to a focus on image-only.

In addition, explorations were conducted to examine the relationship among the memory components and to evaluate the effect of pre-task emotional intensity.

Hypothesis #1

A significant difference between No-EM and the EM conditions.

The first experimental hypothesis was supported (except for emotional intensity in Experiment 1). Both Slow-EM and Fast-EM resulted in significantly smaller ratings of memory quality compared to the No-EM condition, which had minimal divided attention requirements. These findings support the working memory theory that competition for working memory resources during DA tasks will result in a degradation of performance.

When participants engaged in Fast–EM or Slow-EM, the tendency for the memory to become stronger was inhibited. There was no increase in vividness, clarity, or emotion, and scores were significantly smaller than those in the No-EM condition. The finding of a deterioration in performance during dual task activity appears to support working memory theory. It is also congruent with the results of studies (Andrade et al., 1997; Kavanagh et al., 2001; Sharpley et al., 1996; van den Hout et al., 2001), which found that an EM dual task resulted in significantly smaller scores than a control imagery task.

Effects of No-EM.

When participants focused on the memory without divided attention, there was a significant increase in their ratings of image vividness (Experiments 1, 2), thought clarity (Experiment 1) and emotional intensity (Experiment 2, not 1). A number of participants commented, "The more I think about the memory, the stronger it gets." The working memory theory tested in the current research suggests that participants in the No-EM condition were able to focus more intently on the memory because other demands on working memory resources were minimal. The quality of the memory may have been increased through integrative activities of the episodic buffer, combining information from long-term memory, the phonological loop, and visuospatial sketchpad (Baddelely, 2000).

Such an increase in memory clarity is commonly reported in Exposure therapy where clients repeatedly rehearse details of a memory (e.g., Foa et al., 1995; Marks et. al., 1998). The finding that the No-EM (exposure) condition resulted in a different effect on memory components than the EM condition raises questions about theories that EMDR is an exposure therapy (e.g., Lohr et al., 1999). However, before any conclusions can be drawn, the current study must be replicated with longer periods of EM and exposure (No-EM) to determine if the effects continue throughout a longer session.

Changes in emotional intensity.

The lack of change for emotional intensity in Experiment 1 was unexpected, given the findings in the extant literature. The possibility that this was caused by the inclusion of a focus of thought in Experiment 1 was ruled out in Experiment 2. In addition, emotional intensity was responsive to the tasks in Experiment 2, with a significant increase after No-EM, and significant reductions in performance related to the EM tasks.

Why there was an effect on emotionality in Experiment 2, and not an effect in Experiment 1? The ratings for emotional intensity in Experiment 1 were somewhat higher than those in Experiment 2, with a pre-task mean of 7.22 (S.D. = 1.35), compared to 6.40 (S.D. = 1.32) in Experiment 2. However, it does not appear that the higher levels of emotion at pre-task in Experiment 1 inhibited change at post-task. The intensity of pre-task emotionality had a significant negative correlation with changes in emotionality, for all conditions in both Experiments (except Slow-EM, Experiment 1). The pattern of change is the same in both Experiments. It is possible that the lack of effect was an anomaly as it was not replicated in

Experiment 2 and it is incongruent with the findings of previous studies. This is an area requiring further research.

Hypothesis #2

A significant difference between Fast-EM and Slow-EM.

The second experimental hypothesis was supported. The more demanding DA condition (Fast-EM) resulted in larger decreases in ratings of memory quality than the easier DA condition (Slow-EM). In addition, Fast-EM produced two significant pre-post decreases that were not achieved with Slow-EM. The findings are explained by working memory theory, which posits that a more demanding visual-spatial dual task should result in greater interference with task performance because of greater competition for the limited resources of the visuospatial sketchpad.

It could be argued that the larger deterioration of memory quality following the Fast-EM task resulted from its greater attentional demands on the central executive, and that the additional effects were unrelated to the visual-spatial qualities of the task and instead reflected greater involvement by the central executive. However, research that compared EMs to an attentional task (Andrade et al., 1997) reported that EM produced greater reductions in image vividness and emotionality than the task that utilized central executive resources.

Hypothesis #3

No greater effects for EM on image vividness compared to thought clarity.

The third hypothesis was poorly supported as there was little evidence of modal (i.e., visual vs. verbal) specificity. It was anticipated that the EM tasks, which were visual and spatial, would result in greater decrements in image vividness than in thought clarity. In addition to significantly reduced scores, compared to No-EM, for image vividness (Experiments 1, 2), Fast-EM and Slow-EM resulted in significantly reduced scores for thought clarity (Experiment 1). (See Figures 2 and 5).

To compare the size of effects among the various measures, Cohen's *d* effect sizes were calculated. This was the difference between post-condition scores for the EM task and No-EM, divided by the pooled standard deviation. As can be seen in Table 13, there was little difference, within conditions, between the effect sizes for image vividness and thought clarity (Experiment 1). Further evidence for a similar pattern of change is found in the significant correlations between image vividness and thought clarity (Experiment 1).

Table 13

Experiment 1: Cohen's d Effect Sizes for the Comparison of Fast-EM and Slow-EM with No-EM, for Each Memory Component

Comparison Task	Component		
	Image Vividness	Thought Clarity	Emotional Intensity
Fast EM	-1.04	-1.14	-0.32
Slow EM	-0.58	-0.71	-0.04

Working memory theory posits that larger decrements should be seen within the modality of the dual task because of the competition for resources. Several explanations for the apparent lack of modal specificity in the current experiments are examined below.

Use of the same working memory resources.

The assumption that image vividness and thought clarity utilized different working memory subsystems may be incorrect. Asking clients to identify and focus on a verbal thought or caption may not have activated the phonological loop. Research using articulatory suppression could be used to evaluate the role of the phonological loop in autobiographical memory processing.

Demands on the Phonological Loop.

It may be that the phonological loop was activated by the focus on thought, and that participants, while focusing on the memory, repeated the thought, taxing the resources of the phonological loop and that this resulted in a degradation of the verbal memory component. This explanation is ruled out because, during the No-EM condition, the repetition of the thought did not result in a degradation of thought clarity. In fact, the opposite result occurred, with an increase in thought clarity during the No-EM condition. This indicates that the resources of the phonological loop were not sufficiently overwhelmed by repetitions of the thought to cause a reduction in thought clarity.

Demands on the Central Executive.

It is possible that degradation of the verbal memory component resulted from demands made by both Fast-EM and Slow-EM on central executive resources. This appears to be a poor explanation, as the relatively simple Slow-EM condition, which did not require great attentional resources, resulted in significant reductions in thought clarity compared to No-EM.

Interaction between working memory subsystems.

It is likely that the memory components are not independent propositions, and that there are interrelationships among the memory components. Baddeley and Andrade (2000) demonstrated an inter-relationship between long-term memory, the visuospatial sketchpad, and the phonological verbal loop. All these systems were shown to make a separate contribution to imagery vividness. In the current experiment, all components of working memory may have been activated: the visuospatial sketchpad by the memory image and the EM conditions, the phonological loop by the memory thought, the central executive by the attentional demands of the EM conditions, and the episodic buffer, facilitating information exchange among all systems. The current research was not designed to isolate and measure the separate contributions of each working memory subsystem. .

Working memory theory may be an inadequate explanation.

A final explanation is that the modal non-specific findings are not adequately explained by working memory theory and that the effects of the EM conditions may be more complex than predicted by working memory theory.

Hypothesis #4.

No differences between focus on image and focus on image-thought.

The fourth experimental hypothesis was supported. Asking participants to focus on both thought and image did not result in different responses than those achieved when participants focused only on the memory image. It was expected that activation of the phonological loop with verbal material would not tax the resources of the visuospatial sketchpad and would not contribute to, or interfere with, degradation of visual imagery. The findings supported this hypothesis. There were no differences in change scores between groups within conditions. As a matter of fact, the overall effect size for Focus in the multivariate analysis [$\eta^2 = .091$] indicated that the amount of variance accounted for by this variable was small. These findings parallel those of a recent study (Cocchini, Logie, Della Sala, MacPherson, & Baddeley, 2002), which found that simultaneously performing demanding (unrelated) visual and verbal memory tasks resulted in little mutual interference.

Support for Working Memory Theory

The current research found general support for predictions based on working memory theory about the effects of an EM dual attention task on memory clarity. The degradation of imagery and the greater effects resulting from the more complex task (Fast-EM) can probably be attributed to the demands that EMs make on visuospatial sketchpad resources. The EM divided attention conditions also resulted in deterioration of thought clarity (Experiment 1), but the mechanism by which this was achieved is unclear. A possible explanation is the sharing of information among working memory resources in the episodic buffer.

Relationship Among Memory Components

One of the goals of the current research was to explore the relationship among the three components of memory, imagery, emotion, and thought. No hypothesis was made about potential relationships because of a lack of evidence for the proposed theories. Van den Hout et al. (2001) hypothesized that changes in image vividness were secondary to changes in emotional intensity, while Kavanagh et al. (2001) suggested the reverse. In addition, no previous study had investigated the relationship of change in the cognitive component of autobiographical memory with change in the affective and sensory elements.

There is some indication from the findings in this study that the memory components are linked and that they tend to change as a unit. There were significant positive correlations between changes in image vividness and changes in thought clarity (Experiment 1) and significant positive correlations between changes in image vividness and emotional intensity (Experiment 1, just Fast-EM; Experiment 2, all conditions). The memory components showed the same patterns of change within tasks. This association may be the best explanation for the unexpected large changes in thought clarity.

The lack of change in emotional intensity in Experiment 1 did not inhibit changes in image vividness and thought clarity. The current finding that imaginal change occurred without emotional change suggests that perhaps the van den Hout (2001) proposal may not be valid. On the other hand, the current finding also challenged the Kavanagh et al. (2001) theory. It indicated that a decrease in emotionality may not necessarily follow a decrease in image vividness, and that the two components may be somewhat independent. However, it is entirely possible that the current finding was an anomaly; it should be considered as such until it is replicated in other research.

Effect of Pre-Task Emotional Intensity

Another goal of the current research was to explore the effects of pre-task emotional intensity on changes to the quality of the memory during the three DA conditions. Two different analyses were conducted and the results of both demonstrated minimal effects on changes to image vividness and thought clarity.

An ANOVA that used groupings of the participants' mean pre-task emotional intensity scores as a between-subjects variable, found no significant differences between the high, medium, and low emotionality groups on change scores in any condition in both experiments. Correlational analyses determined that, with one exception, levels of pre-task emotion had no association with changes in image vividness and thought clarity (see Tables 7, 12). The changes that occurred in these variables did not seem to be related to the initial level of reported emotion. The sole exception to this finding was a significant negative correlation in the Fast-EM condition (Experiment 2) between pre-task emotional intensity and change in image vividness: High emotionality scores at pre-task were associated with larger decreases in image vividness.

These results seem to indicate that consistent changes occurred within conditions, regardless of the reported intensity of emotion at pre-task. Emotion did not seem to inhibit or facilitate the increased vividness of imagery and thought after No-EM nor did it inhibit or facilitate the decreased vividness of imagery and thought after the EM conditions.

These preliminary results require replication before any definitive conclusions can be drawn. There are however some interesting possible implications. The results suggest that emotional intensity may not be a critical factor in changes to memory components, and that the working memory process occurs regardless of the emotional content. Although this may have relevance for therapeutic work with clinical populations, it should be noted that the current research investigated changes to emotional memories in university students. This is different than investigating changes to memories of individuals who present with mood or anxiety disorders. The emotional state of such individuals may influence working memory processes. A substantial body of research has demonstrated that high anxiety impairs performance (e.g., Ashcraft & Kirk, 2001; Markham & Darke, 1991). In the current experiments, participants were not identified as anxious or depressed. Instead the memories were classified as containing negative emotion. More research is needed to investigate the role of emotional state and the role of emotional material in information processing that occurs during working memory activities.

Theoretical Application of Working Memory Theory to EMDR

The following section is a theoretical application. It is speculative in nature. It describes hypothesized mechanisms of action for various EMDR treatment components, using the language and concepts of working memory theory (Baddeley, 1998, 2000). The section proposes hypothetical possibilities, as it is not known what mechanisms of action are involved in the various steps of the EMDR treatment process. Although the current research provided some preliminary indications of support for a working memory understanding of the EM component in EMDR, the current research did not test EMs in a therapeutic context, and the application of the current research to a clinical setting is speculative.

Linking of the memory components.

The EMDR session begins with a thorough activation of all memory components. The client is asked to simultaneously focus on the memory image, the related negative cognition, affect, and body sensations. From a working memory perspective (Baddeley & Andrade, 2000), this might have the effect of transferring information from long-term memory, through the episodic buffer, to the relevant systems, the phonological loop (for the verbal and auditory aspects of the memory) and the visuospatial sketchpad (for the visual and spatial aspects). The activation and linking of the memory components are a standard part of the EMDR protocol (Shapiro, 2001) but this treatment element has yet to be fully evaluated. Cusack and Spates (1999) investigated the effects of eliminating one of the memory components (the cognitive element). They reported no disadvantage for the procedure without the cognitive element, indicating that direct activation of all memory components may not be required for complete processing. These findings challenge the usefulness of this treatment element.

Eye Movements.

It should be noted that the current research investigated the effects of 2 minutes of EM. This is of much shorter duration than the application of EMs during a 60-90 minute EMDR therapy session. Until research replicates the current studies, in a therapeutic context, it is not possible to determine if the same effects will be produced. Caution should be used when generalizing from these laboratory findings to the clinical setting.

In EMDR treatment, the DA process is administered in a series of 1-2 minute segments. The client focuses on a memory image while simultaneously engaging in EMs for about 30 seconds, and then is encouraged to identify a different image (or thought, emotion, or sensation), that is related to the targeted incident, and to focus on it for the next DA segment. The process is repeated many times. Clients may attend to 20-30 different images throughout the session. It is assumed (Shapiro, 2001) that this sequential process desensitizes a series of related memory images, with associated affect and cognition.

The working memory description of this hypothesized desensitization process is as follows. When EMs begin in the EMDR session, visual and spatial information from the EMs loads onto the sketchpad, taxing its resources, and degrading the memory component, so that the related image and thought become less clear. Working memory theory (Baddeley & Andrade, 2000) suggests that information regarding the changed image would then be transferred, via the feedback loop, to the episodic buffer. Following this, the elicitation of new material activates long-term memory, which transfers the information to the appropriate working memory subsystems. Then, through the dual attention process, the new information loses its salience, is transferred to the episodic buffer, and so on, as the sequential process continues. The desensitized memory is integrated with other information in the episodic buffer and the memory is transformed.

Image vividness and thought clarity.

Although image vividness ratings are not collected in EMDR sessions, clients often spontaneously report that the image is dimmer, or that other material is more visible. Laboratory research has demonstrated the robustness of this degradation effect after EMs, and the findings of Kavanagh et al. (2001) and van den Hout et al. (2001) were replicated in both Experiments 1 and 2. The current research also determined that the more complex dual task, Fast-EM, resulting in greater decreases in image vividness, further demonstrating working memory effects. Research is needed to evaluate whether memory images treated in clinical EMDR sessions show this same reduction of vividness, and to determine if image degradation has any therapeutic value. It has been hypothesized that EMs may assist in the therapeutic process by rendering the memory less salient and less powerful (Kavanagh et al., 2001; van den Hout et al., 2001) but this possible benefit has not been investigated.

The current research demonstrated that EMs decreased the clarity of the related thought, and that Fast-EM achieved greater decreases than Slow-EM. The mechanism by which this occurred is unclear, but is probably related to the interrelatedness of the memory components, and the sharing of information among the working memory systems. To properly evaluate the effects on the verbal or thought components of memory, research is needed to compare an articulatory suppression task to EM.

Emotional intensity.

The mechanism by which EMs may reduce emotional intensity is unclear and is not well explained by working memory theory. The current research did not provide any clear illumination, as the findings in Experiments 1 and 2 differed with regards to changes to emotional intensity. There are indications that emotional intensity is somewhat independent of the other memory components. Future research is needed to more specifically examine these issues. Decreases in emotional intensity were reported in recent EM laboratory research (Andrade et al., 2001; Kavanagh et al., 2001; van den Hout et al., 2001) and appear to be a fairly robust effect. Those findings were replicated in Experiment 2.

EMDR treatment appears to result in strong desensitization effects during the session. Outcome and component studies, which reported SUD ratings, have consistently shown a significant decrease in these ratings of distress. This effect is often reported even when there is not a significant difference in the actual outcome measure. Indeed, a recent meta-analysis of multiple outcome studies (Davidson & Parker, 2001) stated, "In the present meta-analysis, within-subject comparisons on process measures (SUD and VoC) do show a spectacular effect size ($r = .81$, $d = 2.71$, based on 12 comparisons)" (p. 313). Nevertheless, it cannot be concluded that these desensitization effects resulted from EMs, as this has not been determined. Indeed, several clinical dismantling studies (e.g., Renfrey & Spates, 1994) reported that the EMDR-without-EMs produced the same large decrease in SUD ratings as EMDR-with-EMs. See Table 1 for a summary of SUD effect sizes.

Installation of positive material.

EMs are also used in EMDR to accompany the "installation" of the positive cognition or other positive material. It is assumed that EMs will enhance the positive material, and clinical reports suggest that this is indeed the case (Shapiro, 1995, 2001). However, no research has been conducted on this element. Furthermore, the van den Hout et al. (2001), Andrade et al. (1997), and Kavanagh et al. (2001) studies all reported that the laboratory studies of EMs resulted in working memory decreases in positive imagery and positive affect. Research is needed to investigate whether the effects of EM during the installation phase of EMDR follow working memory predictions. If so, EMDR treatment might benefit from discontinuing EMs during the installation phase.

Other dual attention stimuli.

EMDR uses other dual attention stimuli in addition to EMs. These stimuli were not the subject of the current experiments and have not been investigated in any working memory studies. Other dual attention stimuli include auditory tones and tactile stimulation, or tapping. They are administered with alternating rhythmic bilaterality. For example, the Tone is presented first to the left ear, then the right ear, then the left, then the right, etc.

The claimed effects of the touch and acoustic stimuli (Shapiro, 2001) are not well explained by working memory theory. Indeed, working memory theory would predict that the dual attention effects would be less pronounced than those of EMs, as the stimuli contain a spatial element but not a visual element. They would be expected to utilize the spatial resources of the visuospatial sketchpad, and to generate results similar to those of the spatial tapping task in the Andrade et al. (1997) study. This task achieved smaller reductions in image vividness and emotional intensity compared to the EM task.

One dismantling study (Foley & Spates, 1995) compared tones to EMs. It found no difference in outcome between the tone condition and the EM condition. A replication of this study, with the addition of working memory measures would be very interesting. It could examine whether tones and EMs achieve any degradation of image, thought, and affect, and whether such effects contribute to treatment process in a clinically significant way.

Mindfulness

During EMDR, the client is instructed to "just notice," to "just let whatever happens, happen" (Shapiro, 2001, p. 145). In working memory terms, this is an instruction not to engage the central executive or phonological loop with other thoughts or attempts at analysis, and to reduce attentional demands on the central executive. This restriction on ruminating is reinforced by the EM procedure, which reduces resources available for rumination, which may hypothetically reduce anxiety. Research has yet to examine the role of mindfulness in EMDR.

Repeated Access and Dismissal of Traumatic Imagery

EMDR uses short periods of attention on circumscribed memory elements. Research has yet to examine the role of this element in EMDR. This brief narrow focus is probably optimal for working memory processes, which have limited capacities, as it restricts the amount of memory-related material that is retrieved. It allows for the management and thorough activation of the memory components (Baddeley & Andrade, 2001). After each EMDR set, the person is told to "let it go" and then to notice what material they are attending to. It is hypothesized that the process of dismissal may serve to transfer material from the phonological loop and visuospatial sketchpads to the episodic buffer, thus clearing the subsystems for other material.

Free Association

EMDR uses a free association process. The role in EMDR of this process is unknown and the following description is speculative. After each dual attention set, other related material is elicited by asking the client to report whatever thoughts, feelings, or images arise during the sequence. The working memory model (Baddeley, 2000) would describe this process as the central executive retrieving related information from long-term memory. Memory research has shown that it is likely that the information retrieved will be congruent with the affective state (Williams, cited in Baddeley, 1998).

This new material then becomes the focus of the next dual attention task and is hypothetically subject to the same degradation of image, cognition, and emotion. This process is repeated many times, thus hypothetically diminishing the salience of the original image and related memories, and reducing associated negative affect. As the affective state becomes more positive, more positive information is assumed to be retrieved from long-term memory. Bi-directional links communicate these changes among the various working memory subsystems. The changing information is held in the episodic buffer, where there is an integration of visual, verbal, and emotional material with long-term memory. The "revised" memory is then transferred to long-term memory by the episodic buffer. Research has yet to compare EMDR-with-free association to EMDR-without-it. Working memory concepts and measures could be used in research to evaluate possible shifts in information occurring during free association.

Maintenance of Effects

The issue of maintenance of simple working memory effects was investigated in two studies. Van den Hout et al. (2001) determined that the effects continued in the session, after the dual attention task was completed. Kavanagh et al. (2001) determined that although a minor effect was maintained after one week, the original superiority of EMs over the control conditions disappeared. Obviously this is insufficient to explain the substantial and significant effects of EMDR. There are two considerations. First, these working memory experiments treated one memory for approximately two minutes. This is very different from clinical treatment in which the memory is treated in one or more 60-minute sessions, and constitutes a serious limitation of the laboratory research and the current studies. It is not known if a lengthier provision of EM and No-EM would produce different results. Second, it is very possible that the effect of EM is specific to the treatment process, and that the effect does not translate to a better or different outcome.

Working Memory and EMDR

It is the opinion of the investigator that working memory theory appears to provide a promising explanation of the mechanisms of EMDR's components; that this is a parsimonious explanation of EMDR's effects; and that working memory theory also allows predictions of effects that can be tested in future research.

The application of this cognitive science model to a psychotherapeutic intervention is highly relevant because EMDR claims to be an intervention that works with the actual cognitive, affective, and sensory elements of memory. Therefore the theories and predictions of working memory theory about the processing of memory elements are highly applicable. Dual attention is considered an essential treatment element in EMDR, and working memory research uses dual attention task designs to investigate the various components of working memory. Consequently hypotheses derived from working memory research are relevant to an examination of EMDR's dual attention components. It is expected that future investigations will illuminate some of the relationships between long-term memory and working memory, and advance knowledge in the fields of working memory and psychotherapy.

Recommendations for Future Research

Experiment 1 found that the divided attention EM condition resulted in a degradation of thought clarity. It appears that this effect resulted from the inter-relatedness of the various memory components. The variables of image vividness and thought clarity were not independent, and showed a significant correlation with similar patterns of change. Research is needed to more thoroughly investigate the effects of divided attention on the verbal or thought components of autobiographical memory. Research could use an articulatory suppression task to determine if the instruction to focus on thought activates the phonological loop, but not the visuospatial sketchpad. It would be interesting to compare the DA effects of articulatory suppression with those of EM on the components of autobiographical memory. Would articulatory suppression, a DA condition utilizing the resources of the phonological loop, degrade visual imagery in the same way that EMs appeared to degrade thought clarity?

A valuable addition to the literature would be made by research that was designed to isolate and measure each memory component individually, and to assess the separate contributions of each working memory subsystem. In the current studies, it appeared that the autobiographical memory components were inter-related and it was not possible to evaluate the role of the individual components or to determine the specific activities of each working memory subsystems. Further research on the apparent integrative role of the episodic buffer is recommended. Future investigations will illuminate some of the relationships between long-term memory and working memory, and advance knowledge in the fields of working memory and psychotherapy.

It is also recommended that the related changes in memory components be investigated. In the current experiments, the quality of the memory appeared to be diminished. Some participants reported changes in the type of emotion that they were feeling. It is possible that there could also be changes in visual and thought content. An examination of changes in content might reveal activation of the episodic buffer and long-term memory, and perhaps demonstrate interactions between the working memory subsystems. Such processes may be related to the transformational effects reported by Kuiken et al. (2001-2002).

Non-clinical participants were used in all of the research investigating the effects of EMs on autobiographical memory components. This constitutes a limitation of the current research, as clinical populations may be less responsive to the effects of divided attention. Research is needed to replicate the working memory studies using participants with diagnosed disorders to determine if they show similar working memory processes. In the current experiments, there was no effect of emotional intensity at pre-condition. Studies with diagnosed participants could also examine the role of emotional intensity in information processing for this population.

Prior research has shown that high levels of anxiety make demands on the phonological loop and central executive. It would be very interesting to develop a divided attention task that diminishes anxiety by interfering with the tendency of anxiety to dominate working memory resources. The current research is suggestive of this possibility. Developing techniques or procedures that could be utilized by anxious individuals to degrade the intensity of their anxious thoughts and emotions would provide a tremendous benefit to many individuals.

It is replicated that the current study be replicated using conditions of longer duration, similar in length to the duration of an EMDR session, with careful study over the period of implementation to determine image quality and emotional effects. It would also be interesting to compare conditions in which free association was elicited (as in EMDR), and those in which the participants continued focusing on the same image.

In addition to EMs, EMDR commonly uses other dual attention stimuli such as auditory tones and tactile stimulation, or tapping. Although no controlled clinical studies with diagnosed populations have yet assessed the efficacy of this application, clinical reports suggest that these stimuli produce outcomes similar to those achieved by EMs. Anecdotal reports suggest that some clients prefer these stimuli because they do not interfere with the visual image in the same way that EMs do, during the treatment session. It appears from these anecdotal reports there may be a difference in treatment process in that tones and tapping do not cause the same the degradation of image within the session, as EMs. Nevertheless just as the No-EM dismantling studies found no difference in outcome (e.g., Renfrey & Spates, 1994) there is probably no difference in outcome when these other stimuli are used. Research is needed to compare the effects of these stimuli on the various components of memory.

Future research should examine the effects of individual differences regarding the response to desensitization effects in the treatment session. Studies could examine whether there are certain types of clients who show greater benefits from in-session desensitization. Such client characteristics could include high fear of affect or high levels of dissociation. In addition, it would be useful if these desensitization effects are associated with clinical variables such as client comfort or decreased attrition.

Summary

Two experiments were conducted to test predictions from working memory research about the effect of eye movements (EMs) on autobiographical memory. In both experiments, participants identified 3 negative memories and focused on each for 2 minutes, while engaging in one of three conditions: Slow-EM, Fast-EM, and No-EM (imagery). Measures were pre-post ratings of memory-related image vividness, thought clarity, and emotional intensity. In Experiment 2, participants were randomly assigned to a focus on image-only or a focus on image-thought.

It was hypothesized that (1) Slow-EM and Fast-EM would result in decreased ratings of memory quality compared to No-EM which had minimal divided attention requirements; (2) the more difficult Fast-EM would result in larger decreases in ratings of memory quality than Slow-EM; (3), the effects of Slow-EM and Fast-EM would be larger for image vividness than for thought clarity; and (4), that there would be no difference in effect for a focus on image-only compared to a focus on image-thought. All hypotheses were supported except for hypothesis #3, and with some limitations regarding the effects on emotional intensity in Experiment 1. The relationships among memory components were explored and the effect of pre-task ratings of emotional intensity was examined.

No-EM resulted in significant post-condition increases in all measures, except emotional intensity in Experiment 1. When compared to No-EM, both Slow-EM and Fast-EM produced significantly smaller scores for image vividness (Experiments 1, 2), thought clarity (Experiment 1), and emotional intensity (Experiment 2, not #1). At post-condition, Fast-EM resulted in significantly lower scores than Slow-EM for image vividness (Experiment 1, 2) and emotional

intensity (Experiment 2, not 1). There were no differences in the size of the effect of EM on thought clarity and image vividness (Experiment 1) and on emotional intensity and image vividness (Experiment 2). In Experiment 2, there were no differences in outcomes between participants randomly assigned to a focus on image-only, and those assigned to a focus on image-thought. An examination of the relationships among memory components indicated that the components appeared to be linked and to show similar patterns of change, within conditions. Reported levels of pre-task emotional intensity did not predict change in thought clarity and image vividness.

The findings of the current experiments supported a working memory explanation for the effects of EM dual tasks on visual imagery. The degradation of imagery and the greater effects resulting from the more complex task can probably be attributed to the demands that EMs make on visuospatial sketchpad resources. The EM divided attention conditions also resulted in deterioration of thought clarity (Experiment 1) and emotional intensity (Experiment 2), but the mechanism by which this was achieved is unclear. A possible explanation is the sharing of information among working memory resources in the episodic buffer.

A theoretical application of working memory theory to EMDR was presented and recommendations were made for future research.

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Appendix A

Consent Form

Consent Form

Participant No.________

Dual Tasks and Memory

Dual Tasks and Memory Images

1. I ______________________________, consent to take part in a study on dual tasks and memory images. I understand that the purpose of my participation is to further scientific knowledge.

2. I understand that my participation in this study involves the identification of three distressing memories and thinking about each of these for about 2 minutes while I engage in a second activity.

3. I understand that after I have completed the experiment, I will receive academic credit of 1%.

4. I have been assured that the risks involved in this study are minimal. I have been provided with the names of several agencies where I can seek assistance if I feel distressed after completing this experiment.

5. I know that my contributions will remain anonymous and confidential; and that I will receive the results of the study, upon request, following completion of the project. I understand that the data will be stored in a secure place for at least seven years.

6. I know that my participation in this study is completely voluntary and I was told that I could withdraw at any time, even after signing this form. I have also been told that I may obtain a copy of the final results from Louise Maxfield or Dr. WT Melnyk, Department of Psychology, Lakehead University, Thunder Bay, Ontario, P7B 5E1, 343-8441.

Signature: ______________________________________

Date: ______________________________

Appendix B

Description Handout

Lakehead
UNIVERSITY

Department of Psychology

Tel. (807) 343-8441
Fax (807) 346-7734

Dear Participant:

We are conducting a study on "Dual Tasks and Memory." The purpose of this study is to look at the effects of a secondary task on the components (image, feeling, thought) of memories. The research will test a conceptual model called "working memory," and will examine the effects of divided attention on the various aspects of memory.

You will be asked to identify memories of three negative experiences (e.g., illness or death of relative, parental divorce, threats from animals, argument with a friend, horror movies). For each memory you will identify a visual image, a related thought (e.g., "its all my fault"), and associated emotion, and provide ratings of the memory. Then you will be asked to think of the memory image at the same time that you engage in one of three divided attention tasks. The process will take about 2-3 minutes for each memory. After this you will rate the memory again. There are no right or wrong answers and all responses are acceptable. Between each of the memory task conditions, you will take part in a 2 minute test about famous people. Your participation in the study will require about 25 minutes.

Your responses will remain anonymous and strictly confidential. All information with your name (i.e., the consent form) will be stored in a separate location from the questionnaire. The data from all participants will be pooled and analyzed as a group, as the responses of single individuals are meaningful only in relation to the responses of others. This means that no conclusions can be drawn about the responses of individual participants. The data will be stored for 7 years in a secure location.

If you feel distressed after thinking of these memories, feel free to contact Dr. Bill Melnyk (935-2334) for referral information, or you may directly contact any of the following people/organizations: (1) Lakehead University Health and Counselling Services, (2) Community Mental Health Program, Paterson Hall (343-7199); (3) your family doctor.

Your participation in this study is completely voluntary and you can withdraw at any time, even after signing the Consent Form.

You can request a copy of the final results from Louise Maxfield or Dr. Bill Melnyk in the Psychology Department, Lakehead University, Thunder Bay, Ontario, P7B 5E1, 343-8441.

Louise Maxfield, MA

W. T. Melnyk, PhD, C.Psych.

Appendix C

Famous People Test

The following people have been in the news at some time. In a few words, explain why.

Audrey Hepburn ....
Brad Pitt ....
Tiger Woods ....
Diane Keaton..
Melissa Gilbert ....
Pierre Berton ....
Mikhail Baryshnikov ....
Mary Higgins Clark ....
Nicolas Cage ....
Jeffrey Archer...
Billy Crystal ....
Sandra Day O'Connor...
Bobby Fischer ....
John Grisham..
Peter Falk ....
Tom Brokaw...
Dennis Rodman ....
Willie Nelson..
Jim Henson...
Itzhak Perlman..
Michelle Pfeiffer...
Bill Cosby ....
Mordecai Richler...
Michael Ondaatje..
Diana Rigg ....
Lloyd Robertson ....
Elvis Stojko ....
Tom Clancy...
Monica Seles ....
Corazon Aquino ....
Mary Tyler Moore ....
Prince ....
Annette Bening...
Paula Poundstone..
Arthur Miller ....
Steve Yzerman . . . .
Midori ....
Marla Maples..
k.d. lang..

Cameron Diaz ....

Billy Graham ....

Jane Seymour ....

Doug Gilmour ....

Meryl Streep ....

Al Gore ....

Andrew Lloyd Webber ....

Colin Powell ....

Patrick Roy ....

Brian Orser ....

Joe Commuzzi ....

Julia Roberts ....

Bonnie Raitt ....

Andy Garcia ....

Barbra Streisand ....

Dana Carvey ....

Natalie Portman ....

Johnny Carson ....

Wesley Snipes ....

Gilda Radner ....

Tommy Lasorda ....

Jerry Springer ....

Janet Reno ....

George W. Bush ....

Martin Luther King Jr. ....

Mary Hart ....

Liza Manelli ....

Kenny Rogers ....

Dick Francis ....

Osama Bin Laden ....

Joe Carter ....

Bob Mackie ....

ABBA ....

Johnny Cash ....

Roberto Alomar ....

George Burns ....

Paula Abdul ....

Boris Yeltsin ....

Teri Garr ....

Whoopi Goldberg ....

Yosef Karsh ....
Michael Creighton ....
Brian DePalma ....
Hulk Hogan ....
Jacques Cousteau ....
Chris Evert ....
Crystal Gayle ....
Kirstie Alley ....
Dabney Coleman ....
Liberace ....
Harrison Ford ....
Jean Charest ....
Robert Redford ....
Bryan Adams ....
Christina Ricci ....
Neil Diamond ....
Ruth Rendell ....
Greg Louganis ....
Henry Rollins ....
Margaret Atwood ....
Felix Potvin ....
Jodie Foster ....
Andy Rooney ....
Sinead O'Connor ....
Mel Gibson ....
Alice Walker ....
Paul Molitor ....
Steven Jobs ....
Bob Marley ....
Gene Hackman ....
Sidney Sheldon ....
David Koresh ....
Shaun Cassidy ....
Colleen McCullough ....
Oscar Peterson ....
Alan Alda ....
Amy Tan ....
Glenn Gould ....
Anthony Hopkins ....
Jack Masters ....

Wynonna Judd ....
Wayne Gretzky ....
Jason Lee ....
Amy Grant ....
Diane Fossey ....
Ray Charles ....
Jacqueline Bisset ....
Chris Rock ....
Bo Jackson ....
Madonna ....
Silken Laumann ....
Bette Midler ....
Henry Winkler ....
Salman Rushdie ....
Clint Eastwood ....
John Major ....
Angela Lansbury ....
Bruce Springsteen ....
Steve Martin ....
Courtney Cox ....
Lee Iaccoca ....
Magic Johnson ....
Carl Sagan ....
Michael J. Fox ....
Emma Thompson ....
Terry Fox ....
Waylon Jennings ....
Oscar De La Hoya ....
James Earl Jones ....
Bobby Brown ....
Howard Stern ....
Eric Lindros ....
Quincey Jones ....
Jane Pauley ....
Newt Gingrich ....
Jack Palance ....
Elton John ....
Spike Lee ....
Steffi Graf ....
Kevin Costner ....

Juan Antonio Samaranch ....
Jimmy Swaggart ....
Susan Lucci ....
Celine Dion ....
Carrie Fisher ....
Woody Allen ....
Jack Nicholson ....
Bob Costas ....
Audrey McLaughlin ....
Henry Kissinger ....
Paul Newman ....
Robert Dole ....
Mary-Kate and Ashley Olsen ....
Warren Beatty ....
Northrop Frye ....
Mohammed Ali ....
Macaulay Culkin ....
Daniel Day-Lewis ....
Mario Lemieux ....
Jose Canseco ....
Gene Wilder ....
Danielle Steel ....
Jessica Lange ....
Conan O'Brien ....
Anita Hill ....
Pete Rose ....
Lena Horne ....
Shakira ....
John Travolta ....
Nelson Mandela ....
James Baker ....
Rajiv Gandhi ....
Farah Fawcett ....
Gore Vidal ....
Stephen Hawking ....
Jack Nicklaus ....
Kurt Cobain ....
Bob Rae ....
Carly Simon ....
Robert Munsch ....

Sarah Ferguson ....
Elizabeth Taylor ....
Dan Aykroyd ....
Brian Mulroney ....
Calista Flockhart ....
Eduard Shevardnadze ....
Mikhail Gorbachev ....
Dave Matthews ....
Imelda Marcos ....
Don Johnson ....
Sheila Copps ....
Dick Van Dyke ....
Ben Affleck ....
Spike Lee ....
Tom Cruise ....
Al Pacino ....
Mickey Rourke ....
Jennifer Lopez ....
Trisha Yearwood ....
Saddam Hussein ....
Sean Penn ....
Toni Morrison ....
Linda Ellerbee ....
Arnold Schwarzenegger ....
Candice Bergen ....
Ang Lee ....
Sean Connery ....
Rod Stewart ....
Alfred Sung ....
Mark Osborne ....
Tina Turner ....
Norman Schwarzkopf ....
Joe Clark ....
Andrei Sakharov ....
Mike Meyers ....
Kurt Russell ....
Dan Quayle ....
Billy Jean King ....
Terry Anderson ....
Pierre Trudeau ....

Giorgio Armani ....

Anjelica Huston ....

Kurt Browning ....

Michael Jackson ....

Agatha Christie ....

Isabella Rossellini ....

Joe Montana ....

Katarina Witt ....

Jesse Jackson ....

Dolly Parton ....

Pamela Wallin ....

Eddie Murphy ....

Valerie Bertinelli ....

Garth Brooks ....

Calvin Klein ....

Tom Selleck ....

Jane Fonda ....

David Copperfield ....

P. D. James ....

Isaac Asimov ....

Katie Couric ....

Jeff Bridges ....

Claudia Schiffer ....

Marcia Clark ....

Goldie Hawn ....

Sharon Stone ....

Vanna White ....

Jimmy Connors ....

Whitney Houston ....

Phyllis Diller ....

Stephen King ....

Jack Lemon ....

Juan Guzman ....

H. Ross Perot ....

John Candy ....

Leonard Bernstein ....

Dan Rather .... Danielle Steel

Margaret Thatcher ....

Lauren Hutton ....

Sally Field ....

Maurice Richard ....
Yitzhak Rabin ....
Connie Chung ....
Vanessa Redgrave ....
Donovon Bailey ....
Loni Anderson ....
Leonard Nimoy ....
Sally Struthers ....
Robin Williams ....
Dustin Hoffman ....
Montel Williams ....
Kevin Kline ....
Mike Tyson ....
Mel Hurtig ....
Pierre Cardin ....
Loretta Lynn ....
Terry Waite ....
Jerry Seinfeld ....
Steven Spielberg ....
Susan Sarandon ....
Branford Marsalis ....
Dave Winfield ....
Gordon Lightfoot ....
Clint Black ....
Don Cherry ....
Fred Savage ....
Rob Reiner ....
Ivana Trump ....
David Letterman ....
Mandy Moore ....
Barry Bonds ....
Penny Marshall ....
Ernest Hemingway ....
Kathy Lee Gifford ....
George Foreman ....
Arthur Ashe ....
Roseanne Arnold ....
Natalie Cole ....
Michael Jordan ....
Joan Rivers ....

John Larroquette ....
Florence Griffith-Joyner ....
Shannen Doherty ....
Emilio Estevez..
Lucien Bouchard ....
Nicole Kidman ....
Andy Griffith..
Vincent Price ....
Nolan Ryan..
Robin Williams...
Robertson Davies...
Andre Agassi ....
Ben Johnson ....
Kevin Aucoin ....
Melanie Griffith...
Sylvia Brown..
Robert Kennedy...
Derek Jeter ....
Jeremy Irons ....
Tony Fernandez...
Peter Mansbridge...
Rachel Carson ....
Lee Trevino ....
Tom Hanks ....
Alex Haley ....
Neil Young ....
Barbara Mandrell..
John Edwards ....
Bruce Willis ....
Robert Ludlum ....
Lance Ito ....
Kenny Loggins ....
Luciano Pavarotti..
Luke Perry...
Faith Hill ....
Gregory Hines ....
Dionne Warwick..
Sylvester Stallone ....
Guy Lafleur ....
Phil Collins..

Chevy Chase ....

Demi Moore ....

Ed Broadbent ....

Michael Bolton ....

George Benson ....

Martina Navratilova ....

Kurt Vonnegut ....

Lucille Ball ....

Ron Howard ....

Tonya Harding ....

Clyde Wells ....

Arthur Black ....

Neil Armstrong ....

Liz Claiborne ....

Perry King ....

John Le Carre ....

David Suzuki ....

James Michener ....

Faith Ford ....

Billy Joel ....

Nick Nolte ....

Mark Tewksbury ....

Kim Basinger ....

Larry King ....

Ted Turner ....

O.J. Simpson ....

Lyn McLeod ....

Faye Dunaway ....

George Bell ....

Jennifer Aniston ....

Oliver North ....

Rocket Ismail ....

Lily Tomlin ....

Carroll O'Connor ....

John McEnroe ....

Richard Gere ....

Adrienne Clarkson ....

Bryant Gumbel ....

Bob Woodward ....

Anne Bancroft ....

Emmylou Harris ....
Knowlton Nash ....
Luther Vandross ....
Barbara Walters ....
Oliver Stone ....
Oprah Winfrey ....
Boutros Boutros-Ghali ....
Yasser Arafat ....
Margaret Laurence ....
Reginald Denny ....
Denzel Washington ....
William Shatner ....
Peter C. Newman ....
Cindy Crawford ....
Glenn Close ....
Meshach Taylor ....
George Michael ....
Jean-Bertrand Aristide ....
Peter Jennings ....
Diane Sawyer ....
Tim Allen ....
Raymond Burr ....
Hillary Rodham Clinton ....
Jay Leno ....
John Lennon ....
Viktor Tikhonov ....
Germaine Greer ....
Kristi Yamaguchi ....
William Kennedy Smith ....
Danny Aeillo ....
James Herriot ....
Carlos Salinas ....
Riddick Bowe ....
Preston Manning ....
Lance Bass ....
Lenny Dykstra ....
Francis Ford Coppola ....
Arsenio Hall ....

Appendix D

Memory Rating Scale for Imagery, Thought, and Emotional Components

Image Vividness

0	1	2	3	4	5	6	7	8	9	10

no image at all — perfectly clear
as vivid as normal vision

Thought Clarity

0	1	2	3	4	5	6	7	8	9	10

no thoughts at all — perfectly clear
as clear as normal thought

Emotional Intensity

0	1	2	3	4	5	6	7	8	9	10

no emotion at all
neutral — extremely negative

Appendix E

Memory Rating Scale for Imagery and Emotional Components

Image Vividness

0 1 2 3 4 5 6 7 8 9 10

no image at all — perfectly clear, as vivid as normal vision

Emotional Intensity

0 1 2 3 4 5 6 7 8 9 10

no emotion at all, neutral — extremely negative