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Comparisons of eye movements and matched changing visual input

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ABSTRACT

Background and objectives: During EMDR trauma therapy, performing EM taxes WM, and simultaneously recalled memories become less vivid. It has been proposed that this WM occupation results from CVI which occurs during EM. This study sought to compare the effects of EM on memory to a task presenting identical visual stimulus to stationary eyes..
Method: In Study 1, participants recorded RT while performing two tasks: EM, and a task with visually identical images displayed on screen. In Study 2, these same tasks were performed while simultaneously recalling negative emotional memories.
Results: Study 1 found RT was slowest in the EM condition, while RT in the CVI condition was still slower than in the control condition. Study 2 found decreases in memory vividness and emotionality after EM, while after CVI there was a small decrease in negativity which was not greater than in the control..
Limitations: Neither study included EM with no visual input; conclusions cannot be made about the effect of motor movement on WM taxation or recall. As neither study was conducted with trauma patients, it is unknown if the observed effects would be comparable in the population for which EMDR is intended.
Conclusions: Performing EM taxes more WM resources and has greater impact on both memory vividness and emotionality than matched CVI. This demonstrates that the effects observed in EMDR treatment are the result of more than occupying WM systems with visual stimuli alone..
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1. Introduction

Post-traumatic stress disorder (PTSD) is a debilitating condition brought on by traumatic events. According to the US National Institute of Mental Health (NIMH), in 2009 7.7 million adults suffered from PTSD in the US alone (NIMH, 2009). From 2004 to 2009, the US spent over $2 billion on treatment for veterans with PTSD (Congress of the United States Congressional Budget Office, 2012), a group which, incidentally, only accounts for a small portion of PTSD sufferers (NIMH, 2009). In 1989, a treatment for PTSD was introduced in which patients focus attention on traumatic memories while moving their eyes side-to-side (Shapiro, 1989). This treatment, later named Eye Movement Desensitization and Reprocessing (EMDR), has seen an abundance of research confirming it as an effective treatment for PTSD (see Benish, Imel, & Wampold, 2008, Bisson et al., 2007; and Chen, Zhang, Hu, & Liang, 2015; for meta analyses). Few would deny its effectiveness, but questions linger over how eye movements (EM) are able to reduce the symptoms of PTSD. The most compelling and relevant explanations focus on a working memory (WM) model.

Autobiographical memories are subject to change. During recall, a memory becomes alterable by interference (Sara, 2000). This has been observed in criminal justice, where eyewitnesses can inadvertently have their recall altered by simple suggestion or by the wording used in witness interrogation (Loftus, 2003). To demonstrate this, a study by Jaschinski and Wentura (2002) presented participants with misleading information about a previously watched video. Participants with lower trait WM capacity, as measured by a word and mathematics task, showed a greater tendency to internalize misleading information, meaning the task altered their memories for the video after the fact. This observation, that memories can be altered by interfering with WM processes, is the basis of the working memory account (WMA) of EMDR.

The WMA posits that tasks occupying WM interfere with the ability to accurately recall memories. Working memory is a collection of limited resources which provides the short-term storage and manipulation of information needed for a variety of

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cognitive tasks, including recall (Baddeley, 1992). These resources are not infinite; individuals can only process so many things at once (Just & Carpenter, 1992). Occupying WM interferes with focus on memory recall. This is thought to cause memories to become less vivid; these "blurred" recollections become consolidated into long term memory in place of the originals. This may be the key to EMDR's success as a treatment method; the less vivid the memory is, the less able it is to evoke an emotional response.

This is not the only potential explanation of EMDR's effectiveness. In addition to the WMA, there are two other hypotheses of note. One is that EM elicits an orienting response; the other is that EM is linked to the same processes governing rapid eye movement (REM) sleep. Both of these processes are thought to effect memory (Shapiro, 2014). According to the orienting response hypothesis, rapidly moving the eyes causes shifts in attention which attenuates startle response, improves comprehension of figures, and increases communication between various brain regions associated with PTSD symptoms (Kuiken, Chudleigh, & Racher, 2010). The REM hypothesis posits that performing EM accesses memory processes which are otherwise only available during REM sleep, as REM has been shown to have an effect on the processing of autobiographical memories (Stickgold, 2008).

The problem with these alternate hypotheses is that neither one is sufficiently able to explain why tasks occupying WM, even ones not incorporating EM, can alter memories and yield similar effects to EMDR. Studies have shown that performing mathematical tasks reduces the vividness and negative emotionality of simultaneously recalled memories (Engelhard, van den Hout, & Smeets, 2011; van den Hout et al., 2010). Such mathematical tasks surely do not involve the orienting response, nor could they reasonably be thought to reproduce brain activity seen during REM sleep.

van den Hout et al. (2011) compared EM to a control condition on a reaction time (RT) task. Participants had to press a button as quickly as possible after a signal. It was found that RT slowed down while simultaneously performing EM, compared to the control group. The RT measurements of this study can be interpreted as a measure of WM taxation (Vandierendonck, De Vooght, & Van Der Goten, 1998), demonstrating that EM occupies WM resources. Considering this information, along with the previously presented studies demonstrating that WM capacity is linked to memory change susceptibility, and that the effects of EMDR can be duplicated with non-EM WM taxation tasks, the WMA explanation of EMDR seems more plausible than any alternative which has been presented to date.

While the WMA explanation of EMDR's effects is promising, WM is not a discrete entity; research has suggested that it is broken into multiple component processes (Baddeley, 1992). To date, it is uncertain exactly which of these WM components are important in EMDR. The two most relevant WM systems to the present study are the visuospatial sketchpad (VSSP) where visual imagery is held and processed, and the central executive (CE), the "master" system to which the VSSP and other WM systems are subordinate (Baddeley, 1992). After several experiments comparing EM to other tasks such as basic verbal counting, Andrade, Kavanagh, and Baddeley (1997) theorized that the benefits of EMDR are rooted in the VSSP. In elaboration of this, Lilley, Andrade, Turpin, Sabin-Farrell, and Holmes (2009) hypothesized that EM constantly brings new images into the VSSP and limit the ability to visualize traumatic events; this VSSP occupation was proposed as the basis of EMDR's effectiveness. In their study, 18 participants completed three tasks while also recalling negative memories. There was a recall only condition, a condition involving EM while simultaneously recalling a memory, and a third condition which involved counting out loud as quickly as possible while also attempting to recall a negative memory. This third task was chosen to tax the phonological loop, the WM system responsible for processing auditory information and language.

At the start of the study, participants rated their chosen memories on negativity and vividness. At the end, these same measurements were taken again, with the differences between the pretest and posttest ratings being the dependent variables. They found that EM reduced memory emotionality and vividness, but counting did not. Their conclusion was that the effects of EM on reducing memory vividness and emotionality are thereby caused by taxation of the VSSP and are totally independent of other WM systems (Lilley et al., 2009).

While their study examined an important question, it has limitations. The tasks used were never compared on overall WM taxation. EM may tax WM more than counting; a larger degree of WM taxation based in the CE may be the source of their observed results. Demonstrating that EM is more effective at reducing negativity and vividness of memories compared to a counting task does not prove that the benefits of EMDR are exclusive to VSSP taxation. Note that in discussing the effects of EMDR, either in terms of WM (Engelhard et al., 2011; Gunter & Bodner, 2008; van den Hout et al., 2010) or in other theoretical terms (Andrade et al., 1997; Oren & Solomon, 2012; Shapiro, 2012), it is tacitly assumed that it is the changing visual input produced by EM that is responsible for its effects.

Non-visual WM taxation has similar effects to EM on memory and WM (Gunter & Bodner, 2008; van den Hout et al., 2010), suggesting that the effects of EMDR are not exclusive to the VSSP; research has also shown that VSSP occupation is not necessarily as taxing to WM as EM. A series of experiments by Postle, Idzikowski, Della Sala, Logie, and Baddeley (2006) found that EM impaired performance on a WM task where participants had to follow instructions about visualizing movement on an imaginary grid. Presentation of visual input designed to mimic EM showed no impairment on the same task. This would suggest that voluntary, directed EM taxes WM more than by simply occupying the VSSP with visual input. EM does not only bring in new visual information, but also requires coordinated motor movement. In order to perform EM, a person must devote effort to maintain speed and rhythm and follow a moving point. The coordination of visual input with physical EM may tax the CE more than visual input alone (see Postle et al., 2006).

Because of this observation that the effects of EMDR have not been explained by VSSP taxation, we have two hypotheses for the present research. The first hypothesis is that EM, a combination of motor movement and changing visual input (CVI), will show greater WM taxation than CVI presented to stationary eyes. Secondly, we hypothesize that by taxing more WM resources, EM will subsequently show a greater effect in reducing the vividness and emotionality of negative memories compared to CVI presentation.

2. Experiment 1

Voluntarily EM taxes WM resources. It is unclear if this taxation is the result of constantly putting information into the VSSP, or because of the effort required to move the eyes at a specific rhythm, or some combination of the two. This experiment used a modification of the Random Interval Repetition (RIR) task (Vandierendonck et al., 1998), in which participants responded to an intermittent auditory signal as quickly as possible. This RT measurement is highly sensitive to WM taxation (Vandierendonck et al., 1998). Participants performed this RIR task in three conditions: during EM, during a CVI task designed to mimic the visual input received during EM, and a control condition in which participants fixed their gaze on a stationary point. Based on past research which found that RTs slowed down by over 100 ms while EM was being performed (van den Hout et al., 2011), we

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