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## How does EMDR work?

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### Abstract

Eye movement desensitisation and reprocessing (EMDR) is an effective treatment for alleviating trauma symptoms, and the positive effects of this treatment have been scientifically confirmed under well-controlled conditions. This has provided an opportunity to explore how EMDR works. The present paper reports on the findings of a long series of experiments that disproved the hypothesis that eye movements or other 'dual tasks' are unnecessary. These experiments also disproved the idea that 'bilateral stimulation' is needed; moving the eyes up and down produces the same effect as horizontal eye movement, and so do tasks that require no eye movement at all. However, it is important that the dual task taxes working memory. Several predictions can be derived from the working memory explanation for eye movements in EMDR. These seem to hold up extremely well in critical experimental tests, and create a solid explanation on how eye movements work. This paper discusses the implications that this theory and the empirical findings may have for the EMDR technique.

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## Invited Review

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### History and Effects of EMDR

Eye movement desensitisation and reprocessing (EMDR) is used to treat posttraumatic stress disorder (PTSD; see, e.g., Resick, Monson, & Rizvi, 2008). A crucial part of the procedure involves the patient recalling traumatic memories while simultaneously making horizontal eye movements. Increasingly, these eye movements have been replaced by other intermittent bilateral stimulation, such as alternating left and right beeps. This can appear rather strange.

The original rationale for EMDR was equally unusual. The founder of the intervention writes about catalysing a rebalancing of the nervous system, and this leading to a shifting of information that is dysfunctionally locked in the nervous system (Shapiro, 1995, p. 30). This is a puzzling text.

The scientific community responded with scepticism to the introduction of EMDR (e.g., Herbert et al., 2000; Muris & Merckelbach, 1999). This scepticism does not seem inappropriate. As Carl Sagan (2008) famously said: ‘extraordinary claims require extraordinary evidence’.

EMDR seemed to find itself at the fringe of regular treatment, and it is unusual that therapeutically marginal cases make their way to the centre of the profession. This has occurred for EMDR. The treatment has met the strict criteria for ‘evidence-based practice’ set by the National Institute for Clinical Excellence (2005) in the United Kingdom, American Psychiatric Association (2004), and Australian Centre for Posttraumatic Mental Health (2007) in Australia (Lee & Cuijpers, accepted), but it fell short of meeting the Institute of Medicine’s even stricter criteria for efficacy for treating PTSD (see McNally, 2008). EMDR’s status as a clinically valid practice does not depend on how weird the eye movements look or whether it has a transparent rationale. It is an empirical issue. Several comparative effect studies have been conducted and have been examined in critical meta-analyses. A 2005 article in the *American Journal of Psychiatry* concluded on the basis of one such meta-analysis that EMDR was among the most effective treatments (Bradley, Greene, Russ, Dutra, & Westen, 2005). This conclusion was supported by another meta-analysis described in a 2006 article in *Psychological Medicine* (Seidler & Wagner, 2006). A 2007 article in the *British Journal of Psychiatry* reconfirmed the conclusion and further stated that there

was no evidence of a difference in efficacy between EMDR and cognitive behavioural therapy (Bisson et al., 2007). Importantly, a recent meta-analysis suggests that Eye Movements are more than clinical folklore, but add to the beneficial effects of EMDR (Lee & Cuijpers, 2012)

## How to Proceed Now?

One option would be to leave it at this, accredit EMDR courses, train therapists, and start working with EMDR. EMDR works, what more would you want? One thing we would like is to understand how EMDR works. As long as that remains unclear, so does patient selection: why is EMDR applied to PTSD, and should it be used to treat all patients with PTSD? How about other Axis I disorders, and, if so, which ones? Answering that question by conducting randomised controlled trials for each individual disorder would cost a lot of money and take decades. And how is EMDR best applied? The beeps, for example, had never been studied. Is it wise to use them? EMDR therapists have patients make eye movements while recalling negative memories, but also while recalling positive thoughts. Is that clever? And are those eye movements even necessary? If so, why?

How do you get a solid explanation for how EMDR works? Given the confidence with which views supported exclusively by clinical experience are presented, there seem to be quite a few practitioners who believe that gaining clinical experience with EMDR is an 'effective enough' strategy. But people are bad at intuitive statistics and tend to show confirmation bias: information that agrees with their hypothesis is given more weight than information that disagrees. This applies unabated to clinicians. A strategy that seems more sensible is to formulate theories about EMDR and rigorously test them in controlled experiments.

EMDR can be studied using a laboratory model. Using this model, researchers have tested and discarded a few hypotheses about the effectiveness of EMDR. Further studies have provided a new and fresh theory about how eye movement works. And potential clinical implications are clear.

## A Model of EMDR

Procedurally, the model is basically rather simple. First, healthy volunteers recall unpleasant memories for a few seconds. They rate those memories in terms of vividness and emotionality (i.e., unpleasantness). They then recall those memories for a second, longer time (e.g., several periods of about 24 s). During this second recall, there is either no dual task ('recall only') or the participant makes eye movements while recalling the memories ('recall + eye movements'), by visually tracking a white circle that moves from side to side on a computer screen. After a break, lasting from between a few minutes to a few days, the memory is recalled under the same conditions as the first time and is rated again in terms of vividness and emotionality. This model can be used to test hypotheses about EMDR, such as the following.

### Hypothesis 1: EMDR Works by Recalling Aversive Memories and Eye Movements Do Not Contribute Anything

PTSD is an anxiety disorder, and patients are often afraid of recalling memories of the traumatic event. Prolonged exposure to traumatic memories has positive effects and so EMDR may be nothing more than an 'imaginal exposure' therapy. Eye movements may be unnecessary (Davidson & Parker, 2001; MacCulloch, 2006).

If this is correct, then ‘recall only’ should have the same effect as ‘recall + eye movements’. If eye movements do matter, then vividness and/or emotionality should decrease more after ‘recall + eye movements’.

We are aware of at least 16 relevant experiments that measured vividness and emotionality. In all of these experiments, vividness and emotional responses decreased with the addition of eye movements to recall, usually for both measures and sometimes just for one (Andrade, Kavanagh, & Baddeley, 1997; Barrowcliff et al., 2004; Kavanagh, Freese, Andrade, & May, 2001; Kemps & Tiggemann, 2007; Maxfield, Melnyk, & Hayman, 2008; Van den Hout et al., 2001; Van den Hout, Bartelski, & Engelhard, 2012; Van den Hout, Rijkeboer, Engelhard et al., 2012; , experiments 1 and 2; Gunter & Bodner, 2008, experiments 1, 2 and 3; Van den Hout et al., 2010, experiment 4; Van den Hout et al., 2010, experiments 1 and 2, Engelhard, Van den Hout, Janssen & Van der Beek, 2010; Hornsveld et al., 2010).

The pattern of results is unusually robust for this field of study. In a meta-analysis from clinical studies (outside the lab), Davidson and Parker (2001) reported that there was no convincing evidence for the efficacy of eye movements. Lee and Cuijpers (2012) noted that Davidson and Parker treated all studies as if they were of equal weight, but that the usual practice in meta-analysis is to weigh each study in relation to the number of participants and to calculate the degrees of freedom using the total number of participants, which yields a more appropriate test of significance and provides more power to investigate small magnitude effect sizes. An improved meta-analysis by Lee and Cuijpers (2012) involved 14 studies (15 comparisons) that compared eye movements versus no eye movement in full EMDR treatments, including 452 respondents (239 in EMDR conditions, and 213 in EMDR without eye movements conditions). In seven of the studies, all or most participants met criteria for a clinical diagnosis. In seven studies (eight trials), participants were students who reported various levels of distress. In one study, participants were students screened for clinical levels of symptoms. Thirteen studies used self-reports of distress (Subjective Units of Discomfort Scale, SUDS) as outcome measure and five studies used additional measures relevant to the population group they were treating. This meta-analysis suggests that eye movements have an additive effect (Lee & Cuijpers, 2012). The conclusions are clear: eye movements matter, the effects cannot be explained by exposure alone, and this hypothesis can be dismissed.

## **Hypothesis 2: EMDR Works by Stimulating “Interhemispheric Communication”**

This view is widely accepted in EMDR circles; many people have come to believe that eye movements increase communication between the left and right brain hemispheres, thereby enhancing the ability to remember an aversive event while not being negatively aroused (see Gunter & Bodner, 2008), and that it does not matter which sensory channels are used to stimulate “interhemispheric communication” as long as the stimulus is alternating and rhythmically left-right: beeps that are presented left and then right, left and right tactile stimulation, left and right taps on the table, etc. The beeps are especially popular, and we will discuss them in a later section.

Gunter and Bodner (2008) used an effective idea to test this hypothesis. They posited that if eye movements need to be horizontal to decrease the vividness of memories, then vertical eye movements would have no or less effect. Participants were asked to recall unpleasant memories under three conditions: eyes fixated, horizontal movements, or vertical movements. ‘Recall only’ had no effect. When the white circle moved back and forth horizontally (one movement per s) and was visually tracked, the familiar pattern occurred: vividness and emotionality decreased. However, when the circle moved up and

down, vividness and emotionality decreased just as much. This is at odds with the ‘interhemispheric communication’ theory.

A counterargument may be that -- because an eye projects ipsi-laterally and contra-laterally on the visual cortex-- vertical eye movements may also strengthen the interhemispheric communication. There is some logic to this, but not much: interhemispheric communication is stimulated more by horizontal eye movement than by vertical eye movement. We will not go into this any further, because the counterargument (i.e., bilateral communication with vertical movements) loses its cogency in the research discussed below, where no eye movements were used at all, but other ‘dual tasks’ were performed.

### **Hypothesis 3: EMDR Works by Taxing Working Memory During Recall**

Stored information that is currently active and is used to perform cognitive operations is located in working memory (WM). Long-term memory, on the other hand, contains memories and knowledge that is not currently active. The capacity of this long-term memory is extremely large, but the capacity of WM is limited (Baddeley, 1998).

When we simultaneously do two tasks that each tax WM, the tasks compete for this limited capacity. Recalling an emotional memory and making eye movements both require WM capacity, so moving your eyes from side to side while recalling a memory leaves less capacity for the memory. As a consequence, Andrade et al. (1997) explain, the memory should become less vivid and less emotional. This is not unique to traumatic memories; it should also apply for mildly negative memories.

The next step is important. During recall, a memory becomes ‘labile’, meaning that events during recall influence how the memory is restored (or “reconsolidated” as in current parlance) and may be recalled in the future. When a person tries to form a vivid and detailed image during recall, this influences the original memory, which becomes more vivid and realistic. This ‘imagination inflation’ effect (e.g., Goff & Roedinger, 1998) is a notorious phenomenon in police interrogation. When a suspect or witness has visualised a scenario several times, the level of vividness and credibility of the original memory change, meaning that imagination inflation affects the next recall. From a WM standpoint, the ‘recall + eye movements’ combination will lead to ‘imagination deflation’. And this should also be evident when the memory is recalled after the dual-task session.

So the WM theory explains the findings described above: eye movements tax WM and, for this reason, the memory is reconsolidated less vividly. According to this theory, it makes no difference whether eye movements are horizontal or vertical. The effects of vertical eye movements do not agree with an ‘interhemispheric communication theory’, but they do agree with a WM theory.

### **Other Tasks**

A fresh next implication of the WM theory is that not only eye movements, but any taxing task should attenuate the vividness and hence the emotional tone of the memory. This has been found. While recalling negative memories, participants were asked to perform another task or, as a control condition, performed no dual task. These tasks require attention and seem, by definition, to tax working memory (see the section below ‘How do we know if and how much WM is taxed?’). These tasks included 1) auditory shadowing (Gunter & Bodner, 2008); 2) copying a complex figure (Gunter & Bodner, 2008); 3) playing the computer game Tetris (Engelhard et al., 2010); 4) mental arithmetic (Van den Hout et al., 2010; Engelhard, Van den Hout & Smeets, 2011); 5) calculating out loud (Kemps & Tiggemann, 2007); and 6) mindful breathing (Van den Hout, M, Engelhard, Beetsma, D. Slofstra, Hornsveld, Houtveen &

Leer 2011). Compared to the 'recall only', memories became less vivid and/or less emotional during all these tasks. The mindful breathing task reminds one of mindfulness-based cognitive therapy, which we will return to at the end of this paper.

## Positive Memories

For obvious reasons, EMDR practitioners are more interested in decreasing unpleasantness of negative autobiographical details than in weakening joyful memories. But according to the WM theory, all emotional memories should lose their vividness when WM is taxed during recall. This implies that just as negative memories become less unpleasant after using 'recall + eye movements', pleasant memories should also become less pleasant. This has been found (Van den Hout, Muris, Salemink, & Kindt, 2001; Engelhard, Uijen, & Van den Hout, 2010).

In passing, a clinical implication is worth mentioning. A standard part of the EMDR protocol is installing 'positive cognitions' by asking the patient to activate a positive cognition, seemingly in an attempt to strengthen this memory trace. Curiously, patients are also asked to move the eyes from side to side during the 'installation of positive cognitions'. This seems impractical, because the theory suggests that eye movements do not sharpen, but rather weaken the image. Using the very EMDR technique, Hornsveld et al. (2011) tested the effects of (1) recall only, (2) recall + horizontal eye movements and (3) recall+ vertical eye movements on positive memories. Consistent with WM theory, findings showed that making eye movements during activation of positive thoughts rendered these thoughts less vivid and less positive, irrespective whether the movements were horizontal or vertical. This part of the EMDR protocol is not only ineffective: it is counter-effective, and results in effects that are opposite to the desired ones.

## Prospective Memory and Flash-Forwards

EMDR started out as a trauma therapy, but therapists have begun using it to treat a wide range of disorders (see van den Hout et al., 2001). They assume that for many patients psychological complaints have been caused or intensified by an unpleasant event, and this event then becomes the focus of EMDR sessions. Many patients with, for instance, anxiety disorders, eating disorders, hypochondriasis, or depression are not (only) tormented by images and thoughts of past aversive events (stored in 'retrospective' memory), but also by disturbing images and thoughts about possible future events. Such future-oriented images and thoughts are located in 'prospective' memory. Like retrospective memories, they can take on the characteristics of flashbacks or, in this case, 'flash-forwards' (e.g., images about future social, financial, medical, or family catastrophes). The WM theory says that flash-forwards can be stripped of their impact in the same way as flashbacks.

A recent study by Engelhard, Van den Hout, Janssen & Beek (2010) provides support for this. Compared to the effects of 'recall only', 'recall + eye movements' led to flash-forwards becoming less vivid and emotional. Similar effects were found in an analogue study of students suffering from performance anxiety (Engelhard et al., 2012), but the effects were weaker in a study of students suffering from intrusive images related to all kinds of idiosyncratic events (Engelhard, Van den Hout, Dek, Giele et al., 2011).

The application of EMDR to other disorders than PTSD is mainly anecdotal. The WM theory and flash-forwards research seem to provide a rational basis for applying the intervention. Given the importance of problems related to future-oriented mental images (e.g., Brewin, Gregory, Lipton, & Burgess, 2010), there is a need for research of long-term effects and clinical effects.

## How Do We Know If And How Much WM Is Taxed?

A traditional method for determining whether and how much cognitive capacity a mental task requires was developed by F.C. Donders: the reaction time (RT) task. The reasoning is simple and effective: task A is administered, where the participant responds as quickly as possible to a probe, and the RT is measured. Next, task B is added to A. The degree to which the RT to task A slows down produces a quantitative index of the amount of cognitive capacity required by B: the more slowing down, the more capacity B requires.

Eye movements are especially interesting in this context. When participants were asked to respond to high versus low tones by saying 'high' or 'low', the RT of the discrimination task was about 600 ms. But when people simultaneously made EMDR-like eye movements, the RT increased to about 700 ms, which is a significant difference (Van den Hout et al., 2010).

## Low Working Memory Capacity? Benefit From EMDR

There are individual differences in working memory capacity in general. For individuals who have a stronger delay during an RT task when they make eye movements, eye movements evidently have a large impact. The WM theory suggests that, precisely because of this big impact, people with low working memory capacity should benefit a lot from making eye movements. Five studies were conducted to examine whether working memory capacity predicts how much memory vividness and emotionality decreases as a result of eye movements and other dual tasks during recall. Gunter and Bodner (2008) found a significant correlation between working memory capacity and the reduction in vividness and emotionality of memories as a result of 'recall + eye movements' ( $r = -.44$ ;  $r = -.43$ ), 'recall + auditory shadowing' ( $r = -.69$ ;  $r = -.59$ ), and 'recall + drawing' ( $r = -.58$ ;  $r = -.49$ ). We replicated the effects of 'recall + eye movements' ( $r = -.30$ ;  $r = -.29$ ) (Van den Hout, Engelhard, Beetsma et al., 2011) and also found significant effects for 'recall + mental arithmetic' ( $r = -.30$ ;  $r = -.18$ ) (Van den Hout et al., 2010).

The correlations are negative: individuals who are more distracted by eye movements or other dual tasks (as evidenced from a large delay during a RT task) benefit more greatly from EMDR-type procedures.

## Inverted U

If taxing WM during recall leads to changes in the memory, one might think that increasing the taxing load would increase the memory effects. Gunter and Bodner (2008) argued that this would be a misconception. The WM theory states that the competition between recall and the distracting task leads to a decrease in vividness and emotionality. For this to happen, there needs to be a minimum degree of taxing, but if this taxing exceeds a certain level there will be too little room for recall: if you say the multiplication table of 37 as quickly and accurately as possible, you will not be able to (simultaneously) recall a memory. This would, in turn, mean that the link between taxing WM and the memory-effect has the form of an inverted U: too little and too much taxing both have little or no effect. According to the theory, the biggest effect should occur when WM is taxed at a level somewhere in between 'too little' and 'too much'. There is no way of knowing in advance what the optimal taxing level is; it must be measured.

Engelhard, Van den Hout & Smeets (2011) found that participants in their study needed an average of 410 ms to respond to a RT task without using a dual task. When they were asked to simultaneously subtract by 1 from 1000, the RT increased to 520 ms; when they subtracted in steps of 2, the RT became 560 ms; and when they subtracted in steps of 7, the RT rose to about 700 ms. Thus, the taxing of WM increased as the dual task became more complex. When these same arithmetic tasks were added while recalling an upsetting memory, an interesting pattern emerged: a general arithmetic effect

on the vividness and emotionality of the memory was found. Emotionality did not decrease after 'recall without a dual task' or 'recall + complex arithmetic', but it did after 'recall + slightly complex arithmetic' (subtracting 1 or 2). This seems to imply the existence of an inverted U: not taxing WM or heavily taxing it during the recall does not change the memory, but taxing at a level somewhere in between does produce effects (Engelhard, Van den Hout & Smeets, 2011).

## The Effect of Beeps

Theories about how a procedure such as EMDR works influence how the procedure is applied. The theories of 'bilateral stimulation' and 'increase of interhemispheric communication' inspired practitioners to replace eye movements with other forms of bilateral stimulation. A popular method is to have patients listen to alternating left and right beeps through headphones during the recall. During the 10th EMDR European conference in Amsterdam in 2009, participants were asked if they used binaural stimulation during their EMDR sessions and, if so, how often. Out of 414 respondents, 299 (72%) said they used binaural stimulation in, on average, 69% of the sessions. A first rough estimate is therefore that about half ( $72\% \times 69\%$ ) of the EMDR treatments consist of binaural stimulation sessions (Van den Hout, Rijkeboer, et al., 2012). This change in technique was not based on research: not a single effect study had been conducted on the effects of beeps (Maxfield, 2008). In line with the interhemispheric communication theory, it is plausible that there is little difference between beeps and eye movements. According to the WM theory, however, very little can be expected from 'beeps'. Interventions such as eye movements, Tetris, and mental arithmetic require that the participant actively performs a task of some sort. However, registering beeps is a passive task that may not even tax WM.

We first investigated this by using a stimulus discrimination RT task: high versus low tones. These were presented under three conditions: 'RT without a dual task', 'RT + mental arithmetic' (subtracting from 3,000 in steps of 10) and 'RT + beeps'. Participants using 'RT + mental arithmetic' were substantially slower than participants using 'RT without a dual task', but the beeps did not affect the speed. This suggests that the beeps do not tax WM capacity, which would not be good.

The random interval task is another simple test used to measure RT. During this test, a probe is presented at alternating intervals and participants only need to indicate whether they registered the stimulus. Because it is simple, it is also fast. And because it is fast, there is a lot of room to slow down, which is exactly why this test might be sensitive enough and therefore suitable for registering miniscule levels of WM taxation. Perhaps beeps lead to a slowing down if such a hypersensitive task is applied. Our aim was to directly compare the size of WM taxation by eye movements with the possible effects of beeps. This cannot be done with visual stimuli (people would lose track during the eye movement condition) or auditory stimuli (similar problem). For these reasons, tactile (i.e., electrical) stimuli were presented to the non-dominant hand at alternating intervals. The probes were clearly noticeable but not uncomfortable and certainly not painful.

Participants were extremely fast in the 'RT without dual task' test (290 ms), and they were substantially slower in the 'RT + eye movements' test (415 ms). The score for the 'RT + beeps' test was in between (325 ms): significantly slower than 'RT without dual task', but also significantly faster than 'RT + eye movements'. Eye movements affected RT about three times as much as beeps did. When we tested the effects of beeps and eye movements on the emotionality and vividness of memories, we found no effect for emotionality in any of the three conditions; for vividness, the RT pattern was reflected. Vividness was not affected by 'recall only', but dropped substantially as a result of eye movements and a small but significant amount as a result of beeps. The effects of eye movements were about three times that of the beeps (Van den Hout, Engelhard, Rijkeboer, Koekebakker et al., 2011).



No studies have been conducted on the clinical effects of beeps, but earlier experimental data suggest that effective interventions need to tax the WM and the present experiments show that the beeps contribute little. They reduce the vividness of a memory but one needs to look very closely to see the effects, and the effect was only about one-third of the effect observed with the eye movements.

Recently, we tested whether beeps might be as effective as eye movements in a clinical context (van den Hout, Rijkeboer, Engelhard et al., 2012). Twelve patients with severe PTSD, mainly after sexual violence (incest, rape), recalled the most distressing image during the first EMDR session six times: twice without a dual task (recall only), twice while making eye movements (recall + eye movements) and twice while hearing beeps (recall+ beeps). The order of the interventions was balanced. Before and after each intervention the patient shortly recalled the image and rated its vividness and aversiveness. The largest decreases were found for recall + eye movements, and there was no effect at all for recall + beeps. Curiously, patients expressed a preference for beeps relative to eye movements and in written clarifications of their preferences; they mentioned that eye movements were “distracting” and “tiring”, and, ironically, this may signal the efficacy of the eye movements. Patients may communicate their satisfaction with beeps to therapists, who may mistake satisfaction for effectiveness.

## Mindfulness and Mindful Breathing

Mindfulness-based cognitive therapy (MBCT) is effective in preventing relapse after treatment for depression (for review, see Coelho, Canter & Ernst 2007), and treating patients with depression (e.g., Barnhofer et al., 2009; Kingston, Dooley, Bates, Lawlor & Malone 2007).

Like EMDR, MBCT is a package of interventions, but eye movements are a crucial element of EMDR, just like ‘mindful breathing’ (MB) is the core part of MBCT. In weekly group or individual sessions, patients are taught to focus their attention on breathing. Thoughts or images that appear are not analysed; instead, the person is advised to accept thoughts or images as they present themselves and to slowly draw their attention back to breathing. Starting in the fourth session, patients are advised to turn to MB when depression-related thoughts or images (e.g., self-depreciation, suicidal thoughts, despair) enter the mind outside the sessions.

Although EMDR and MBCT differ in many respects, they show a striking procedural parallel: both start with patients reporting disturbing thoughts or images; patients are instructed not to suppress the images, but to accept them; and patients are advised to perform another task while having those thoughts (eye movements for EMDR and MB for MBCT). This made us curious about whether the WM theory could be used to explain how MB may work in MBCT.

A first, cautious step was to find out whether MB taxes WM, and, if so, how this taxing compares to eye movements. This was done using two different RT tasks: a stimulus discrimination task and a random interval task (see above). Findings were identical: for both tasks, participants’ RTs increased when making eye movements and when practicing MB. The degree to which they increased was significant for both eye movements and MB, and for both RT tasks this increase did not differ between eye movements and MB. What about the effects of MB on unpleasant memories?

To make a long story short, we conducted two independent experiments to try to quantify the effects of MB on unpleasant memories. The first found that eye movements and MB both significantly reduce memory emotionality (with no difference between the two). Both interventions reduced emotionality of memories in study 1, and eye movements also reduced vividness, but MB did not (but with a non-significant difference between the two). In the second experiment, neither of the interventions had an effect on emotionality, but both interventions had an equal effect on vividness (Van den Hout, Engelhard,

Beetsma, Slofstra et al., 2011). It therefore appears that eye movements and MB tax WM to the same degree and grosso modo both techniques affect vividness and emotionality of unpleasant memories.

## Discussion

EMDR has been validated as an effective treatment for PTSD based on controlled clinical research. The clinical findings have been confirmed in the lab, where memories change as a result of eye movements and other dual tasks. Like other lab models, the present one is, by its very nature, a simplification of the phenomenon that is modelled. First, in laboratory studies on eye movements, individuals recall memories for a series of, for instance, 4 episodes of 24 s, while in clinical EMDR, the 'dosage' of recall + eye movements is much higher, and sessions take 60 to 90 min. Furthermore, the same traumatic image may be recalled again during subsequent sessions. The fact, however, that even such small dosages of recall + eye movements have reliable effects, attests to the robustness of the phenomenon. Second, in the clinical EMDR procedure, recalling an aversive memory serves as the starting point of the session. Individuals are then instructed to follow their stream of thoughts/associations while making eye movements. Whether or not this association part adds to EMDR effects has (as far as we know) not been studied, and awaits testing. Many of the associations will have a negative valence, and combining these recollections with eye movements may reduce this negativity. However, if associations relate to positive material, the data presented here (see "*positive memories*") strongly suggest that simultaneous eye movements are counterproductive. Therapists may want to monitor the nature and valence of the associations, and discontinue dual tasking when associations are hedonically positive. Third, in the lab studies, researchers typically concentrate on short term effects of eye movements and other dual tasks on memory recall, which is the laboratory equivalent of 'within session' improvement. The fact that such short term effects are observed in the lab and during EMDR sessions is itself no guarantee that clinical EMDR reduces PTSD symptoms. This is an empirical issue and outcome studies show that such clinical improvement occurs.

The lab research has the added benefit of providing the opportunity to find out why EMDR works. 'Just exposure' can be ruled out as a cause for the effectiveness of eye movements, both on the grounds of clinical research (Lee & Cuijpers, 2012) and the laboratory studies: briefly recalling a memory without a dual task does not change the memory. Also, although the belief that bilateral stimulation plays a crucial role is popular among EMDR practitioners, it is not consistent with the data.

The WM theory is stronger. As with the exposure theory and interhemispheric communication theory, predictions can be based on the WM theory. A range of predictions have been tested: the effects of interventions other than eye movement; effects on positive emotions; the reduction of RTs; effects by working memory capacity; the inverted U-shape relation between WM taxation and memory effect; the effect of beeps; and finally the curious parallel between EMDR and MBCT procedures. Of course, the EMDR protocol has various components, but it is unknown if and to what degree these extra components add to the effects of EMDR.

Not every clinical procedure can be tested for effectiveness in large scale RCTs, if only for practical reasons and the fact that practitioners have to improvise. Similar to music, a theme is needed on which to improvise. For treatment, this is a theoretical heuristic that suggests why some procedures are sensible and others are not. The explanation that EMDR helps to process traumatic memories because EMDR stimulates 'interhemispheric communication' provides such a heuristic, but the research summarised here suggests that the WM explanation is better. This explanation has potential clinical implications. We will discuss a few of them here.

EMDR has proved most useful in treating PTSD i.c. processing traumatic memories. According to WM theory and supported by experimental data, flash-forwards and flashbacks are similarly affected by eye movements. This has potential implications for use with patients, but there are also technical implications. We emphasise this again: the clinical effects of beeps had never been studied until very recently. The WM heuristics suggests that beeps have no or hardly any effects and that eye movement works much better. Experimental research supports this and replacing eye movement with beeps seems an awkward manoeuvre. In addition, the EMDR procedure involves the 'installation' of positive cognitions: while patients try to concentrate on a positive thought, the practitioner distracts them by asking them to make eye movements or listen to beeps. The latter is mainly problematic because it is ineffective. Far more serious are the effects of eye movements on positive recollections. It makes them less positive, which is exactly the opposite of the intended effect. Making eye movements during pleasant thoughts should be discouraged.

The WM theory also allows researchers to predict which individuals will benefit a lot or very little from EMDR. People with low working memory capacity should benefit from the dual task approach, and this seems to be correct. It seems important to adapt the degree of WM taxation to the individual patient as much as possible. There is no theoretical or empirical reason to maintain the speed of one left-right-left cycle for eye movements or other stimulation. Depending on the patient, this can be done quicker or slower. Vivid memories require dual tasks with moderate levels of cognitive load, but if a traumatic memory is relatively vague, less taxing tasks should yield better effects. It is possible that in rare cases where traumatic memories are relatively vague, tones may outperform eye movements. Furthermore, the WM theory and a number of experimental findings suggest that, rather than eye movements and beeps, other tasks can be used that require working memory capacity: counting out loud for instance. It is not difficult to take individual differences in distractibility into account. If the memory image remains too vivid, the taxing of WM can be increased (e.g. more difficult sums). If a memory is difficult to recall (e.g., for people with low working memory capacity), the speed of the eye movements can be reduced or a less taxing task can be presented.

Admittedly, these suggestions have not been tested. But they are derived from an explanation that flows from a strong theory that is supported by experimental data. Improvising on the basis of empirically validated heuristics is preferable to improvising on the basis of untested presumptions.

The history of EMDR is ironic. It was first thought to be a silly intervention based on a silly theory, which led to scorn and ridicule. But then the effects of EMDR were studied. EMDR was effective, and is now one of the preferred treatments for PTSD. The technique seems silly, but it is not. Currently, about half of EMDR sessions are conducted with beeps that have no proven effect and an implausible theoretical and (pre-)clinical/experimental basis. By replacing eye movements with beeps, EMDR is back where it started: a non-evidence-based intervention that contradicts experimental data and strong scientific theory.

EMDR used to be surrounded by a cloud of mystery that was encouraged by its crypto-neurological terminology, peculiar theories and techniques, unusual training courses, internal certifications, etc. (e.g., McNally, 1999; Muris & Merckelbach, 1999; Herbert et al., 2000). But scientific research, and especially its outcomes, have normalised the technique. Imagery is a powerful intervention: it can lead to a great deal of misery, for example, in the case of sexual abuse being made credible by imagining. But from a therapeutic perspective, imagery can also be used sensibly and effectively (Arntz, 2011; Hackmann, 2011; Holmes & Mathews, 2010; Huijbregts & Daansen, 2009; Korrelboom, de Jong, Huijbrechts, & Daansen, 2009; Wild, Hackmann, & Clark, 2007). It no longer evokes surprise that imagination can strengthen the vividness, emotionality, and even the credibility of a mental image through imagination

inflation. The WM study suggests that EMDR practitioners have bumped into a technique that brings about the reverse: imagination deflation. In the end, perhaps it is not so surprising that it may work this way, and it is nice that we are finally starting to understand those eye movements. It can now become a standard cognitive behavioural therapy technique, just like exposure and relaxation exercises.

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