**Desensitisation and facilitation of memory after eye movements:**

**An effort to solve an apparent contradiction.**

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**Abstract**

Post-traumatic stress syndrome (PTSD) is a disorder characterized by frequent vivid memories of a traumatic event. A current effective treatment for PTSD is Eye Movement Desensitisation Reprocessing treatment (EMDR). A model to explain the desensitizing effects by eye movements is the dual task hypothesis of working memory (WM). This posits that eye movements as second task exceed WM capacity, thus blurring subsequent reconsolidation of the (traumatic) memory. Eye movements prior to recall however have also been observed to *facilitate* memory. This thesis reviews several models to analyse whether the conflicting findings could result from one underlying process, or whether procedural differences in study design are likely to generate the opposing effects.

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**List of abbreviations in order of appearance**

Post-traumatic stress disorder: PTSD

Eye Movement Desensitisation and Reprocessing treatment: EMDR

Validity of Cognition: VoC

Subjective Units of Discomfort scale: SUDs

Working Memory: WM

Deese-Roediger-McDermott: DRM

Electro-encephalography: EEG

Prefrontal Cortex: PFC

Interhemispheric Communication: IHC

Corpus Callosum: CC

Cognitive/Affective Ratio theory: C/A-R

**1. Post-traumatic stress disorder**

**1.1. Definition and symptoms**

According to the DSM-IV guidelines (American Psychiatric Association, 2000), Post-traumatic stress disorder (PTSD) is a severe anxiety disorder that develops after physical or psychological trauma, either experienced or witnessed, with the symptoms remaining well after the interval of one month after the event. The disorder is characterized by frequent vivid memories of the traumatic event, often in combination with impaired memory for some aspects of the event. Ehlers, Halligan and Clark (2005) find that rather than thoughts about the event, many patients report sensory intrusions. These intrusions are often brief fragments, or flash-backs of visual images, although intrusions of other modalities, such as memories of pain, sounds and odours are commonly reported as well. This seems to imply that enhanced memory for the traumatic event relates more to the sensory, or emotional component, rather than for the conceptual (cognitive) aspects.

**2. Eye Movement Desensitisation Reprocessing**

Eye Movement Desensitisation and Reprocessing treatment, or EMDR, has been observed to effectively treat PTSD (meta-analyses: Bison et al., 2007; Bradley et al., 2005). This procedure has been invented by Shapiro in 1989. She postulated that (excessive) rumination could be seen as information that is ‘locked’ in the nervous system, and treatment should focus on rebalancing this system.

**2.1. Procedure EMDR**

The EMDR procedure involves several steps. First the patient is required to recall a traumatic event and imagine the most distressing scene of this memory. Then a negative and positive thought are formulated, e.g. ‘It is my own fault’ and ‘I did what I could’. These cognitions are scored using the 7-point Validity of Cognition (VoC) scale. The distressing memory is scored on the 10-point subjective units of discomfort scale (SUDs). The next step is to re-experience the scene and while doing so, the patient is required to follow the index finger of the therapist that usually moves horizontally, at a speed of approximately twice per second. After a minimum of 20 repetitions, the patient is requested to report thoughts, images of feelings that arise. These ‘recall plus eye movements’ blocks are repeated up to the point when these associations are no longer of negative valence. At this point the traumatic memory is scored again using the SUDs. If necessary, these steps are repeated until the SUDs score drops to 0 or 1 (i.e., no tension). The final component of EMDR involves instating the positive cognition. The original memory is now imagined together with the positive thought while making the eye movements. This is repeated until the positive thought has a high score on the VoC (i.e., very credible). Each session usually processes one specific memory.

**2.2. Effects EMDR**

**2.2.1. Clinical studies**

The effects of EMDR therapy have been extensively investigated in clinical studies. Bison et al. (2007) and Bradley et al. (2005) performed meta-analyses of 38 and 26 studies, respectively. They reported that EMDR is equally effective compared to Trauma-Focused Cognitive Behavioral Therapy, and superior compared to waiting list or other forms care such as relaxation/biofeedback. The number of sessions that are required varies, although on average, five sessions seem sufficient to reject the PTSD classification (Narimani, Sadeghieh Ahari and Rajabi, 2008).

**2.2.2. Laboratory studies**

To understand this evidence-based technique, many experimental studies have tried to replicate the findings in the lab (for an overview: see van den Hout & Engelhart, in press). These studies have systematically investigated eye movements on emotional memories by comparing the effects of ‘recall only’ (exposure) versus ‘recall + eye movements’. The procedure is comparable to that followed in clinical setting, with a few notable exceptions. After retrieving an emotional memory, the participants rate them on a 10-point scale of vividness and on a 10-point scale of emotionality (10 = extremely vivid or extremely emotional, resp.), to function as a baseline. To ensure identical speed of eye movement throughout and between sessions, instead of a human finger the participants watch a stimulus on a computer screen. This is usually a dot that moves from side to side on the screen with a speed of once or twice per second, resulting in smooth pursuit, or a dot that alternates position between the left and right visual field, inducing saccadic eye movements. The participants in the ‘recall only’ condition are usually instructed to keep their gaze fixated on a stationary dot. Often this dot alternates in colour to reduce habituation, to ensure no eye movements. To investigate the effects of eye movements, usually four blocks of eye movement + condition are administered, after which the degree of vividness and emotionality is reported and compared against baseline. Similar to the results found in clinical setting, making eye movements during recall has been observed to decrease the amount of vividness and emotionality significantly more compared to keeping the eyes stationary. The memories furthermore remain less vivid and emotional after intervals ranging between a minute to 6 days (Van den Hout & Engelhart, in press)

**2.3. The dual task hypothesis of working memory**

The effects of EMDR that have been observed are quite robust, both in experimental and clinical setting (Van den Hout & Engelhart, in press). To explain the desensitizing property of eye movements, several models have been proposed. A popular theory is the dual task hypothesis of working memory (WM). To recall information from long term memory, the memory is ‘loaded’ into the capacity-limited WM. Subsequent storage occurs via a reconsolidation process. This reconsolidation process renders the memory most vulnerable (Schacter, Guerin & St. Jacques, 2011). Following from these WM characteristics, the dual task hypothesis is based on the premise that eye movements also use WM capacity. This implies that as (emotional) retrieval/recalling uses WM capacity, adding another task will exceed its capacity, leading to impaired subsequent reconsolidation of the memory. If this theory is correct, the type of secondary task is arbitrary, albeit it requiring WM. To test the hypothesis, a variety of studies have substituted eye movements with other tasks, using the standard EMDR protocol.

**2.3.1. Procedure WM studies**

One of the tasks that have been investigated is complicated finger tapping (Andrade, Kavanagh and Baddeley, 1997). A study by Van den Hout, Muris, Salemink and Kindt (2001) used a similar procedure, although noteworthy difference being that the finger tapping was less complex. Gunter and Bodner (2008) investigated an auditory shadowing task and a complex drawing task to investigate the WM dual task hypothesis. The auditory shadowing task consisted of a voice recording of a male saying ‘ta’ at the rate of one word per second. The participants in the drawing condition copied the Rey complex figure. Another study by Van den Hout et al. (2011) investigated the effect of binaural beeps. Apart from the study by Andrade and colleagues, all studies followed standard protocol, i.e., initial recall of emotional memory, after which 4 blocks commenced of; recall + task for 24 seconds, and a 10-second break to indicate emotionality and vividness. Andrade and colleagues only had one 8-second period of recall + task. All studies compared the effects of the secondary task/tasks against those of the ‘no eye movement’ and ‘eye movement’ conditions.

**2.3.2. Effects WM studies**

All aforementioned studies found that eye movements were superior to no eye movements. Furthermore, all tasks that sufficiently taxed WM were found to differ significantly from the ‘no eye movement’ condition in the degree of decreased vividness and emotionality. It appears that other tasks requiring WM can have similar effects as making eye movements. Difficulty of the task, i.e., amount of WM capacity it requires, does seem to be of influence. This could explain why Van den Hout et al. (2001), using finger tapping as second task, did not find significant effects contrary to Andrade et al. (1997) who used more complex finger tapping. That task difficulty influences the effects is furthermore supported by the finding that eye movements were superior to binaural beeps, reported by Van den Hout et al. (2011), as these beeps were observed to tax WM significantly less compared to eye movements. Task difficulty seems to be related to efficacy of the therapy following an inverted U shape (Van den Hout et al., in press). Along with task difficulty, individual differences in WM capacity may also explain (absent) effects. Gunter and Bodner (2008) and Van den Hout & Engelhart (in press) found that individual differences in WM capacity related negatively to effectiveness of EMDR. In sum; it appears that the dual task hypothesis of WM has high predictive power and aids in explaining the effects of eye movements on episodic memory.

**3. Eye movements and memory facilitation**

**3.1. Procedure memory facilitation studies**

Where eye movements during recall have been observed to desensitize memories, some researchers have investigated the effects of eye movements *preceding* recall. Instead of traumatic or emotional memories, Parker and Dagnall (2012) investigated recognition of a large list of words using a Deese-Roediger-McDermott (DRM) paradigm. |The DRM paradigm is designed to test true memory for words just studied, and false memory for words that were not studied, but resembled this material strongly, either semantically or perceptually. For example the word ‘candy’ can be falsely remembered/recognised when the words ‘sweet’, ‘sugar’, ‘bar’, icing’ are among the studied list. In the Parker and Dagnall study, both children and young adults listened to a recording of the words, spoken at a rate of one word per second. Following completion of the lists, 30 seconds of horizontal, vertical or no eye movements commenced. The instruction was to follow a black dot either going from left to right or from top to bottom, or to keep the eyes stationary by looking at a dot at a central fixation point that changed colour every 30 seconds, similar to the speed of the moving dot in the eye movement conditions. After these 30 seconds, the participants got a booklet of words and were instructed to indicate whether the words were old or new. The authors observed that bilateral (horizontal) eye movements increased the number of hits (correctly recognized) and decreased the amount of false alarms (falsely recognized) compared to no movement. This was observed for both children as well as young adults. Vertical eye movements only lowered the false alarm rate for adolescents, though not as much compared to bilateral eye movements.

Samara, Elzinga, Slagter and Nieuwenhuis (2011) investigated whether free recall of emotional and neutral words would be influenced differently by eye movements. They furthermore recorded the effects of eye movements on brain activity using Electro-encephalography(EEG) electrodes. The design they used was a within-subjects counterbalanced design. A list of words was offered that consisted of neutral and emotional ones, which were shown on a computer screen for the duration of 2 seconds. After presentation of the words, there was a 30-minute break where the EEG electrodes were placed while a neutral documentary was presented. Additionally, a 4-minute EEG procedure took place that involved alternating minutes of ‘eyes open’ and ‘eyes closed’ to function as a pre-condition baseline. The participants then either watched a stationary dot, or made saccades from left to right by tracking a black dot that changed position twice a second, for the duration of 30 seconds. Then, before free recall commenced, another 4-minute EEG period was administered, as a post-condition baseline. The free recall period consisted of 5 minutes where the participants could write down all the words they still remembered. All participants participated in both conditions, counterbalanced, with one week apart.Samara et al. found that horizontal eye movements increased memory of emotional, but not neutral words. That the facilitating effect of eye movements was not found for neutral words, they suggest, may have resulted from the interval of 4 minutes between movements and recall. This interval may have confounded the results.

**3.2. Effects of eye movements prior to recall**

As Parker and Dagnall (2012) and Samara, Elzinga, Slagter and Nieuwenhuis (2011) report, eye movements prior to recall seem to facilitate (emotional) memory. Similar findings are reported by other studies ([Christman et al., 2003](http://www.sciencedirect.com.proxy.library.uu.nl/science/article/pii/S0887618510001507" \l "bib0055); Christman et al., 2004; Propper and Christman, 2008; and Parker, Ralph & Dagnall, 2008).

**4. Desensitization versus facilitation after eye movements**

It appears that the reported effects of eye movements are conflicting. Where Van den Hout & Engelhart (in press) provides an overview of studies observing desensitisation of emotional memories, other studies, such as those by Parker and Dagnal (2012) and Samara, Elzinga, Slagter and Nieuwenhuis (2011), observed facilitation of episodic (emotional) memory. Aiming to reconcile the conflicting findings, the next section lists first the procedural differences between the paradigms used.

**4.1. Procedural differences between desensitization and facilitation studies**

1. Timing of eye movements: Memory desensitization studies induce eye movements simultaneous to recall, making it a dual task. The memory facilitation studies let the participants make eye movements prior to retrieval, making it a sequential task
2. Nature of memory: Even though both studies test episodic memory, desensitization studies often test the effects on autobiographical emotional memories, while the memory facilitation studies usually investigate memory of both neutral and emotional words studied during the experiment.
3. Strength of consolidation: The nature of the memory also indicates another difference; the length of time the information has been stored. Where EMDR studies test the desensitization of ‘old’ memories retrieved from long term memory; the memory facilitation studies often use information that has been stored for the duration of several minutes up to half an hour. It is not clear whether memories that have been retrieved from long term memory are subject to a similar degree of interferences as to recently acquired memories (< 30 minutes), i.e., whether the reconsolidation and consolidation processes are equally prone to interference.
4. Assessed dependent variables: The different constructs (inhibition versus facilitation of memory) are measured using different outcome variables. Memory desensitization is assessed using 10-point scales of vividness and emotionality. Memory facilitation is often measured in terms of number of hits and false alarms (following a/an adjusted DRM paradigm).

The question arises whether the different results are due to these procedural differences, or whether they are two phenomena from the same underlying process. Perhaps eye movements applied at different moments of the memory consolidation/retrieval/ reconsolidation process renders the memory either stronger or vaguer. The following section will discuss three hypotheses to see whether this apparent contradiction can be integrated into one working model of the effect of eye movements.

**4.2. The Interhemispheric communication theory as a working model of the effect of eye movements**

According to the hemispheric encoding/retrieval asymmetry model, the process of encoding and retrieving episodic memories occur in specialized areas in both hemispheres. The left prefrontal cortex (PFC) is more involved in encoding, whereas the right PFC is more involved in retrieval (Habib, Nyberg & Tulving, 2003). This indicates that superior memory results from highly functioning brain regions *only* when in combination withproper interhemispheric communication (IHC). Studies by Christman and Propper (2010) and Parker and Dagnall (2012) indeed found a positive relation between episodic memory and size of the corpus callosum (CC), the large bundle of fibres connecting the two hemispheres. Parker and Dagnall furthermore observed that damage to the CC impaired recognition of episodic memory. Based on these findings, if bilateral stimulation by eye movements stimulates and increases IHC, the IHC theory could be a proper model to explain how eye movements prior to retrieval facilitate episodic memory. However, does it also explain the desensitizing effects? The IHC theoryhas been investigated in both paradigms. Gunter and Bodner (2008) postulated that it would not seem plausible that vertical eye movements would induce the same amount of IHC. Following the standard EMDR procedure, they compared no movement to horizontal and vertical eye movements. They observed that memories in the ‘no movement’ condition did not decrease in vividness and emotionality, while eye movements in both directions produced similar results and appeared equally effective. While this study revealed equal desensitizing properties for a stimulus with less interhemispheric activation, bilateral beeps studied by Van den Hout et al. (2011), supposedly also increasing CC activity, did not appear to have similar results compared to horizontal and vertical eye movements. These two findings seem to render it unlikely that increased IHC explain the desensitizing effects on episodic memory. Similar findings have been observed for the memory facilitating effects. As mentioned, Parker and Dagnall (2012) found that bilateral (horizontal) eye movements increased the number of hits and decreased the amount of false alarms compared to no movement. However, vertical eye movements also resulted in lower false alarms scores in adolescents. More compelling were the results of the EEG recordings in the study by Samara, Elzinga, Slagter and Nieuwenhuis (2011). The analysis did not reveal interhemispheric phase and amplitude coherence, not during nor directly after horizontal eye movements. These findings make it implausible that IHC underlies the facilitating effect of eye movements. Taken together, the IHC theory is not supported by both types of studies, and does not help to answer whether the contradicting findings result from a shared underlying process.

**4.3. The Working Memory theory as a working model of the effect of eye movements**

The WM theory has been thoroughly investigated using the dual task approach. It has been observed that other tasks can be substituted for eye movements, and seem to result in desensitization, depending on the degree of WM capacity required and individual WM capacity. The theory therefore seems to be supported by the data, and offers an explanation for the desensitizing effects of eye movements during recall. Studies using a sequential task design however do not appear to support the WM theory as explaining the facilitating effects on memory. Clapp, Rubens and Gazzaley (2009) investigated memory performance on a task that required encoding of faces and subsequent recognition whether the probes matched or not. They found that introducing a task between the encoding and recognition phase significantly impaired recognition. Task difficulty related negatively with performance. Yoon, Curtis and D’esposito (2006) reported similar results; introducing another task that requires WM capacity is distracting and impairs subsequent memory. Even though the findings reported by Clapp et al., and Yoon et al., seem to underscore the WM theory as is adopted by EMDR research, i.e., desensitizing by disruption of memory, the results do not appear to be in agreement with the theory that WM can also explain the facilitating effects by eye movements. In other words; the theory of WM function as a model to explain the dual effects of eye movements does not find support by the data.

**4.4. The Cognitive/Affective Ratio theory as a working model of the effect of eye movements**

The last hypothesis reviewed in this thesis is derived from a proposition by Harper, Rasolkhani-Kalhorn and Drozd (2009). They state that events experienced in daily life are multimodal by nature. During the memory consolidation phase, the cognitive and affective memory traces are integrated and stored in the neocortex. When an event is high in emotional intensity, this can lead to an ineffective integration, resulting in a memory with high affective properties and a low degree of cognitive information attached to it. This seems to be confirmed by findings that patients with PTSD display decreased episodic memory function for neutral and positive stimuli (Geraerts & McNally, 2008), and that memory intrusions reported by these patients are often sensory by nature, rather than elaborated thoughts (Ehlers, Halligan & Clark, 2005). Following this assumption, Samara, Elzinga, Slagter and Nieuwenhuis (2011) postulate that by facilitating the cognitive component of a stored memory, the emotional focus on traumatic memories should be decreased by the desensitization of the affective component. Theoretically, this should result in a more balanced memory in terms of the cognitive versus affective ratio without emotional intrusions being most dominant. This Cognitive/Affective Ratio theory (C/A-R) supports the idea that the apparently contradicting findings could result from a single construct. This hypothesis furthermore offers an explanation for the EMDR procedure, where desensitisation of emotional memory is followed by a strengthening of a (positive) thought. To investigate whether the C/A-R hypothesis is supported by scientific studies, an EMDR study using completeness as variable, and memory research distinguishing emotional and neutral stimuli will be reviewed.

In an experimental EMDR design, Gunter and Bodner (2008) recorded the degree of completeness of unpleasant memories. They found that completeness did not increase significantly after eye movements or other WM tasks simultaneous to recall. Interestingly, in some conditions completeness did increase in the ‘eyes stationary’ condition. This implies that not eye movements, but exposure could explain these results instead. Caution is warranted here however. Completeness was not objectively tested, but indicated by the participants using a visual scale (1 = not at all complete and 10 = extremely complete). It may well reflect the observed decrease in emotionality and vividness, resulting in a less complete memory with regards to affective aspect of the memory.

As mentioned, Samara et al. (2011) performed memory research using emotional and neutral words in a free recall paradigm. According to the C/A-R theory they should observe that neutral words are remembered better. The opposite was reported. However, it must be taken into consideration that emotional stimuli tend to increase memory via attentional modulation of the amygdala (Kenemans & Ramsey, submitted). To properly investigate the hypothesis, the ratio of neutral versus emotional words should be compared between the ‘no eye movement’ and ‘eye movement’ conditions. Again, not in compliance with the C/A-R theory, they observed that the ratio of emotional versus neutral was higher in the ‘eye movement’ condition, i.e., making eye movements increased memory for emotional words more compared to that for neutral words. Even though the 4-minute period between eye movements and recall may confound the results, it is not likely that an opposite pattern would be observed when tested immediately after the 30 seconds of eye movements. The hypothesis that desensitization of emotional memory functions by increasing the cognitive component does not seem to be supported by the data reviewed above. It does raise the question about the functionality of the final step in the standard EMDR procedure; the re-instatement of a positive thought about the traumatic experience by eye movements. It is plausible that this functions by mere exposure in the absence of intense negative emotions.

**5. Conclusion**

The research described above has not supported any of the three working models of the effect of eye movements on memory. It therefore seems unlikely that the results are due to a shared underlying process. It appears that procedural difference/differences may instead account for the conflicting findings. A study by Van den Hout, Bartelski and Engelhard (in press), seems to further indicate that a shared underlying process is not plausible. They tested episodic memory of two neutral stimuli on 32 students, using an adjusted DRM-paradigm. Two pictures were studied, for 60 seconds each. Then almost 10 minutes commenced of either keeping the eyes stationary or making bilateral eye movements. During this procedure one of the pictures had to be kept in mind. The order of and picture to be held in mind were counterbalanced between subjects. After this procedure 72 picture fragments were shown, of which 36 were new. The participants had to indicate whether the pictures belonged to the studied pictures or not. As an objective measure for vividness, and in line with previous desensitization studies; recognition rate went down for the picture that was kept in mind while making eye movements. On the other hand, and in line with previous memory facilitation studies; recognition rate went up for the picture that was not kept in mind while making eye movements. Even though these effects were not significant, it does seem to indicate that the desensitizing and facilitating effects of eye movements appear to result from different processes, and that timing of the eye movements determines which process occurs: When eye movements are part of a dual task design, they cause interference and decrease memory. When eye movements are performed sequential, they appear to facilitate subsequent memory.

**Literature**

## American Psychiatric Association. (2000). Diagnostic and statistical manual of mental disorders (3rd ed. Rev.) Washington, DC: Author.

## Andrade, J., Kavanagh, D., & Baddeley, A. (1997). Eye-movements and visual imagery: A working memory approach to the treatment of post-traumatic stress disorder. British Journal of Clinical Psychology, 36, 209–223.

## Bisson, J.I., Ehlers, A., Mathews, A., Pilling, S., Richards, D, & Turner, S (2007). Psychological treatments for chronic post-traumatic stress disorder: systematic review and meta-analysis. British Journal of Psychiatry, 190, 97-104.

## Bradley, R., Greene, J., Russ, E., Dutra, L., & Westen, D. (2005). A multidimensional meta-analysis of psychotherapy for PTSD. American Journal of Psychiatry, 162, 214-227.

Christman, S. D., Garvey, K. J., Propper, R. E., & Phaneuf, K. A. (2003). Bilateral eye movements enhance the retrieval of episodic memories. *Neuropsychology, 17*, 221–229.

Christman, S. D., Propper, R. E.,&Dion, A. (2004). Increased interhemispheric interaction is associated with decreased false memories in a verbal converging semantic associates paradigm. *Brain and Cognition*, *56*, 313–319.

## Christman, S.D. & Propper, R.E. (2010). Episodic memory and hemispheric interaction: Handedness and eye movements. Psychology Press, Hove, 185–205

Clapp, W.C., Rubens, M.T. & Gazzaley, A. (2010). Mechanisms of working memory disruption by external interference. *Cerebral cortex, 20,* 859-872

Ehlers, A., Hackmann, A., Steil, R., Clohessy, S., Wenninger, K. & Winter, H. (2002). The nature of intrusive memories after trauma: The warning signal

hypothesis. *Behaviour Research and Therapy, 40*, 995–1002

Geraerts, E. & McNally, R.J. (2008). Forgetting unwanted memories: Directed forgetting and thought suppression methods. *[Acta psychologica](http://omega.library.uu.nl/seal/omegasearch.php?cfg=omega&applid=omegajournal&act=content&idx=omegajournals&ref=000000000001937&lan=nl)*, *127 (3),* 614 -622

## Gunter, R.W. & Bodner, G.E. (2008). How eye movements affect unpleasant memories: Support for a working-memory account. Behaviour Research and

## Therapy, 46, 913-931.

Habib, R., Nyberg, L. & Tulving, E. (2003). Hemispheric asymmetries of memory: The HERA model revisited. *Trends in Cognitive Sciences, 7*, 241-245

Harper, M.L., Rasolkhani-Kalhorn, T. & Drozd, J.F. (2009). On the Neural Basis of EMDR Therapy: Insights From qEEG Studies. *Traumatology, 15(2)*, 81- 95

Kenemans, L. & Ramsey, N. *Psychology in the brain: Integrative Cognitive Neuroscience*. Submitted

Narimani, M., Sadeghieh Ahari, S. & Rajabi, S. (2008). Comparison of Efficacy of Eye Movement, Desensitization and Reprocessing and Cognitive

Behavioral Therapy Therapeutic Methods for Reducing Anxiety and Depression of Iranian Combatant Afflicted by Post Traumatic Stress Disorder.

*[Journal of applied sciences](http://omega.library.uu.nl/seal/omegasearch.php?cfg=omega&applid=omegajournal&act=content&idx=omegajournals&ref=000000000018802&lan=nl), 8(10)*, 1932-1937

Parker, A. & Dagnall, N. (2007). Effects of bilateral eye movements on gist based false recognition in the DRM paradigm*. Brain & Cognition, 6*, 221–225

Parker, A. & Dagnall, N. (2010). Effects of handedness and saccadic bilateral eye movements on components of autobiographical recollection. *Brain & Cognition, 73*, 93-101.

## Parker, A. & Dagnall, N. (2012). Effects of saccadic bilateral eye movements on memory in children and adults: An exploratory study. Brain and Cognition,

## 78, 238-247

Parker, A., Relph, S., & Dagnall, N. (2008). Effects of bilateral eye movements on the retrieval of item, associative, and contextual information. *Neuropsychology, 22*, 136-145.

Propper, R. E., & Christman, S. D. (2008). Interhemispheric interaction and saccadic horizontal eye movements. *Journal of EMDR Practice and Research, 2*, 269-281.

Samara, Z. Elzinga, B.M. Slagter, H.A. & Nieuwenhuis, S. (2011). Do Horizontal Saccadic Eye Movements Increase Interhemispheric Coherence? Investigation of a Hypothesized Neural Mechanism Underlying EMDR. *[Front Psychiatry](http://www.ncbi.nlm.nih.gov/pubmed/21556274" \l "#" \o "Frontiers in psychiatry / Frontiers Research Foundation.), 2*, 1-9

Schacter, D.L., Guerin, S.A. & Jacques, P.L. (2011). Memory distortion: an adaptive perspective. *Trends in cognitive sciences, 15(10)*, 467-474

Van den Hout, M.A., Bartelski, N. & Engelhard, I.M. On EMDR: eye movements during retrieval reduce subjective vividness and objective memory accessibility during future recall. *In press*

Van den Hout, M.A. & Engelhard, I.M. How does EMDR work? *In press*

Van den Hout, M.A., Muris, P., Salemink, E. & Kindt, M. (2001). Autobiographical memories become less vivid and emotional after eye movements. *British Journal of Clinical Psychology, 40,* 121- 130.

### Yoon, J.H., Curtis, C.E. & D'Esposito, M. (2006). Differential effects of distraction during working memory on delay-period activity in the prefrontal cortex and the visual association cortex. *Neuroimage, 29*, 1117-1126