# A Working Memory Explanation for the Effects of Eye Movements in EMDR

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Research has consistently demonstrated that performance is degraded when participants engage in two simultaneous tasks that require the same working memory resources. This study tested predictions from working memory theory to investigate the effects of eye movement (EM) on the components of autobiographical memory. In two experiments, 24 and 36 participants, respectively, focused on negative memories while engaging in three dual-attention EM tasks of increasing complexity. Compared to No-EM, Slow-EM and Fast-EM produced significantly decreased ratings of image vividness, thought clarity, and emotional intensity, and the more difficult Fast-EM resulted in larger decreases than did Slow-EM. The effects on emotional intensity were not consistent, with some preliminary evidence that a focus on memory-related thought might maintain emotional intensity during simple dual-attention tasks (Slow-EM, No-EM). The findings of our experiments support a working memory explanation for the effects of EM dual-attention tasks on autobiographical memory. Implications for understanding the mechanisms of action in EMDR are discussed.

**Keywords:** EMDR; eye movements; working memory; mechanisms of action; memory components

Eye movement desensitization and reprocessing (EMDR) is a psychotherapeutic intervention that has established efficacy in the treatment of posttraumatic stress disorder (e.g., American Psychiatric Association, 2004; Bisson & Andrew, 2007). EMDR uses a dual-attention 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 eye movement (EM), bilateral 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, 2002).

Research has yet to determine whether the dual-attention component contributes to treatment outcome, and further studies are needed to resolve this issue. Another important question is whether dual attention affects the treatment process, and, if so, what mechanisms of action might be involved. Many different theories about the role of EM in EMDR have been proposed. These include hypotheses related to working memory (e.g., Andrade, Kavanagh, & Baddeley, 1997), reciprocal inhibition (e.g., van den Hout, Muris, Salemink, & Kindt, 2001), detached processing (e.g., Lee, Taylor, & Drummond, 2006), interhemispheric integration (e.g., Christman, Garvey, Propper, & Phaneuf, 2003), physiological effects (e.g., Sack, Hofmann, Wizelman, & Lempa, this issue), orienting response (e.g., MacCulloch & Freeman, 1996), and possible neurobiological mechanisms (e.g., Shapiro,


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2001; Stickgold, 2002). There is some preliminary support for the first four theories, with research results supporting theory predictions. However, the relationship between the proposed mechanism and treatment response has only been evaluated for the detached processing hypothesis and physiological effects, with findings providing preliminary support (Lee, this issue; Sack et al., this issue).

One way to evaluate the effect of EM on treatment process is to investigate how the client's engagement in the EM process influences his or her experience of the targeted memory. The current research sought to investigate the effects of EM on the components of autobiographical memory by testing predictions from working memory theory. Implications for understanding the mechanisms of action in EMDR are discussed.

## Working Memory

Working memory research has consistently found that performance is degraded when participants engage in two simultaneous tasks that require the same working memory resources (Baddeley, 2000). Related studies have found that EM impairs the ability to hold a visual image in conscious awareness, with resulting degradation of vividness (Andrade et al., 1997; Kavanagh, Freese, Andrade, & May, 2001). Working memory theory posits that this is because both tasks require the same limited working memory resource and that competition for this resource impairs performance. Other spatial tasks, such as tapping a pattern, have also been found to have some effect on image vividness, but they produced a smaller effect than EM (Andrade et al., 1997).

Working memory is understood to underlie 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 (Baddeley, 1998). Working memory is necessary for such complex tasks as learning, comprehension, and reasoning. It allows us to access our memory files, retrieve related material, compare this to what we are currently perceiving, and then to synthesize new material with old, reach new understandings, and decide on appropriate conclusions and/or actions. It can be understood as the system that is involved with the reconsolidation of memory (Baddeley, 2000).

Working memory is the memory system that is involved with the temporary storage and manipulation of information (Baddeley, 1998). For example, in addition to remembering the numbers 3, 6, and 9, working memory provides the resources to add the first and last numbers together and then divide by the middle number to arrive at the answer of 2. Working memory may then facilitate memory of that answer through its integration into related memory networks.

The model of working memory primarily referred to in this article is Baddeley's multicomponent model (Baddeley, 1986, 1998, 2000; Baddeley & Hitch, 1974, 1994). It is the most cited, researched, and empirically supported model. It describes four functional components: the central executive, visuospatial sketchpad, phonological loop, and episodic buffer (Baddeley, 2000). The central executive is understood to provide 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, and inhibition of interference from environmental stimuli and events stored in long-term memory. The episodic buffer integrates information from long-term memory and the phonological and visuospatial subsystems, across space and time, and across modalities, as well as consolidating information by chunking it into episodes. The phonological loop is the verbal and auditory subsystem. It stores, rehearses, and processes auditory and verbal information. It plays an important role in the learning of language and is implicated in subvocalization—that is, repetition of cues for a task, internal dialogue. The visuospatial sketchpad is the visual subsystem. It stores, rehearses, and processes visual and spatial information. It stores information about form and color and works with spatial and movement information.

A large body of research supports the premise that each component of this model operates independently. Many studies (e.g., Friedman & Miyake, 2000) have determined that visuospatial and verbal dimensions are independently developed and maintained and that interference with one modality does not impair the function of the other system. This separability is evident at the level of complex cognitive processes such as spatial thinking and language processing (Shah & Miyake, 1996).

### Working Memory Capacity

Working memory capacity is limited. Humans are only able to hold a small amount of information in conscious awareness. Research has consistently found that performance is degraded when two simultaneous tasks require the same working memory resources (Baddeley, 2000; Baddeley & Andrade, 2000; Baddeley, Chincotta, & Adlam, 2001; Bourke, Duncan, &

Nimmo-Smith, 1996; Cocchini, Logie, Della Sala, MacPherson, & Baddeley, 2002; Friedman & Miyake, 2000). Performance deteriorates when two tasks make demands on the attentional capacity of the central executive and/or common resources of the visuospatial sketchpad or the phonological loop. As the dual-attention task becomes more difficult, performance on the primary task decreases. This finding has important relevance when considering the role of EM in EMDR. EM taxes the resources of the visuospatial sketchpad. When someone engages in EM while simultaneously focusing on a memory image, the quality of that image deteriorates; it becomes less vivid and less emotional.

## Research on Dual-Attention Tasks: Focusing on Memory Images With Concurrent EM

Working memory theory predicts that EM will reduce the vividness of the memory image. The results of experiments have been, for the most part, consistent with predicted effects. Seven studies have investigated the effects of eye movements on the vividness and emotionality of memory images. Six of these experiments were nonclinical laboratory experiments in which participants focused on a memory image while moving their eyes or engaging in other dual-attention tasks. The seventh study (Lee & Drummond, 2008) examined the effects of EM and No-EM after one session of EMDR with nonclinical participants. While some other studies have investigated the effects of EM on memory processes (e.g., Propper & Christman, this issue) and physiological arousal (e.g., Sack et al., this issue), those studies have not evaluated the related effects on the memory image.

### Sharpley, Montgomery, and Scalzo (1996)

Sharpley and colleagues (1996) compared 60 seconds of visualizing a memory while engaging in one of three dual-attention tasks: (1) EM (presented in six 10-second sets, tracking the researcher's moving hand); (2) No-EM (eyes rolled up, fixed on a point between the eyebrows); and (3) relaxation, keeping the mind blank. Twenty-four participants identified one "important event," with a related image for which they provided a vividness rating. They performed each of the three tasks, which were presented in a counterbalanced order, with the same memory discussed for 3 minutes before each task. Both EM and No-EM resulted in a significant decrease in vividness, and EM was significantly more effective than the other conditions. Methodological problems included 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 test any theory and did use a working memory paradigm.

### Andrade, Kavanagh, and Baddeley (1997)

Andrade et al. (1997) used a working memory paradigm to evaluate how three dual-attention tasks (EMs, complex tapping, fixed eyes) affected the vividness and emotiveness of personal memories. The complex tapping was a spatial dual task, and involved tapping a specific pattern. EM was induced by having the participant monitor letters that flashed for 200 milliseconds on alternate sides of a computer screen, with a 200-millisecond interdisplay interval. No-EM involved the participant gazing at a spot on the computer screen. The 24 participants identified six autobiographical memories (three positive, three negative). Each image was held in awareness for 20 seconds, then it was paired with one of the three tasks for 8 seconds, after which the participant rated the vividness and emotiveness of the image. 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 No-EM.

Andrade et al. (1997) concluded that these effects were attributable to the demands made by EM on the visuospatial sketchpad and the competition for resources with the mental image. The tapping task had a smaller effect than EM, "suggesting that there is something special about eye movements" (p. 220). The authors provided a possible explanation: tapping requires only spatial processing, whereas EM requires 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, Freese, Andrade, and May (2001)

A second study by these authors (Kavanagh et al., 2001) further examined the effects of dual-attention task manipulations. The 18 participants identified three positive and three negative memories and focused on the mental image of each memory while engaging in one of the three conditions: EM, visual noise (a flickering pattern on the computer screen, observed passively), and No-EM (eyes fixed, "exposure alone"). The EM and No-EM conditions used the same procedure as Andrade et al. (1997). However, rather than using just one 8-second trial, Kavanagh et al. used eight trials (sets) of 8 seconds each. Each EM set consisted of 10 EMs (left–right–left). After each trial, vividness and emotionality were rated. This process was followed for each of the six memories. After one week (posttest), participants again rated each memory.

The ratings taken after each trial showed that EM produced significantly greater decreases in vividness and emotionality than No-EM (exposure) for the negative and positive images. The effects of the visual noise condition were midway between those of EM and No-EM and were not significantly different from either. After 1 week, postmeasurements showed that the superiority of EM was not maintained: all tasks had produced a significant pre–post decrease in ratings, with no differences between tasks. 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 EM compared to visual noise may occur because EM utilizes both the visual and spatial resources of the sketchpad, whereas visual noise utilizes only the visual resources. Although the effect of EM was primarily on within-session vividness and distress, it is possible that the poor maintenance of effects was a dosage effect; EM was applied for a total of only 64 seconds. The authors concluded that the results were consistent with working memory predictions that competition for visuospatial resources interferes with imagery. They further suggest that EM may have clinical value "by reducing the vividness of the image and modifying its emotional impact slightly" (p. 277).

### van den Hout, Muris, Salemink, and Kindt (2001)

A similar study was conducted by van den Hout et al. (2001), who also examined the effects of EM 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 one of three task conditions: EM, rhythmic tapping, and No-EM (imagery), with four sets (trials) of 24 seconds each, and a 10-second rest between sets. EM was induced by the experimenter's hand, moving 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 designed as a control for the movement involved in EM. In the exposure condition, the participants visualized the image. EM significantly reduced the vividness and emotionality of both positive and negative memory images; tapping and No-EM had no effect on the negative images. With the positive images, No-EM increased the vividness of positive images, and EM resulted in a significant decrease in emotionality compared to No-EM. The authors concluded that working memory theory "adequately accounts for reduced vividness/emotionality during eye movements, but that [it] does not predict or explain generalization to future recollections" (p. 131). They suggested that generalization effects might be best understood as related to reciprocal inhibition.

### Barrowcliff, Gray, Freeman, and MacCulloch (2004)

Barrowcliff and colleagues (2004) compared the effects of EM and No-EM on skin conductance (electrodermal arousal) and on pre- and postmemory vividness and emotionality. One positive and one negative memory were recalled by 80 participants, who provided pretask ratings of emotionality and vividness. Then they focused on each image while engaging in EM and No-EM tasks, for one trial of 24 seconds each, during which skin conductance measures were taken. After each task, they provided posttask ratings of emotionality and vividness. EM resulted in significant pre–post reductions in image vividness for both positive and negative memories, with EM producing larger reductions than No-EM. Emotional intensity was decreased following the EM task and was increased following the No-EM task. The skin conductance tests showed a decrease in arousal only for the negative memories during the EM task; no dearousal effect was found for the positive memories. The authors concluded that "it may be that two processes are operating here: both disruption of the visuospatial sketchpad and a process of physiological dearousal" (p. 342).

### Kemps and Tiggemann (2007)

Kemps and Tiggemann (2007) conducted two experiments to investigate the effects on visual and auditory memory images: of EM (requiring visuospatial sketchpad resources), counting (requiring phonological loop resources), and No-EM (looking at a blank computer screen). The EM procedures replicated those used by Andrade et al. (1997). The 30 participants recalled two memories (one happy, one distressing) and then focused on the memory while engaging in each of the three tasks. Both EM and counting produced greater decreases in emotionality and vividness than No-EM for both happy and distressing memories, and EM produced significantly larger decreases than counting.

However, when an analysis was conducted to control for the more dominant sensory image (visual or auditory), it was found that the difference between EM and counting disappeared. This suggested that counting may be effective in reducing the clarity and emotionality of auditory images through its influence on the phonological loop.

A second experiment was conducted in which 68 participants were instructed to specifically focus on either a visual or an auditory component of their memory. Results showed that both EM and counting produced significant decreases in vividness/clarity and emotionality compared to No-EM (exposure). There was a significant statistical interaction: EM significantly reduced the vividness of the visual component, and counting significantly reduced the clarity of the auditory component. Kemps and Tiggemann (2007) concluded that EM—a visual dual-attention task—has its largest effect on the visual memory component, while counting—an auditory task—has its largest effect on the auditory memory component. They labeled these "modality-specific interference tasks" (p. 420). Working memory effects were clearly supported in this study, and there are interesting implications for treatment applications.

### Lee and Drummond (2008)

In an earlier study, Lee et al. (2006) found that the greatest improvement in EMDR occurred when clients with posttraumatic stress disorder (PTSD) gave distancing responses, indicating the use of an observational or detached perspective from the traumatic memory. (See also Lee, this issue.) Lee and Drummond (2008) conducted another study to evaluate whether distancing was generated by EM or was a result of therapist instruction. Forty-eight nonclinical participants received one treatment session using all eight phases of the EMDR protocol for a distressing memory. They were randomly assigned to receive EMDR with EM or without EM (eyes stationary) and to receive therapist instructions related to either reliving the experience or distancing from the experience. Results were measured on scales evaluating image vividness and emotional distress. While the therapists' instructions had no effect on the outcome, EM was found to result in a significant reduction in distress at the end of the session and at 1 week follow-up. There was no decrease in vividness for the No-EM conditions or for the EM-reliving condition; a significant decrease in memory vividness was reported only for participants who received both EM and distancing instructions. The authors questioned whether the reliving instruction interfered with the reduction in vividness usually produced by EM.

## Current Research

In the current research, two experiments were conducted to investigate the effects of EM on the components of autobiographical memory, by testing predictions from working memory theory to determine whether the model can explain the possible mechanisms of action of EM in EMDR. The research evaluated the effects of EM dual-attention tasks on the cognitive, affective, and imagery components of autobiographical memory and examined whether speed and complexity of presentation impacted these effects. Working memory theory predicts that faster and more complex tasks will result in a larger effect compared to simpler tasks.

The current research did not examine the effects of other dual-attention stimuli used in EMDR such as tapping and auditory tones. These bilateral stimuli are passive spatial tasks, and the model predicts that these would result in a smaller effect than EM, which is an active complex task, requiring more working memory resources. Support for these differential effects has been found (e.g., Andrade et al., 1997; van den Hout et al., 2001).

The procedure used in this study was a replication of that used in Kavanagh et al. (2001) and therefore did not employ the standard protocols used in EMDR treatment. In EMDR, the client focuses on a memory for a "set" of about 24 seconds while engaging in a dual-attention task, during which the focus is often reported to shift to associated material (Shapiro, 2001). The purpose of the current research was to evaluate the effects of EM on memory components, and it therefore utilized a procedure to ensure that participants remained directly focused on the targeted memory and to inhibit associations. The 120-second focus on the memory was broken into 10 trials (sets) and provided repeated instructions to remain focused on the targeted memory.

## Experiment 1

Several hypotheses, derived from working memory theory, were tested in Experiment 1: (1) 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) 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) that the effects of Slow-EM and Fast-EM would be specific to the visual modality as opposed to the verbal modality, and therefore larger for image vividness than for thought clarity.

## Method

***Participants.*** Participants were 25 university students in northern Ontario, Canada, who were enrolled in a first-year introductory psychology course in 2002 and who received course credit for participation. One participant did not engage in the dual-attention task, and she was dropped from all analyses. Of the remaining 24 participants, 37.5% were male and 62.5% were female; 45.8% were 17 to 19 years of age, 33.3% were 20 to 29 years, and 20.8% were 30 years and older. The ethnic background was 83.3% White, 8.3% First Nations (Canadian aboriginal), 4.2% Black American, and 4.2% Asian.

***Procedure.*** The study was approved by the local research ethics committee, and participants gave written informed consent. After being instructed not to choose memories about the worst events in their life, each participant identified memories of three negative experiences (e.g., illness or death of a relative, parental divorce, threats from animals, an argument with a friend, horror movies). The participant was then asked to rank the memories in terms of their negativity, indicating the most and least negative memories. Each memory was then 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 self-referencing thought (e.g., "It's all my fault"), and associated emotion. The participant then focused on the memory and its components for 20 seconds, after which he or she provided pretask ratings of image vividness, thought clarity, and emotional intensity. After this, the participant was seated in front of a computer screen at a distance of approximately 45 centimeters. The participant was instructed to think of the memory, with its image, thought, and feelings, at the same time he or she 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 image, thought, and feelings. After the 10th trial, the participant was asked to provide postcondition ratings of image vividness, thought clarity, and emotional intensity. This was followed by a 2-minute distracter activity to diminish any carryover effects. The entire process was repeated with the second memory, pairing it with a different dual-attention task. After completion of the posttask ratings and a second administration of the distracter activity, the process was repeated with the third memory and the third dual-attention task.

***Dual-Attention Tasks.*** There were three dual-attention tasks. In the No-EM condition, participants stared at a blank computer screen. Fast-EM was a difficult task, expected to place demands on the resources of the visuospatial sketchpad and the central executive. Slow-EM was a moderately difficult task, expected to require fewer resources. No-EM was easy and was expected to require minimal resources. For the Slow-EM and Fast-EM conditions, the cue for eye movement was the repeated appearance of the 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 millimeters in height. 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. In 50% of the trials, the researcher acknowledged *q* recognition by saying "good" or "mm-hmm" after the participant raised his or her hand. In No-EM, 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.

For the Slow-EM condition, each of the 10 trials consisted of eight left–right–left horizontal eye movements, conducted at a consistent speed of one movement (cycle) per second. Each cycle consisted of a 300-millisecond left stimulus presentation followed by a 200-millisecond interdisplay interval (with no stimulus), then a 300-millisecond right stimulus presentation followed by a 200-millisecond interdisplay interval (with no stimulus). For the Fast-EM condition, each of the 10 trials consisted of 10 left–right–left eye movements conducted at an inconsistent speed, averaging one movement (cycle) per 0.8 second. Each cycle consisted approximately of a 200-millisecond left stimulus presentation, a 200-millisecond interdisplay, a 200-millisecond right stimulus presentation, and a 200-millisecond interdisplay interval. 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.

***Measures.*** Each of the three memory components was measured using an 11-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 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 an 8.

## Experiment 1 Results

Preliminary analyses were conducted to examine the formative features of the data. The variables were normally distributed and without skew. 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 ($F[15, 54] = 1.02$, $p > .10$). 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. The most frequent type of negative memory (chosen by 25% of participants) was a negative interpersonal incident. At pre-condition, the mean score (range 0 to 10) across participants for emotional intensity was 7.22 ($SD = 1.35$), for image vividness 7.96 ($SD = 1.13$), and for thought clarity 7.96 ($SD = 1.18$). The mean score of emotional intensity was significantly smaller than mean scores of both image vividness ($t[23] = 3.69$, $p = .001$) and thought clarity ($t[23] = 3.07$, $p = .005$). There were no differences between dual-attention tasks for pretask scores on any measure (see Table 1).

A multivariate analysis of variance with repeated measures was conducted on the three measures, with the three tasks as within-subjects factors and the two occasions (pre and post) as repeated measures factors. Analyses also included a measure of effect size, partial eta squared ($\eta^2$) (range 0 to .99), which measures the independent contribution of each task or interaction to the outcome. Multivariate tests showed a significant interaction between the EM tasks and occasion, indicating that the different dual-attention tasks resulted in different amounts of change on the combined measures ($F[6, 18] = 5.92$, $p = .001$, $\eta^2 = .66$). Both Slow-EM and Fast-EM resulted in significant reductions in image vividness and thought clarity compared to the No-EM condition. There were no significant differences between tasks on emotional intensity.

Planned comparisons, using one-tailed simple contrasts, showed that, at posttask, images in both EM conditions were rated as significantly less vivid than those in the No-EM condition (Fast-EM: $F[1, 23] = 22.64$, $p < .001$, $\eta^2 = .50$; Slow-EM: $F[1, 23] = 9.55$, $p = .005$, $\eta^2 = .29$). Similarly, thoughts in both EM tasks were rated as significantly less clear than those in the No-EM condition (Fast-EM: $F[1, 23] = 19.67$, $p < .001$, $\eta^2 = .46$; Slow-EM: $F[1, 23] = 6.40$, $p = .019$, $\eta^2 = .22$). Compared to Slow-EM, Fast-EM produced significantly smaller scores for image vividness ($F[1, 23] = 6.85$, $p. = .008$, $\eta^2 = .23$) and marginally significantly smaller scores for thought clarity ($F[1, 23] = 2.80$, $p. = .054$, $\eta^2 = .11$) (see Table 2 and Figure 1).

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 ($r = 0.632$, $p = .001$), Fast-EM ($r = 0.720$, $p < .001$),

**TABLE 1. Experiment 1: Means (With Standard Deviations) for Memory Components at Pre- and Post-Task**

| | Image Vividness | | Thought Clarity | | Emotional Intensity | |
|---|---|---|---|---|---|---|
| Task | Pretask | Posttask | Pretask | Posttask | Pretask | Posttask |
| Slow-EM | 8.33 (1.43) | 8.21 (1.50) | 7.96 (1.43) | 7.50 (1.91) | 7.46 (1.96) | 7.42 (2.21) |
| Fast-EM | 7.79 (1.86) | 6.88 (2.64) | 8.04 (1.81) | 6.58 (2.19) | 7.08 (2.19) | 6.58 (2.43) |
| No-EM | 7.75 (1.96) | 8.96 (1.04) | 7.88 (1.70) | 8.67 (1.37) | 7.13 (2.25) | 7.33 (2.38) |
| Mean | 7.96 (1.15) | 8.01 (1.44) | 7.96 (1.18) | 7.58 (1.22) | 7.22 (1.35) | 7.11 (1.59) |

*Note.* All variables are measured on a Likert scale, where 0 = *none* and 10 = *highest possible*. See page 252 for descriptions of Slow-EM, Fast-EM, and No-EM.

**TABLE 2. Comparison of Posttask Scores: Statistical Significance of Task Comparison and Partial Eta Squared Effect Size**

| | Experiment 1 | | | Experiment 2 | | |
|---|---|---|---|---|---|---|
| | | | | | Emotional Intensity | |
| Comparison Task | Image Vividness | Emotional Intensity | Thought Clarity | Image Vividness | Image Only | Image-Thought |
| Slow-EM vs. No-EM | $p = .003$ $\eta^2 = .29$ | *ns* $\eta^2 = .00$ | $p = .010$ $\eta^2 = .22$ | $p = .042$ $\eta^2 = .09$ | $p = .003$ | *ns* |
| Fast-EM vs. No-EM | $p < .001$ $\eta^2 = .50$ | *ns* $\eta^2 = .06$ | $p < .001$ $\eta^2 = .46$ | $p < .001$ $\eta^2 = .44$ | $p < .001$ $\eta^2 = .29$ | |
| Fast-EM vs. Slow-EM | $p = .008$ $\eta^2 = .23$ | *ns* $\eta^2 = .09$ | $p = .054$ $\eta^2 = .11$ | $p = .010$ $\eta^2 = .15$ | $p = .035$ $\eta^2 = .09$ | |

*Note.* Effect size is $\eta^2$ (partial eta squared, range 0 to .99), which measures the independent contribution of each task or interaction to the outcome; *ns* = not statistically significant.

and No-EM ($r = 0.630$, $p = .001$), indicating that these two memory components showed the same patterns of change within tasks. Changes in emotional intensity were correlated with changes in image vividness ($r = 0.780$, $p < .001$) and thought clarity ($r = 0.792$, $p < .001$) only in the Fast-EM task (see Figure 1).

## Discussion of Findings in Experiment 1

When participants focused on the memory with a minimal dual-attention task (No-EM), there was a significant increase in their ratings of image vividness and thought clarity at posttask. 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; instead, there was a decrease in vividness and clarity, and scores were significantly smaller than those of the No-EM condition. Posttask 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 and thought clarity than Slow-EM. Although emotional intensity showed the same pattern and directions of change, the analyses failed to reach significance. 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,

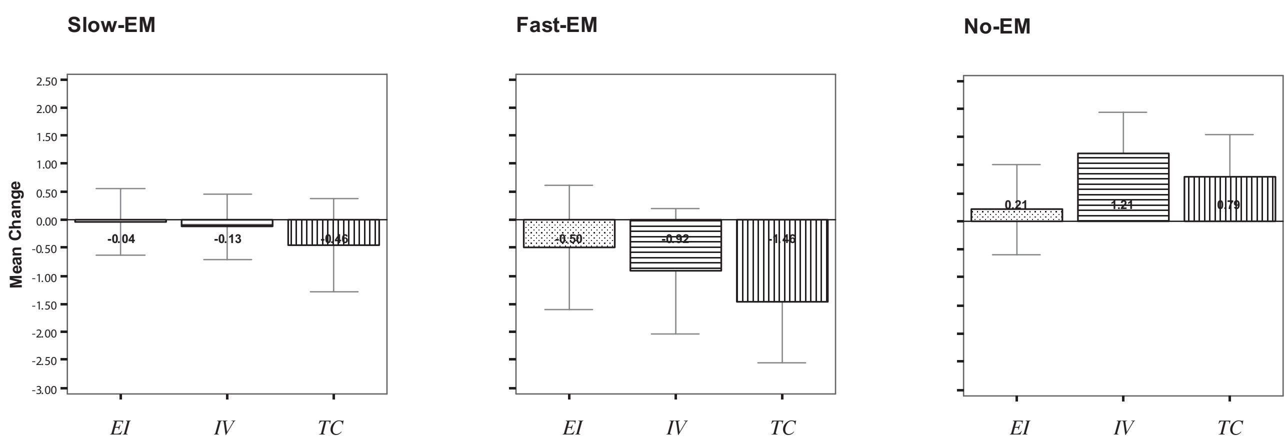


**FIGURE 1.** Experiment 1: Comparison of pre–post changes across measures, for each dual-attention task, illustrating the pattern of change.

*Note.* EI = emotional intensity; IV = image vividness; TC = thought clarity. Error bars indicate 95% confidence intervals.

in the current study, the effect on emotional intensity failed to reach significance.

Not only were the pre–post changes in emotional intensity nonsignificant, the effect sizes were small for Fast-EM (Cohen's $d = 0.22$) and extremely small for Slow-EM ($d = 0.02$) and No-EM ($d = -0.09$). In order to have sufficient statistical power to detect the change in emotional intensity for Fast-EM, a sample size of almost 200 participants would have been needed. Given the large effects of the other findings in this experiment, it is unlikely that this represents a Type 2 error.

Although this lack of effect on emotion could simply be an anomaly, it is possible that it was related to the inclusion of the new variable: thought clarity. Perhaps asking clients to repeatedly attend to the cognitive component of the memory maintained emotional intensity.

## Experiment 2

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.

### Method

***Participants.*** Participants were 36 university students in northern Ontario, Canada, who were enrolled in a first-year introductory psychology course; 30.6% were male and 60.4% female; 52.8% of the participants were 18 to 19 years of age, 27.8% were 20 to 29 years, and 19.4% were 30 and older. The ethnic background was 88.9% White, 8.3% First Nations, and 2.8% Asian.

***Procedure.*** The procedures were identical to those used in Experiment 1, except that participants were also randomly assigned to one of two groups, "focus on Image-Only" and "focus on Image-Thought." Participants in the Image-Thought group identified a visual image, a related thought (e.g., "It's all my fault"), and associated emotion for each memory. In the Image-Only group, participants identified visual images and associated emotions but no related thoughts. Eighteen participants were assigned to the Image-Thought focus group and 18 to the Image-Only focus group. The experimental procedure was identical to that used in Experiment 1, with two exceptions: (1) only two memory components were measured: image vividness and emotional intensity; (2) in the Image-Thought group, participants were instructed to focus on the memory image, thought, and emotions, while in the Image-Only group, participants were instructed to focus on the memory image and emotions. Each participant was reminded of the focus during four of the nine between-trial intervals.

***Dual-Attention Tasks.*** The dual-attention tasks, 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.

***Measures.*** Two measures were used: image vividness and emotional intensity. They were each rated on an 11-point Likert scale and were measured and scored as in Experiment 1.

## Experiment 2 Results

Preliminary analyses were conducted to examine the data. The variables were normally distributed and without skew. There was no effect for sex ($F[2, 31] = .10$, $p > .10$) or age ($F[4, 60] = .14$, $p > .10$) and no effect for order of condition presentation ($F[10, 48] = .67$, $p > .10$). 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%. At pre-task, the mean score (range 0 to 10) across participants for emotional intensity was 6.40 ($SD = 1.32$) and for image vividness 7.53 ($SD = 1.34$). The mean score of emotional intensity was significantly smaller than that of image vividness ($t[35] = 4.18$, $p < .001$]. There were no differences between dual-attention tasks, for pre-task scores on either measure (see Table 3).

A multivariate analysis of variance with repeated measures was conducted; focus was a between-subjects variable, the three dual-attention tasks were within-subjects factors, with two measurement occasions (pre and post), and two measures (emotional intensity and image vividness). There was a significant two-way interaction for the complete model between tasks and occasions ($F[4, 31] = 5.18$, $p = .003$, $\eta^2 = .400$), indicating that the conditions resulted in significantly different pre–post changes. Both Slow-EM and Fast-EM resulted in significantly larger reductions in image vividness and emotional intensity compared to No-EM. There was also a significant three-way interaction for emotional intensity between occasion, focus, and task for the Slow-EM and No-EM conditions ($F[1, 34] = 5.35$, $p = .027$, $\eta^2 = .136$).

## Emotional Intensity

A primary purpose of Experiment 2 was to evaluate the effect of the focus (Image-Only, Image-Thought) during the dual-attention tasks on emotional intensity. The significant three-way interaction between occasion, focus, and task indicated that there were different pre–post changes for the Slow-EM and the No-EM tasks in the Image-Thought group as compared to the Image-Only group (see Figure 2). A comparison of posttask emotional intensity scores showed that participants in the Image-Thought group showed no significant difference between Slow-EM and No-EM ($t[17] = .251$, $p = .805$). However, for participants in the Image-Only group, the difference between the two tasks was significant, with Slow-EM producing less emotional ratings than No-EM ($t[17] = 3.491$, $p = .003$). Focus did not show any effect within the Fast-EM task, with no differences on emotional intensity for Image-Thought and Image-Only. Planned comparisons, combining focus groups and using one-tailed simple contrasts showed that, at posttask, emotions in Fast-EM were rated as significantly less intense than those in No-EM ($F[1, 34] = 14.13$, $p < .001$, $\eta^2 = .29$), and Slow-EM ($F[1, 34] = 3.52$, $p = .035$, $\eta^2 = .09$) (see Table 2 and Figure 3).

## Image Vividness

An analysis of pre–post changes in image vividness ratings showed significant task by occasion interactions for both Fast-EM and Slow-EM in comparison to No-EM (Fast-EM: $F[1, 34] = 19.07$, $p < .001$, $\eta^2 = .36$; Slow-EM: $F[1, 34] = 15.61$, $p < .001$, $\eta^2 = .32$), indicating significantly different pre–post changes in scores. Planned comparisons combining focus groups and using one-tailed simple contrasts showed that, at posttask, images in Fast-EM were rated as significantly less vivid than those in No-EM ($F[1, 34] = 27.20$, $p < .001$, $\eta^2 = .44$) and Slow-EM ($F[1, 34] = 6.061$, $p = .010$, $\eta^2 = .15$). Likewise, images in Slow-EM were significantly less vivid than those in No-EM ($F[1, 34] = 3.175$, $p = .042$, $\eta^2 = .09$). (See Table 2 and Figure 3.)

## Interrelationship of Components

Bivariate correlations for change scores were conducted to examine the relationship among the memory

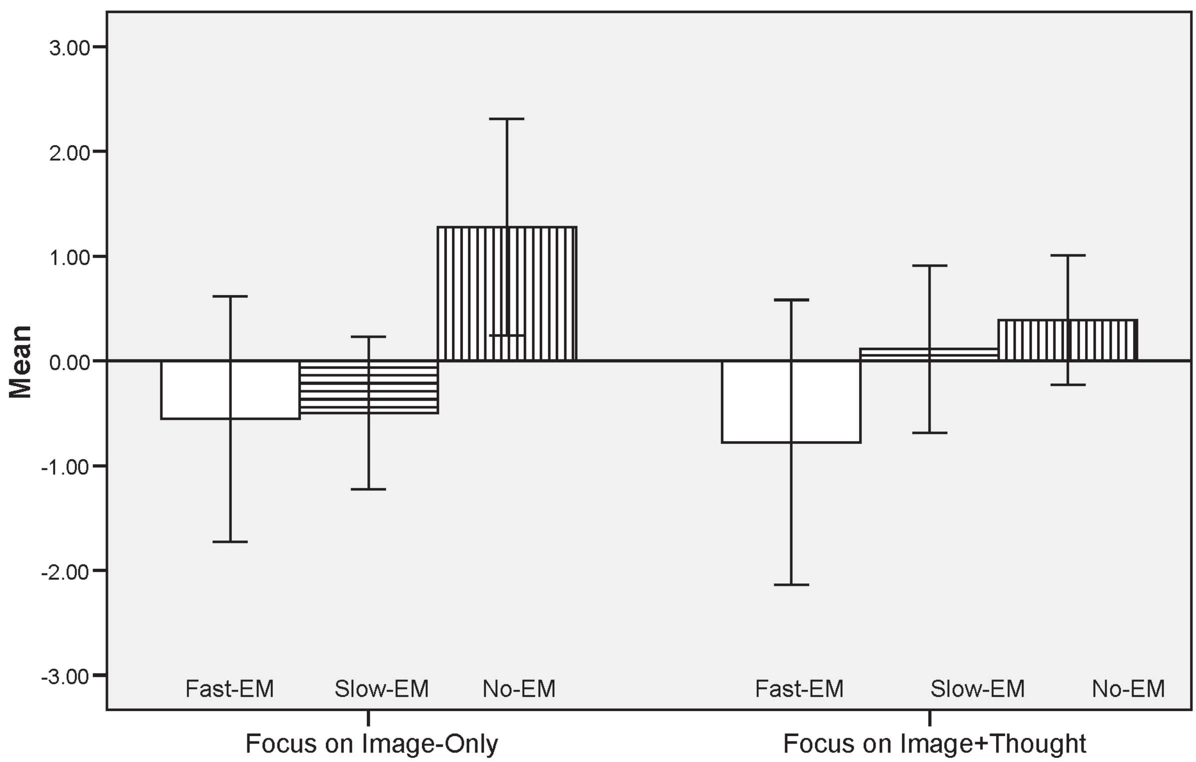


**FIGURE 2.** Experiment 2. Pre–post change in emotional intensity for two types of memory focus.

*Note.* Error bars indicate 95% confidence intervals.

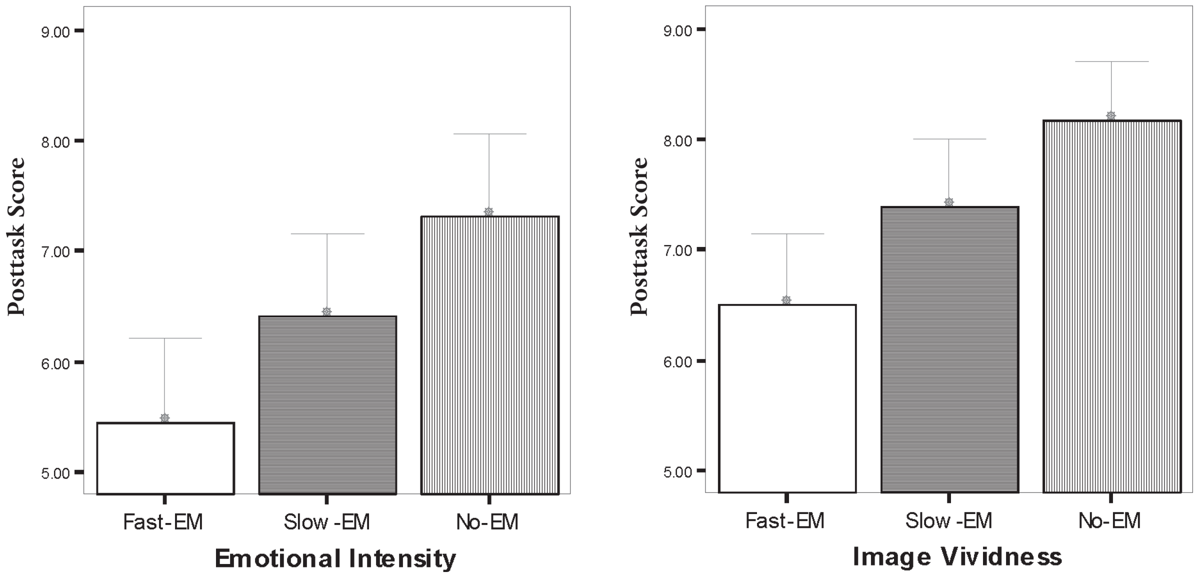


**FIGURE 3.** Experiment 2: Posttask scores with focus groups combined.

*Note*. Error bars indicate 95% confidence intervals.

**TABLE 3. Experiment 2: Means (With Standard Deviations) for Memory Components at Pre- and Post-Task**

| | Image Vividness | | | | Emotional Intensity | | | |
|---|---|---|---|---|---|---|---|---|
| | Pretask | | Posttask | | Pretask | | Posttask | |
| EM Task | *I-O* | *I-T* | *I-O* | *I-T* | *I-O* | *I-T* | *I-O* | *I-T* |
| Slow-EM | 7.61 (1.50) | 8.06 (2.21) | 7.22 (1.77) | 7.56 (1.92) | 6.22 (2.37) | 7.00 (2.14) | 5.72 (2.37) | 7.11 (1.84) |
| Fast-EM | 7.72 (2.22) | 7.06 (2.01) | 7.00 (1.85) | 6.00 (1.91) | 5.78 (2.24) | 6.44 (2.04) | 5.22 (2.65) | 5.67 (1.91) |
| No-EM | 7.56 (1.58) | 7.17 (1.82) | 8.83 (1.25) | 7.50 (1.65) | 6.39 (2.04) | 6.56 (2.23) | 7.67 (2.20) | 6.94 (2.24) |
| Mean | 7.53 (1.34) | | 7.35 (1.19) | | 6.40 (1.32) | | 6.39 (1.44) | |

*Note*. I-O = focus on Image-Only ($N = 18$); I-T = focus on Image-Thought ($N = 18$). All variables are measured on a Likert scale, where 0 = *none* and 10 = *highest possible*.

components. There were significant positive correlations within tasks and 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, although the effect was noticeably less for Slow-EM.

### Summary of Findings in Experiment 2

The inclusion of the focus on thought appeared to inhibit changes in emotional intensity for the Slow-EM and No-EM tasks. This effect was not found within the Fast-EM task, and Fast-EM, regardless of focus, produced significantly greater reductions in emotional intensity than No-EM. Fast-EM also produced significantly smaller posttask scores on image vividness and emotional intensity than No-EM and Slow-EM.

## Discussion

Several hypotheses derived from working memory theory were tested, and, with two exceptions, the results were consistent with predictions. Slow-EM and Fast-EM resulted in decreased ratings of image vividness, thought clarity, and emotional intensity compared to the No-EM condition, and the more difficult Fast-EM produced larger decreases than the easier Slow-EM. Working memory theory provides a parsimonious explanation of the effects seen in this study. From this perspective, EM produces visual and spatial information, which loads onto the visuospatial sketchpad. When the attention is simultaneously focused on a visual image, there is a competition for the limited working memory resources, producing a deterioration in the quality and vividness of the memory image and related components.

## Inclusion of Cognitive Component

This study was unusual in its inclusion of the cognitive component of the memory and the related rating of thought clarity. The prediction that the EM tasks, which were visual and spatial, would result in greater decrements in image vividness than in thought clarity, was not supported. Compared to No-EM, Fast-EM and Slow-EM resulted in significantly reduced scores for thought clarity. As can be seen in Table 2, there was little difference within tasks between the effect sizes for image vividness and thought clarity and no evidence for the modal (i.e., visual vs. verbal) specificity reported by Kemps and Tiggemann (2007).

A number of explanations for the degradation of thought clarity are possible. First, 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 appeared to result in an increase of thought clarity. Second, 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, because the relatively simple Slow-EM condition, which did not require great attentional resources, resulted in significant reductions in thought clarity compared to No-EM. Third, the more likely explanation for the degradation of thought clarity is that the memory components are not independent propositions, that there are interrelationships among the memory components.

## Relationships 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 previous study had investigated the relationship of change in the cognitive component of autobiographical memory to that in the affective and sensory elements. Findings in this study indicated that the memory components were linked and tended 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, Fast-EM only; Experiment 2, all tasks). This association may be the best explanation for the unexpected large changes in thought clarity. Memory components tended to show the same pattern of change within tasks (see Figure 1). This is consistent with the predictions of Shapiro's (2001) adaptive information processing model.

In Experiment 1, the lack of change in emotional intensity did not inhibit changes in image vividness and thought clarity. Although that lack of change may be an anomaly, it suggests that decreases in emotionality and image vividness may not necessarily be linked. On the other hand, in Experiment 2, a significant correlation was found between changes in image vividness and emotional intensity. This discrepancy in results highlights the need for further research, and no conclusions can be drawn from the current study about the relationship between image and emotion.

## Emotional Intensity and Cognitive Thought

The lack of change for emotional intensity during all three of the tasks in Experiment 1 (see Figure 1) was unexpected given the findings in the extant literature. Experiment 2 was designed to test the possibility that the added focus on cognition might have served to maintain the emotional intensity, preventing change in emotionality scores. Some evidence was found for this hypothesis. When the dual-attention task was less demanding (Slow-EM, No-EM) and the focus included thought, the emotional change was inhibited. However, when the task was complex (Fast-EM), it resulted in the expected degradation of imagery and emotion (see Figure 3). Future research is needed to investigate the role of thought in memory processing and working memory. It appears that repetition of the thought maintained the emotional elements of the memory when the visuospatial task was simple and did not make strong demands on working memory resources. Some support for this hypothesis is found in research by Kemps and Tiggemann (2007), who found a modality-specific effect for dual-attention tasks: verbal memories showed a stronger response to an auditory task, and visual memories showed a stronger response to a visual task. In the current experiment, it is possible that the repetition of the verbal thought component rendered the memory less susceptible to the effects of the visual dual-attention task. If so, it is interesting to note that the effect appeared to be on emotion and not on thought clarity. Further research is needed to investigate the role of each of these components in EMDR processing.

## Limitations of the Current Research

The current study used nonclinical participants. Working memory deficits have been identified in patients with PTSD and depression, and it is unknown how that type of impairment might interact with the working memory effects seen in this study. More research is needed to investigate the roles of mental disorders and emotional states in the information processing that occurs during dual-attention activities. Future research should also examine the effects of individual differences to determine whether there are certain types of clients who show greater benefits from working memory effects. Such client characteristics could include high fear of affect or high levels of dissociation. The memories selected by the participants were not designated as traumatic, so the study findings may not generalize to the type of memories that cause PTSD. Nevertheless, many participants chose memories of painful incidents that would have met criteria for PTSD. Also, the pretask intensity of the selected memories was not associated with the task effects.

The current research did not test EM in a therapeutic context: Only 2 minutes of EM were provided per memory. This is of much shorter duration than the application of EM during a 60- to 90-minute EMDR therapy session, although it is somewhat representative of the time that might be spent on a single image during EMDR. In addition, the breakdown of the dual-attention task into 10 short sets of 8 seconds, to ensure a direct focus on the memory and inhibit associations, is not the standard protocol, which uses approximately 24 seconds per set. Research is needed to evaluate whether the same effects will be produced in a clinical setting using the standard EMDR protocol. Also, it is not known whether working memory effects are related to treatment outcome.

## A Working Memory Explanation for Eye Movement Effects in EMDR

EMDR does not involve simply focusing on one memory image with simultaneous EM. The protocol also includes the elicitation of associated material. At the end of each set, the client is asked to let their mind go blank and then report whatever comes to mind. This new "image," whether memory, visual image, thought, emotion, or sensation, becomes the focus of the next dual-attention set. The process is repeated many times, and clients focus on numerous different images throughout the session. The protocol also involves, at specific times, going back to the original memory and reassessing it. During this process, links are forged between the associated material and the original memory, thus transforming the way that the traumatic memory is stored in memory networks.

From a working memory perspective, this process involves the sequential deterioration of each component of the original memory and its associated aspects. As a targeted image becomes less vivid and emotional, the elicitation of association evokes other information that has greater vividness, emotionality, or clarity. This new information becomes the focus of the next set of EM and is subjected to working memory effects, with subsequent degradation of vividness and emotionality as well as loss of salience. The process is repeated many times, resulting in significant changes in the client's experience of the memory and its components, with desensitization of all aspects of the targeted memory. There is a consolidation of these effects through the activation of the four functional components of working memory, including the episodic buffer, which transfers information and integrates it within long-term memory (Baddeley, 2000). It is proposed that this consolidation accounts for the maintenance of the working memory effects within EMDR.

In addition, it is likely that the degradation of the memory produces a distancing effect. The decrease in vividness, clarity, and emotionality renders the specific memory less salient and less distressing and may increase the client's sense of detachment from the incident. Lee (this issue) found that detachment during EMDR is predictive of better treatment outcomes, and determined that detachment appeared to be related to EM. Although research is needed to examine the sequential relationship, if any, between working memory effects and detachment, it is hypothesized that the degradation of the memory precedes detachment because a decrease in image vividness is apparent within seconds of instituting EM (e.g., Andrade et al., 1997).

## Recommendations for Future Research

The current research is a preliminary step in evaluating whether working memory is a mechanism in EMDR treatment outcome. This study determined that EM dual-attention tasks resulted in a significant degradation of memory quality, with decreases in image vividness, thought clarity, and emotional intensity. Research is needed to evaluate whether memories treated in clinical EMDR sessions show this same effect. Does EMDR result in decreases in image vividness, thought clarity, and emotional intensity? If so, what is the relationship of these effects to treatment outcome? The determination that working memory effects are a mechanism in EMDR outcome depends on the establishment of this relationship. If these effects are not related to EMDR outcome, then it is possible that EM may function as a treatment moderator, influencing the process of treatment but not directly effecting outcome.

Other research that would be valuable includes determining whether the alternate stimuli used in EMDR produce any working memory effects. Working memory theory predicts that the dual-attention effects of bilateral taps and tones would be less pronounced than those of EM, because the stimuli contain a spatial element but not a visual one. They would be expected to utilize the spatial resources of the visuospatial sketchpad and to generate results similar to those in the Andrade et al. (1997) study, in which the spatial tapping task produced smaller reductions than EM in image vividness and emotional intensity.

In the current research, both Slow-EM and Fast-EM resulted in a degradation of thought clarity. It was hypothesized that this effect resulted from its significant relationship with image vividness. Research is needed to more thoroughly investigate the effects of various tasks on the verbal and thought components of autobiographical memory by comparing activities that activate the phonological loop versus the visuospatial sketchpad. Would a verbal task that utilized the resources of the phonological loop degrade visual imagery in the same way that EM appeared to degrade thought clarity?

It is also recommended that related changes in the memory content be investigated. In the current experiments, some participants reported shifts 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, Bears, Miall, and Smith (2001–2002). 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.

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