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Rapid Eye Movement Effects on Traumatic Memories: A Test of the Working Memory Hypothesis

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by

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Abstract

Eye Movement Desensitization and Reprocessing therapy (EMDR) is a psychotherapy that uses rapid eye movements to alleviate traumatic memories. This experiment examined two working memory hypotheses proposed to explain how performing rapid eye movements can affect the vividness, emotionality and completeness of traumatic memories. Participants (N=25) recalled three traumatic memories and rated them on vividness, emotionality and completeness before and after performing rapid eye movements. Participants also completed six working memory tasks to see if a correlation existed between working memory and the effect of rapid eye movements on memory rating variables. Findings illustrate that there was a significant decrease pre-test to post-test in vividness. Additionally, the factor underlying the reading span operation task and the Sternberg item order task significantly correlated with the effect of rapid eye movements for all memory ratings. The results of the current study support the central executive hypothesis explanation more than the visuospatial sketchpad storage hypothesis for EMDR.

Rapid Eye Movement Effects on Traumatic Memories: A Test of the Working Memory

Hypothesis

In 1987, Francis Shapiro discovered that performing horizontal eye saccades while

holding a traumatic event in mind helped her alleviate the negative symptoms she experienced

from that memory. She developed this intuition into a psychotherapy that is called Eye

Movement Desensitization and Reprocessing (EMDR). This therapy is now a widely-used

technique to treat victims of trauma, people suffering from post-traumatic stress disorder

(PTSD), and people suffering from phobias and other anxiety disorders (Muris & Meckleberger,

1999). Shapiro (2001) describes EMDR as an eight-phase treatment method that includes history

taking, client preparation, assessment, desensitization, installation, body scan, closure and re-

evaluation. An important, and distinguishing, component of the EMDR procedure involves the

patient performing rapid bilateral eye movements while thinking about their traumatic memory

and communicating any negative cognition associated with that memory. The horizontal saccadic

eye movements generally involve watching the therapist's quickly moving finger for 15-20

seconds/set (Shapiro, 2001). Eye saccade sets continue until the patient begins to report that

negative aspects of the memory are being alleviated, and that positive self-cognitions have

replaced the negative self-cognitions associated with the memory (Shapiro, 2001).

Since its inception, the eye movement component of EMDR has remained controversial.

Initially, psychologists questioned the need for the eye movements as EMDR could be replaced

by other therapies without eye movements (Devilly & Spence, 1999; Rosen, Lohr, McNally &

Herbert, 1999). However, clinical research found that the inclusion of the eye movement

component provided significant improvements in symptoms (Bisson et al., 2007; Rothbaum,

Astin & Marsteller, 2005). The American Psychiatric Association currently gives EMDR their

"highest level of recommendation" for treatment of trauma. Secondly, psychologists doubted the utility of eye movements when the descriptions for the underlying mechanisms that explain their benefits were not forthcoming from Shapiro and her colleagues. However, in recent years a number of valid mechanisms have been postulated by cognitive psychologists and neuroscientists (Andrade, Kavanagh & Baddeley, 1997; Barrowcliff, Gray, MacCulloch, Freeman & MacCulloch, 2004). This includes the investigatory reflex account (Barrowcliff et al., 2004), the increased hemispheric communication account (Christman, Garvey, Propper & Phaneuf, 2003) and the working memory (WM) hypothesis (Andrade, Kavanagh & Baddeley, 1997). The goal of this thesis is to examine the most popular explanation: the WM hypothesis.

The WM hypothesis is based on the WM model of short-term memory proposed by Baddeley and colleagues (Baddeley & Hitch, 1974; Baddeley, 1986; Baddeley, 1998, Baddeley, 2000). The WM model consists of two temporary storage buffers, the phonological loop and the visuospatial sketchpad (VSSP). At the center of the WM model is a central executive that controls the storage of information in these two buffers. The central executive allocates attention, regulates information storage, and inhibits unnecessary responses that compete for access to the buffers. The initial WM hypothesis provided by Andrade, Kavanagh and Baddeley (1997) for the effects of eye movements on traumatic memories inferred that the effects resulted from competition for storage in the VSSP. The unpleasant memory images and visual stimuli being tracked by the horizontal eye saccades both need access to the VSSP. This competition for limited storage results in the temporary storage of a memory image that is less detailed and vivid. As a result, this less vivid image is reconsolidated back into long-term memory from working memory. When this memory is retrieved again from long-term memory, the less vivid memory elicits fewer emotional responses in the individual. Similarly, Kemps and Tiggemann (2007)

found that eye movements affected the recall of visual information of a memory, while an auditory secondary task interfered with the auditory information contained in a memory. This again supports that poorer storage of memorial images in VSSP is the source of the effect.

More recently, a second WM hypothesis has emerged that may provide a better explanation for the eye movement effect. This hypothesis can also explain why other forms of the dual stimulation tasks, such as binaural auditory tones, can produce similar effects, (e.g., Andrade et al., 1997; Gunter & Bodner, 2008). This new WM hypothesis, the central executive hypothesis, focuses on the central executive rather than the VSSP. These researchers suggest that performing the eye movements puts a cognitive load on the central executive as it is required to maintain dual attention to both tasks. This load results in the central executive's inability to maintain a detailed, vivid image of the memory in the VSSP, and consequently, results in reduced images reconsolidated into long-term memory. In a similar fashion, Towse and Hitch (1995) suggest that a memory can become less vivid because attention is switched away from it to perform the secondary task of performing eye movements. Gunter and Bodner (2008) showed that any attention demanding task, visual or not, can tax the central executive and reduce the vividness and emotionality of traumatic memories. Participants recalled traumatic memories in their study and rated the vividness and detail of the memories before and after performing eye movements, shadowing spoken speech, or copying graphical figures. Each of these tasks reduced the memory ratings from pre-test to post-test. However, copying graphical figures reduced ratings more than shadowing spoken speech or performing eye movements (which reduced ratings equally). This finding not only supports the idea that any attention demanding task that taxes the central executive can reduce memory ratings, but also that more taxing tasks will have a greater reduction in memory ratings.

Gunter and Bodner (2008) provided a further test of their central executive hypothesis by requiring their participants in a third experiment to provide reading operation span scores. This is a cognitive task that measures WM capacity while maintaining and accessing additional information in WM. Participants read a sentence aloud that is followed by a word. They were then required to make a semantic or linguistic judgment about the sentence and also hold the word in WM. They are given a sequence of two to six sentences and then asked to recall all of the words in the same order that followed the sentences in the sequence. The number of words they recall is deemed a valid and reliable measure of WM capacity and central executive functioning. Gunter and Bodner reasoned that if the eye movements work because of their taxation on central executive processing, then individuals with low reading span scores should provide a larger eye movement effect on trauma memory vividness and detail. This is exactly what they found.

However, the reading operation span task is not just a measure of central executive capability. It is also, more specifically, a measure of VSSP capacity. Participants have to control attention while processing the sentences and words simultaneously, but they also have to maintain the words in a buffer while doing so. As the number of words and sentences increase, so do the demands on the VSSP for maintaining the memory of the word order.

In addition, over the past few years, the notion of a unitary central executive is now being replaced by a view of the central executive consisting of separate, independent executive processes (Caplan & Waters, 1996; Baddeley, 1998). This theoretical change parallels recent developments in the study of executive functions in the frontal lobes. For example, Smith and Kosslyn (2006) suggest that some of these executive functions can include response inhibition, attention switching, and sequencing.

The goal of the current experiment is to provide a more comprehensive test of the central executive hypothesis than conducted by Gunter and Bodner. Rather than using just one WM task, we plan to score participants on a variety of executive tasks reported in the literature. Some tasks will impose a load on memory buffer capacity, whereas others will tax central executive processing (central executive processing will be based on the independent processes approach). We will then be in a much better position to test the efficacy of EMDR as predicted by the central executive hypothesis.

Participants will complete an attention switching task (Sylvester, Wager, Lacey, Hernandez, Nichols, Smith & Jonides, 2003) to focus on the executive function of attentional control. The participant must first identify the direction an arrow is pointing and then update the mental count for the number of arrows seen pointing in that direction. The arrows can point in two directions (left or right) and so the participant is required to maintain and update two mental counts at the same time. This task involves accessing WM, updating the contents of WM, and selecting the appropriate contents of WM. This task also measures attention switching performance, because it takes longer to press the button triggering the next stimulus when a switch in count is required from one arrow direction to the other. This change in response time measures performance of attention switching by the central executive.

Participants are also required to perform the Sternberg item order task (Sternberg, 1966) that measures task sequencing. Task sequencing specifically refers to the process of coding the order of information or events in WM, in order to accomplish a goal. For the Sternberg item order task, participants are presented with a sequence of letters followed by a probe letter from the sequence. They then retrieve the letter in the input sequence that followed the probe letter. As the number of letters held in WM increases, so does the time it takes to retrieve the desired

information. This task requires that the item identity and order information be stored in WM. Additionally, participants' ability to retrieve order information is distinguished by their recall reaction times.

Participants also complete a Sternberg item identity task (Sternberg, 1966) that measures the capacity of the VSSP. Participants are presented with a sequence of letters followed by a probe letter from the sequence. They then decide if the probe letter was or was not in the input sequence. This task is similar to the Sternberg item order task because as the number of letters held in WM increases, so does the time it takes to retrieve the desired information. This task requires only that the sequence of letters be stored in WM.

Participants then complete a 'go/no-go' task (McNab, Leroux, Strand, Thorell, Bergman & Klinberg, 2007) that measures response inhibition. In the go/no-go task, the participant first identifies the shape's color and then follows a simple procedural rule. If the triangle or square is yellow, participants press the 'yes' button. If the color is blue, the participant inhibits their response. As the probability of a 'go' response increases, it becomes more difficult for the participant to inhibit their response to a 'no-go' trial (Smith & Kosslyn, 2006). The 'go/no-go' task puts limited demands on the VSSP, and response inhibition appears to be the only executive function in play. A VSSP hypothesis would expect that performance on this task predicts the size of the eye movement effect; however, the central executive hypothesis would not predict such a relationship.

Participants also complete a Random Letter Generation task (RLG) (Baddeley, 1998). In the RLG, participants verbally choose any letter from the alphabet at the sound of the beep. They are asked to produce a random sequence of letters that that do not rely on repeating the same letters, patterns, or acronyms. There is one beep per second for 60 seconds, and the experimenter

records what the participants says after each beep. Responses will be assessed based on the total number of letters produced, the number of letters the participants used, the redundancy of repeated letters, and the amount of alphabetically ordered pairs. The RLG requires participants to keep mental track of all used letters, as well as keep track of the short sequence of used letters.

As mentioned previously, Gunter & Bodner (2008) relied on only one measure of central executive performance in the form of a reading operation span task. Participants in this experiment will also complete the same reading operation span task.

If the central executive hypothesis is correct, WM tasks that load on central executive functions (e.g., attention switching, response inhibition, monitoring processes) should show the strongest correlations with eye movement effects on trauma memory vividness. I predict that performance on the reading operation span, the attention switching task, the Sternberg item order task, the go/no-go and the RLG should all correlate with the size of the eye movement effect on the vividness, emotionality and completeness of memories. If it is simply VSSP capacity that underlies the eye movement effect, then all of the VSSP tasks completed by participants will provide significant correlations. This not only includes the reading operation span and the Sternberg item order task, but also the Sternberg item identity task. The Sternberg item identity task arguably provides the purest measure of the capacity of the VSSP buffer without central executive confounds.

<div align="center">Method</div>

Participants

A total of 25 participants (17 females and 8 males) participated in this experiment. The participants were 18-20 years old (M=18.49 years, SD=0.12) and attended a small liberal arts college. The participants received course credit for participating in this experiment.

Apparatus

A 17 inch computer monitor displayed the eye movement targets and the working memory tasks. All tasks were created using SuperLab 4.0 and a CEDRUS RB-830 response pad was used to record participant responses to millisecond accuracy.

Procedure

The participant met the experimenter at the laboratory and given written consent before participating.

Traumatic memory recall.

The experimenter then left the room for 5-10 minutes, while the participant wrote down details of three memories that made them feel anxious, distressed, or fearful. The instructions were taken from the study conducted by Van den Hout, Muris, Salemink and Kindt (2001).

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

Following this period of memory recollection, the participant was told to:

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

The participant then verbally rated the memory on its vividness (1=not clear at all, 10=extremely clear), emotionality (1=not at all distressing, 10=extremely distressing) and completeness (1=not at all complete, 10=extremely complete). For each memory, the participant

held their image in mind while simultaneously following the 1cm blinking circle on the computer screen for 4 periods of 24 seconds each. The circle alternated about once per second on opposing sides of the screen approximately 21.5 cm apart. There was a 10 second rest period between each 24 second period. After doing eye movements, the participant had 1 minute 30 seconds to re-rate the memory and then rate the next memory on vividness, emotionality and completeness. The difference between these scores and the initial ratings provided a measure of the effect of eye movements. This procedure was repeated for all three memories.

Working memory tasks.

The participant then completed six working memory tasks. The order of the task was the same for each participant (in the order presented below). Task order was decided based on WM and central executive taxation. More taxing tasks were earlier in the experiment, before participants became fatigued. There was a one minute rest period between each task.

Reading operation span task

The reading operation span is based on the task described in Engle et al. (1999). The participant read aloud sentences displayed on the computer monitor. At the end of each sentence, an unrelated, one-syllable, all-capitalized word was displayed. For example, 'For many years, my family and friends have been working on the farm. SPOT.' After the participant read the sentence and unrelated word aloud, they pressed a button to make the next sentence appear. Each sentence consisted of 13-16 words. The first trial consisted of two sentences. At the end of a sequence of sentences, the participant was prompted to state the capitalized words in the order that they were shown. After three trials of a set of two sentences, the participant read a set of three sentences. This task was repeated for sentence sets sizes of four, five, and six sentences. After the word recall for each set of sentences, the participant was asked a comprehension

question about one of the sentences in the set. This provided a measure of how much attention the participant was paying to reading the sentences and not just memorizing the all-capitalized words. There was one practice set before beginning this task. A participant's reading span score comprised the number of all-capitalized words recalled from perfectly recalled trials. Participants' comprehension accuracy and word recall were assessed.

Attention switching task

This task was based on the one described by Sylvester et al. (2003). A trial began by viewing a centrally located fixation point for 500 ms that was followed by a right or left pointing arrow. The participant had to keep a mental count of the number of right arrows and a mental count of the number of left arrows. After updating their mental count, the participant pressed a button to view the next fixation point and arrow. Each trial consisted of between 8 to 11 arrows. After each set of arrows, a count number was displayed on the screen for either a right arrow or a left arrow. The participant had to decide whether the count displayed matched their mental count for that arrow type. If the participant's mental count was the same as the possible count, they pressed 'Y'; if their count was different, they pressed 'N'. One second after the participant responded another trial began. There were 45 trials in all. Successive arrows in the same direction were coded as 'non-switch' sequences and successive arrows in the opposite direction were coded as 'switch'. The proportions of switch to non-switch arrow sequences and right to left arrows were about equal. In addition, the order of right and left arrows was randomized. Before beginning the test, participants had one practice trial. Response times were recorded for switch versus non-switch responses. The participant's mental count accuracy was also recorded.

Sternberg item order task

The item order test is based on Sternberg's (1966) task. The participant was presented with a memory set of four to seven capitalized letters for 1500 ms followed by a red, minuscule letter for 2000 ms. The participant then recalled the letter immediately following the red letter, as seen in the previous sequence. For example, if the sequence was [G R C H] and the red letter was "r", their response should be "c". There were 10 trials for each memory set. Response time started as soon as the red letter appeared on the screen. Participants' accuracy, as well as their response time for each set size was assessed.

Sternberg item identity task

In the item identity task (Sternberg, 1966), the participant was presented with a memory set of four to six capital letters for 1500 ms each followed by a red, minuscule letter for 2000 ms. The participant decided if the red letter appeared in the previous sequence by pressing 'Y' or 'N'. There were 10 trials for each memory set; 5 trials assessed positive probes (when the red letter appeared in the previous sequence), and 5 trials assessed negative probes (when the red letter did not appear in the previous sequence). Response time started as soon as the red letter appeared on the screen. Participants' accuracy, as well as their response time for each set size was assessed.

Go/no-go task

Participants completed a go/no-go task based on one conducted by McNab et al. (2007). The participant pressed a response button when a yellow square or triangle appeared on the screen (i.e., the 'go' trial). The participant did not press a response button when a blue square appeared on the screen (i.e., the 'no-go' trial). Each shape was displayed for 1300 ms, followed by a blank screen for 1400 ms, and a fixation point for 300 ms. The participant performed 152 trials of the go/no-go task. The 'go' trials occurred on 75% of the trials and the 'no-go' trials

occurred on 25% of the trials. The yellow square appeared on 67% of the 'go' trials and the yellow triangle ('oddball' stimulus) appeared on the remaining 34% of 'go' trials. The oddball stimulus was a control trial not requiring response inhibition, but seen just as frequently as the no-go trial. This allows one to compare oddball trials and no-go trials while controlling the differences associated with the oddball effect (described by Halgren et al. (1998) as "novel stimuli that elicit additional cerebral activity"). The participant's response times was recorded as soon as the shape appeared on the screen. The go and the oddball trial response time, as well as commission errors, were assessed.

Random letter generation task

This task is based on Baddeley's 1966 random generation tasks. Participants are instructed (Baddeley, 1998):

"What I would like you to do is attempt to generate a random sequence of letters between A and Z. Imagine, if you will, having these numbers written on pieces of paper placed in a hat. Shake the hat, draw out a piece of paper and read the letter. Then put the paper back into the hat, shake it again, and draw another number out, and continue this process."

Participants verbally generated one letter per second at the sound of the beep. The experimenter recorded participants' responses, to be later assessed as described above in the introduction.

Participants were debriefed after completing all of the experimental tasks. Participants were provided with contact details for the College's Counseling Center and encouraged to visit the center if the traumatic memories were persistent and affecting their daily lives adversely.

Results

Eye Movement Effect

A one-tailed t-test examined whether the difference between pre-test and post-test ratings of vividness, emotionality and completeness of traumatic memories was significantly less than zero. The average vividness ratings (M= -0.55; SD= 1.45) decreased significantly from pre-test to post-test t (24) = -1.88, p = .036. However, eye movements did not significantly decrease emotionality (M = 0.33; SD = 1.43) nor completeness ratings (M = 0.19; SD = 1.28), p > .05. Even though eye movements did not significantly decrease pre-test to post-test ratings for all memory measures, these variables were highly correlated: r (24) = .698, p < .001 for memorial vividness and emotionality, r (24) = .802, p < .001 for memorial vividness and completeness, and r (24) = .785, p < .001 for memorial emotionality and completeness.

Working Memory Tasks

For the reading span score, participants correctly remembered from 4 to 37 words at the end of each sentence (M = 18.33; SD = 9.06). In the attention switching task, participants' inaccuracy in matching their mental count to the number count on the screen (M = 2.33; SD = 2.48) ranged from 0 to 10 times. For the Sternberg item order task, participants' incorrectly recalled a letter (M = 7.46; SD = 8.86) from 0 to 37 times. In the Sternberg item identity task, participants incorrectly identified from 0 to 5 letters (M = 1.38; SD = 1.31). For the go/no-go task, participants' had from 1 to 11 commission and omission errors (M = 4.13; SD = 2.59). Lastly, in the RLG task, participants used from 20 to 25 letters of the alphabet (M = 23.33; SD = 1.61).

A factor-analysis was performed on the working memory tasks using an oblique rotation (employing a promax rotational method with Kaiser normalization) to determine if multiple tests shared common cognitive mechanisms or factors. A three factor solution illustrated: one factor consisting of high factor loadings for the reading operation span score and the Sternberg item

order inaccuracy score, a second factor for the go/no-go inaccuracy and the Sternberg item

identity inaccuracy, and a third factor for how many different letters were used in the RLG task

and the attention switching task inaccuracy. Refer to Table 1 for descriptive statistics of factor

loadings.

Predicting Eye Movement Effects

An examination of the relationships between the three memory measures and the three

contributing working memory factors revealed a significant correlation between Factor 1 and the

difference in pre-test to post-test ratings for vividness, r (24) = -.570, p = .004, emotionality, r

(24) = -.437, p = .033 and completeness, r (24) = -.469, p = .021. However, there were no

significant correlations for Factor 2 and Factor 3 and the three memory measures, p > .05.

Discussion

The current experiment investigated two working memory hypotheses proposed to

explain how performing rapid eye movements can affect the vividness, emotionality and

completeness of traumatic memories. One hypothesis focuses on the competition for storage in

the VSSP, while the other focuses on competition for central executive resources. The results of

the current study support the central executive hypothesis explanation more than the VSSP

storage hypothesis, however, the VSSP storage hypothesis cannot be ruled out (as discussed

below).

Our results add to the growing body of findings that performing rapid eye movements can

reduce the vividness of traumatic autobiographical memories (Van den Hout et al., 2001;

Kavanagh et al., 2001). However, previous studies have shown that a reduction in vividness

typically produces a corresponding reduction in emotionality (Van den Hout et el., 2001). Our

inability to find this result may reflect the low levels of emotionality reported by participants in

this experiment. Yet, we still obtained significant correlations between the different memory rating variables.

We found that three factors accounted for performance measures involving the six working memory tasks. Factor 1 incorporated the reading operation span task and Sternberg's item order task. The reading operation span task requires a participant to comprehend the sentences they read, in addition to storing the last word of each sentence in the VSSP. The reading span score measures how well the participant encoded, stored or recalled the words in the VSSP, while also recalling sentence comprehension (Daneman & Carpenter, 1980). Similarly, the Sternberg item order task necessitates that one holds the sequence of letters in the VSSP. After seeing a probe letter, the participant must recall the following letter in the previous sequence. The participant cannot just recognize the information; they must access the sequence to recall it. The Sternberg item order inaccuracy measures how many mistakes the participant made in encoding, storing or recalling the sequence. Both tasks involve the maintaining and accessing visual information in the VSSP. Furthermore, the central executive must control and monitor this process.

Factor 2 loaded on the go/no-go task inaccuracy and the Sternberg item identity task inaccuracy. The go/no-go requires very little information to be stored in WM. All the participant needs to remember is when to inhibit their responses. However, there is no WM storage or processing component involved. In this manner, the go/no-go acts more like a continuous performance task than a working memory task: the participant focuses their attention on the screen to determine when to correctly inhibit their response. The Sternberg item identity task is similar to the go-no go task in the fact that there is little strain on WM. It is more consistent with a verbal short-term memory (STM) measure (Unsworth & Engle, 2007), because it is

reminiscent of a digit-span task when a participant needs to keep the items in the VSSP. However, unlike a digit-span, the participant only needs to recognize an item from the previous sequence. For both tasks, the participant needs to maintain information in the VSSP but little updating is required.

Factor 3 underlies the RLG measure and the attention switching task inaccuracy. In RLG, the participant must remember which letters have been used, and inhibit the already-used letters to access unused letters. There is no visual aspect in RLG; the participant hears the tones and then says the letters, all relying on the phonological loop. The participant may access the VSSP if they want to visualize the letters, but it is impossible to keep the running sequence of letters in the VSSP, because so many letters are being used. Seitz (2002) reinforces that the RLG is phonologically based by using the task to interrupt arithmetic tasks that store numeric information in the phonological loop. Moreover, since there are 26 available letters, the participant creates possible retrieval plans, which they then re-use. Baddeley (1998) postulates that the participant most likely switches attention within their retrieval plans, since it requires less attention than generating new ways of accessing semantic memory. The arrow attention switching task requires the participant to keep a running count of directional arrows in WM, while frequently updating this information. The participant must switch their attention between the switch count and the non-switch count, requiring inhibition of one count while updating the other (Garavan, 1998; Garavan et al., 2000). Garavan (1998) argues that the attention switching task is more reliant on the phonological loop than on the VSSP. The participant visually sees the arrows; however, subvocal rehearsal of updating the mental counts occurs in the phonological loop. Hence, both tasks share response inhibition and attention switching aspects. Furthermore,

neither task solely maintains or accesses visual information in the VSSP; they use the phonological loop. The central executive controls and monitors this process.

Three factors underlie the memory tasks, but only Factor 1 directly correlates with vividness, emotionality and completeness. As discussed, Factor 1 relies heavily on maintaining and accessing visual information in the VSSP and the central executive controls and monitors this process. The memory tasks under Factor 2 minimally interact with what is stored in VSSP. Factor 3 memory tasks, on the other hand, do require maintaining and accessing information (including attention switching and response inhibition), but more in the phonological loop than in the VSSP; the central executive controls and monitors this process.

The current research cannot rule out the possibility that both WM hypotheses could play a role in the eye movement effect on traumatic memories. The reading operation span and the Sternberg item order task correlate with a decrease in vividness, emotionality and completeness. These tasks involve maintaining and accessing VSSP information, as well as central executive control. In fact, we should not leave out eye movement effects on the phonological loop buffer, because EMDR generally requires the patient to perform a third task involving changes to cognitive labels describing positive cognitions that relate to the traumatic memory (Shapiro, 2001).

Despite the usefulness of these theories, a different approach should be taken while investigating rapid eye movements and traumatic memories. It is nearly impossible for memory tasks to measure only one aspect of WM. For example, visual tasks require some usage of the VSSP, while tasks may also prompt subvocal rehearsal in the phonological loop. Furthermore, the central executive monitors, allocates information and uses broad executive attentional control during these tasks. This is in addition to whatever the task measures, be it response inhibition,

sequencing or rote working memory. In the future, more studies should examine methodologies that blend the WM hypotheses, instead of attempting to identify specific executive functions that underlie the ratings benefits.

There are important implications for the practice of EMDR that relate to the finding of the current study. First, a secondary task that produces more central executive demands in addition to taxing the VSSP should work better than eye movements in this treatment. For example, Gunter and Bodner (2008) found the strongest eye movement effect using a drawing task. Second, measures of working memory could predict the success of different therapies in treating patients. For example, a patient that has high WM and central executive functioning may benefit more from other types of therapies. On the other hand, patients who are lower in WM and central executive functioning could benefit significantly from EMDR. This is important because the dual-attention component of EMDR allows patients to revisit traumatic memories without feeling their full impact (Gunter & Bodner, 2008). Optimizing the use of therapies in treating mental illness is an important goal for treatment success and for maximizing affordable therapeutic options. It is imperative to study how EMDR works in order to achieve these objectives.

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Table 1

Pattern Matrix of Factor Loading in Working Memory Tasks

_____

	Component		
WM Tasks	1	2	3
Attention switching inaccuracy	___	___	.832
Item order inaccuracy	.835	___	___
Item identity inaccuracy	___	.890	___
Reading span score	-.872	___	___
RLG different letters used	___	___	.846
Go/no-go inaccuracy	___	.834	___

Note. Factor 1 involves maintaining and updating visual information in the VSSP; the central executive must control and monitor this process. Factor 2 involves VSSP maintenance. Factor 3 involves maintaining and updating information in the phonological loop; the central executive must control and monitor this process.