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A meta-analysis of the contribution of eye movements in processing emotional memories.

Short title: Meta-analysis of eye movements

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Abstract

Background and objectives: Eye Movement Desensitisation and Reprocessing (EMDR) is now considered evidence based practice in the treatment of trauma symptoms. Yet in a previous meta-analysis, no significant effect was found for the eye movement component. However methodological issues with this study may have resulted in a type II error. The aim of this meta-analysis was to examine current published studies to test whether eye movements significantly affect the processing of distressing memories.

Method: A systematic review of the literature revealed two groups of studies. The first group comprised 15 clinical trials and compared the effects of EMDR therapy with eye movements to those of EMDR without the eye movements. The second group comprised 11 laboratory trials that investigated the effects of eye movements while thinking of a distressing memory versus the same procedure without the eye movements in a non-therapy context. The total number of participants was 849.

Results: The effect size for the additive effect of eye movements in EMDR treatment studies was moderate and significant (Cohens d = .41). For the second group of laboratory studies the effect size was large and significant (d = .74). The strongest effect size difference was for vividness measures in the non-therapy studies (d = .91). The data indicated that treatment fidelity acted as a moderator variable on the effect of eye movements in the therapy studies.

Conclusions: Results were discussed in terms of current theories that suggest the processes involved in EMDR are different from other exposure based therapies.

Keywords
EMDR, eye movements, randomized comparison, trauma memory, meta-analysis

A number of previous meta-analyses have found that EMDR has sustained and lasting treatment effects for Posttraumatic Stress Disorder (Bradley et al. 2005; Seidler & Wagner, 2006; Bisson et al. 2007). EMDR is now considered to meet criteria for evidence-based practice in the United Kingdom by the National Institute for Clinical Excellence (2005), in America by the American Psychiatric Association (2004), in Australia by the Australian Centre for Posttraumatic Mental Health (2007), and in the Netherlands by the Dutch National Steering Committee for Guidelines for Mental Health Care (2003).

Although the active processes in EMDR appear to be different to traditional exposure treatments (Lee et al. 2006), the mechanism of action for the success of EMDR remains controversial (Rogers & Silver, 2002; Smyth & Poole, 2002; Shapiro, 2012). There is disagreement as to whether eye movements add anything to the effectiveness of EMDR (Davidson & Parker, 2001; MacCulloch, 2006).

The treatment studies that have attempted to isolate the eye movement component from the full treatment package have produced results ranging from a very large effect size consistent with eye movements enhancing processing (Wilson et al. 1996) to findings of no differences (Renfrey & Spates, 1994). *On the other hand, non-clinical laboratory s*tudies that investigated the effects of eye movements on autobiographical memories have found decreases in vividness and/or emotionality compared to control conditions such as finger tapping (van den Hout et al. 2001), spatial tapping (Andrade et al. 1997), and no eye movement (Kavanagh et al. 2001; Barrowcliff et al. 2004; Gunter & Bodner, 2008). Whilst these laboratory studies show a clear processing effect for eye movements, they did not involve all the procedural elements of EMDR (Shapiro, 1995).

In an attempt to discover any general trends in research that has examined the effects of eye movements on memory, Davidson & Parker (2001) conducted a meta-analysis of published studies investigating effect size differences between EMDR with eye movements

and EMDR without eye movements. Their conclusion when looking at pre-versus-post single session measures was that there was no significant additional effect of eye movements. Their measure of effect size was R, which ranges from plus one to minus one; R^2 is the amount of variance in the dependent variable accounted for by the independent variable. However there were methodological problems in this meta-analysis. Initially R scores were converted to Z scores. The simple mean of these scores was converted back to R, and then subjected to a t-test using the number of studies to determine the degrees of freedom. The problem with this approach is that it treats all studies as if they are of equal weight. The usual practice in meta-analysis is to weight each study in relation to the number of participants and for the degrees of freedom to be calculated using the total number of participants (Rosenthal & DiMatteo, 2001). This provides a more appropriate test of significance and provides more power to investigate small magnitude effect sizes (Rosenthal, 1991).

Since 2001, there have been additional published papers investigating the effects of eye movements on various measures. Therefore, we decided to conduct a new meta-analysis, including all studies published in the past 23 years and adjusting for the sample size in each study.

2.0 Method

2.1 Search Procedure

Searches were conducted in Medline, PsycINFO, and Science Direct databases. The search was done in two parts: the first used the keywords *non eye movement* or *no eye movement* or *eyes fixed* or *eyes stationary* or *without the eye movement* or *eye stationary* paired with *eye movements*, or *eyes moving* or *eye movement*; the second also used a keyword search of *eye movements* paired with *eye movement desensitization*. The search was restricted to articles only involving humans and between 1989 (when EMDR was first published) and

2012. An *a priori* decision was made to search only published work and to control for publication bias by *a posteriori* analysis. Additional studies were identified by manual searches of past meta-analyses (Davidson & Parker, 2001; Rodenburg et al. 2009) and recent reviews of the role of eye movements in EMDR (Smeets, Dijs, Pervan, Engelhard, & van den Hout, 2012; Gunter & Bodner, 2009).

2.2 Inclusion/Exclusion Criteria

We included randomized controlled trials in which a negative memory task with eye movements was compared to the same task but without the eye movements, under otherwise identical conditions. Thus if a study compared eye movement plus tapping to no eye movement plus tapping then such a study could be said to compare the presence or absence of eye movement in identical conditions. However a study that compared eye movement without tapping to no eye movement with tapping is not comparing the main variable of interest in identical conditions. Therefore we included only studies comparing eye movements versus no eye movement, studies in which eye movements were compared with an alternative stimulus were excluded.

We included two types of studies. In the first type, (laboratory studies) the participants simply were asked to think of a distressing memory and then they were randomized to a procedure with eye movements or to the same procedure but without eye movements. This was done in all these studies over a very short period of time and in one session (average total eye movement exposure 52 seconds).

The second group of studies (treatment studies) examined the effects of EMDR on participants with an anxiety disorder or a distressing memory, and compared EMDR with eye movements with exactly the same procedure but without the eye movements. These clinical interventions used between 5 to 8 phases of the EMDR treatment protocol (Shapiro, 2001)

and these studies had more extensive exposure to eye movements than the first group of studies. We decided to conduct an independent meta-analysis for each of these two groups of studies.

2.3 Quality Assessment

We assessed the validity of the treatment and laboratory studies using four criteria of the 'Risk of bias' assessment tool, developed by the Cochrane Collaboration (Higgins & Green, 2008). This tool assesses possible sources of bias in randomized trials, including the adequate generation of allocation sequence; the concealment of allocation to conditions; the prevention of knowledge of the allocated intervention; and dealing with incomplete outcome data. The two other criteria of the 'Risk of bias' assessment tool (suggestions of selective outcome reporting; and other problems that could put it at a high risk of bias) were not used in this study, because we found no clear indication that they had influenced the validity of any of the studies reviewed.

We also rated the quality of the treatment implementation using three criteria which were based on an authoritative review of empirically supported psychotherapies (Chambless & Hollon, 1998): (1) the study referred to the use of a treatment manual (either a published manual, or a manual specifically designed for the study); (2) the therapists who conducted the therapy were trained for the specific therapy, either specifically for this study or as general training; (3) treatment integrity was checked during the study (by supervision of the therapists during treatment or by recording of treatment sessions, or by systematic screening of protocol adherence with a standardized measurement instrument). The ratings were made by two PhD students and each study was discussed until a consensus was reached.

2.4 Analyses

For each study, we calculated Cohen's d (standardized mean difference) by subtracting (at post-test) the average score of the control group (M_c) from the average score of the experimental group (M_e) and dividing the result by the pooled standard deviations of the experimental and control group (SD_{ec}). Effect sizes of 0.80 and higher are regarded as large, while effect sizes of 0.50 to 0.80 are moderate, and lower effect sizes are small (Cohen, 1988). Because several studies had small sample sizes we corrected the effect size for small sample bias according to the procedures suggested by Hedges (1985). Each author separately calculated effect size data from each study and discrepancies were discussed until consensus was reached. When means and standard deviations were not available in the study, we used other statistics (t-value, p-value) to calculate the effect size using Comprehensive Meta-analysis software (version 2.2057; CMA). When a study reported only a non-significant difference between conditions at post-test without reporting more specific statistics, we conducted the authors and asked for more specific data otherwise we assumed a zero effect size. The calculated effect sizes were based on self report and observer rated symptoms only. An early attempt was made to include physiological measures. However, these varied largely between the studies in the type of physiological measures used and the way that they were reported. This prevented any meaningful analysis across the studies and so this data was excluded.

We pooled the mean effect sizes (Cohen's d) with CMA. If there were multiple outcomes within a study we selected the CMA option to use the mean of the selected outcomes. We choose to conduct random effects meta-analysis. Therefore, each study was weighted by the inverse of its variance, in which the variance includes the within-studies variance plus the estimate of the between-studies variance, tau-square. More information about the exact methods for pooling studies in a random-effects model is detailed in Borenstein, Hedges, Higgins & Rothstein (2009).

As a test of homogeneity of effect sizes, we calculated the I^2-statistic which is an indicator of heterogeneity in percentages. A value of 0% indicates no observed heterogeneity, and larger values show increasing heterogeneity, with 25% as low, 50% as moderate, and 75% as high heterogeneity (Higgins et al. 2003). We also calculated the Q-statistic, but only report whether this was significant or not.

Subgroup analyses were conducted according to the mixed effect model. In this model, studies within subgroups are pooled with the random effects model, while tests for significant differences between subgroups are conducted with the fixed effects model. For continuous variables, we used meta-regression analyses to test whether there was a significant relationship between the continuous variable and the effect size, as indicated with a Z-value and an associated p-value. Two subgroup analyses were planned to see if previous meta-analysis findings would be replicated in the treatment studies. The first was that treatment integrity had been found to moderate the effect size of symptom reduction following EMDR (Maxfield & Hyer, 2002) and the second was that EMDR effect size was moderated by the type of population treated with larger effect sizes associated with non-student populations (Davidson and Parker, 2001)

Publication bias was tested by inspecting the funnel plot on primary outcome measures, and by Duval and Tweedie's trim and fill procedure (Duval & Tweedie, 2000), which yields an estimate of the effect size after the publication bias has been taken into account (as implemented in Comprehensive Meta-analysis, version 2.2.021).

3.0 Results

3.1 Inclusion of Studies

A flowchart describing the selection of studies is reported in Figure 1. The three searches and four articles resulted in 891 unique studies. Of these 103 were excluded because they studied the effect of eye movement during sleep and 314 were excluded because they contained no original data and were review papers only. A further 297 were excluded because they were either a case report of EMDR treatment or a study looking at a treatment outcome study comparing EMDR to a waitlist or an alternative treatment procedure. A further group of 61 studies were excluded either because the eye movements was not compared to no eye movement under identical condition, for example (Elofsson et al. 2008), or the comparison lacked sufficient randomisation, or the study was a prepost design that did not control for order effects for example (Montgomery & Ayllon, 1994).

[Insert figure 1]

Of the 116 remaining studies, 82 were excluded because they did not test for the effects of eye movement on any negative or trauma memory. Within these studies, 72 investigated the effects of eye movements compared to no eye movements on a purely perceptual task, for example (Schmidt et al. 2007), and were therefore excluded. A further 11 studies were excluded because the effect of eye movements was not tested on a negative memory. Such studies investigated diverse phenomena ranging such as investigating the effects of eye movements on performance of a memory recognition task (Parker et al. 2008), or whether eye movements improved performance on a semantic flexibility task (Kuiken et al. 2001), or whether it affected exposure to gory slides (Tallis & Smith, 1994), or whether it effected current distress associated with an anticipated aversive experience (Engelhard et al., 2011).

Of the 33 remaining studies, which all tested the effects of eye movement on a negative or trauma memory, 5 were excluded because the eye movements condition was not compared to a no eye movement control. In these studies, a control procedure involved another attention demanding task such as tapping, for example (Pitman et al. 1996), or

auditory tones (Servan-Schreiber et al. 2006). Given that such tasks have been described as alternatives to eye movements in EMDR therapy (Shapiro, 2001) and that two possible theories to account for EMDR effectiveness suggest that alternative stimulation may be as effective as eye movements, namely the working memory paradigm (Gunter & Bodner, 2008) and the orienting response paradigm (Armstrong & Vaughan, 1996), it was decided to restrict the meta-analysis to studies comparing a procedure with eye movements with the same procedure but without eye movements. In studies that included an eye movements versus no eye movement trial and an eye movements versus an alternative stimulus trial, only the eye movements versus the no eye movement trial was included in the analysis. Finally 4 studies were excluded because the eye movement and no eye movements conditions were complicated by simultaneously assessing reaction time (Maxfield, Melnyk, & Hayman, 2008; van den Hout et al., 2011).

After the above exclusions, 24 studies remained containing 26 separate comparisons. Fourteen treatment studies (15 trials) compared EMDR treatment including eye movements with EMDR but without the eye movements. Ten laboratory studies (11 trials) compared eye movements with no eye movements while the respondents simply focused on an autobiographical memory.

3.2 EMDR Treatment with Eye Movements versus EMDR without Eye Movements

3.2.1Description of included studies

The 14 studies (15 comparisons) comparing eye movements versus no eye movement in full EMDR treatments, included a total of 452 respondents (239 in the EMDR conditions, and 213 in the no eye movement conditions). Selected characteristics are presented in Table 1. In six 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

students were used but screened for clinical levels of symptoms (Sanderson and Carpenter, 1992). Thirteen studies used self report of distress Subjective Units of Discomfort Scale (SUDS) as an outcome measure and five studies used additional measures relevant to the population group they were treating. For example the Body Sensations Questionnaire (BSQ) was used in assessing response to treatment for panic disorder (Feske & Goldstein, 1997), the Mississippi Scale for Combat-related PTSD (MSCR), the Impact of Events Scale (IES) or the Clinician-Administered PTSD Scale **(**CAPS) was used for people with PTSD (Boudewyns et al. 1993) and the State Trait Anxiety Inventory (STAI) or the Beck Anxiety Inventory (BAI) was used to assess the levels of anxiety (Devilly et al. 1998; Renfrey & Spates, 1994).

[Insert table 1]

3.2.2 Quality of included studies

None of the studies described an adequate sequence generation, and only one study reported adequate concealment of allocation to respondents. Because all outcome measures were self-report (apart from one measure in one study), blinding of assessors was not relevant. None of the studies described whether incomplete outcome data were handled adequately. In terms of treatment integrity, five of the 14 treatment studies did not use a treatment manual and only three checked the fidelity of the treatment. Therapists were untrained in one study and only fully trained in the procedure in six studies.

3.2.3 Effect sizes in the treatment studies

The results indicating the difference between eye movements and no eye movement in full EMDR treatments are presented in Table 2. The effect sizes and 95% confidence intervals of the individual studies are plotted in Figure 2. The mean effect size indicating the

difference between eye movements and no eye movement was Cohen's d g=0.41 (95% CI: 0.13~0.70), with moderate heterogeneity (I^2=48.59).

[Insert table 2]

[Insert figure 2]

Inspection of the funnel plot suggested that two studies were possible outliers, because their 95% confidence intervals fell outside the 95% confidence interval of the pooled effect size (Shapiro, 1989; Wilson et al. 1996). After removal of these two studies from the sample the mean effect size was 0.27 (95% CI: 0.07~0.47) with zero heterogeneity.

In our analyses, we included one study in which two separate psychological treatments were compared to the same control group (Lee et al. 2007). This means that multiple comparisons from this study were included in the same analysis. These multiple comparisons, however, are not independent of each other, which may have resulted in an artificial reduction of heterogeneity and a distortion of the mean effect size. Therefore, we conducted another meta-analysis, in which we included only one comparison per study (Table 2). From the study with multiple comparisons we first included only the comparison with the largest effect size. We then conducted another meta-analysis in which we included only the smallest effect size from the study. As can be seen in Table 2, these analyses did not indicate that the mean effect size changed considerably, nor did we find indications that heterogeneity was affected by this study in either meta-analysis.

Neither the funnel plot nor Duval and Tweedie's trim and fill procedure pointed at a significant publication bias. The effect size indicating the difference between the two conditions was only slightly smaller after adjustment for publication bias (0.35; 95% CI: 0.03~0.68; number of trimmed studies: 1), than the unadjusted effect size (0.41; 95% CI: 0.13~0.70).

3.2.4 Type of measures used

Given that Davidson and Parker (2001) reported SUDS values separately claiming that SUDS was a process measure and might be different to other outcome measures we looked at the effects of this variable separately. Only SUDS values reported after treatment was completed were used in the meta-analysis. The effect size indicating the difference between the two conditions using SUDS was moderate and significant (0.53; 95% CI: 0.20~0.85). As can be seen in Table 2, after removing the so-called process variables of SUDS and VOC the effect size for the difference between the two conditions was still significant (0.33; 95% CI: 0.07~0.060).

3.2.5 Subgroup analyses in the treatment studies

In order to examine the possible effect of moderators we conducted a series of subgroup analyses (Table 2). We found no indication for a significant difference between studies with clinical populations and those with student populations, between studies in which participants met diagnostic criteria for a mental disorder versus other studies, between studies which were aimed at posttraumatic stress and those aimed at other anxieties. For the subgroup analysis using variables associated with treatment fidelity we found a significant effect for whether or not the paper cited the used an EMDR treatment manual. The effect size for studies that used a manual was significantly greater than zero whereas the effect size was not significantly greater than zero for those that did not use a treatment manual (see Table 2). There was a also trend ($p<0.1$) indicating that the effect sizes in studies in which the therapies were delivered by fully trained EMDR therapists were larger than the effect sizes found in other studies.

3.3 Eye Movements versus No Eye Movement in Laboratory Studies

Ten studies (11 comparisons) tested eye movements versus no eye movement while the person focused on an emotional autobiographical memory. A total of 397 participants participated in these studies with 200 in the eye movements and 197 in the no eye movement condition (see Table 3). These results are presented in Figure 3 and Table 4. As can be seen, the mean effect size of all studies was 0.74 (95% CI: 0.57~0.91) with low, and non-significant heterogeneity (I^2=12.15). Several of the included studies used the same instruments to measure the effects of the interventions (in Subjective Units of Change). Therefore, we were able to calculate separate effect sizes for Subjective Units of Change in emotion associated with the memory and Subjective Units of Change in vividness of the memory. As can be seen in Table 4, the mean effect size of emotion was 0.66 (95% CI: 0.46~0.85) with low heterogeneity, and for vividness it was 0.91 (95% CI: 0.65~1.16) with moderate heterogeneity. Because the number of studies was small, we did not conduct subgroup analyses.

[Insert table 3]

[Insert figure 3]

[Insert table 4]

4.0 Discussion

The present meta-analysis provided an up-to-date evaluation of the efficacy of eye movements in processing emotional memories. The 14 studies that investigated the additional value of eye movements in EMDR treatment averaged a significant medium effect size advantage for eye movements over no eye movement. Heterogeneity was found to be moderate in these analyses, and this was reduced to zero after removal of two possible outliers. In 10 laboratory studies that looked at the effects of eye movements in a non-therapy

context, a significant medium to large effect size advantage was found for eye movements, with low heterogeneity.

The results of this study are at odds with a previous meta-analysis (Davidson & Parker, 2001) which found no significant advantage for eye movements. However, in Davidson and Parker's analysis an adjustment for sample size was not made before calculating the average effect size. Furthermore, a fixed effects model was used rather than a random effects model, but given the heterogeneity of the studies a random effects model would have been more appropriate. These differences in methodology and the inclusion of 12 more recent studies appear to account for the differences in the findings of the two studies.

Similarly another earlier meta-analysis also failed to use a random effects model (Devilly, 2002). In addition a single rater selected the studies and calculated the effect sizes which increases bias, particularly given unpublished studies were included. Over the years there has been agreement that meta-analysis should involve multiple raters (Bullock & Sysvyantek, 1985; Stroup et al., 2000). The issue of possible publication bias in the current analysis was examined with funnel plot and Duval and Tweedie's trim and fill procedure. Neither indicated a significant publication bias.

Davidson and Parker reported results separately for SUDS and VOC which they called process measures and they named the other measures 'outcome measures'. In the studies examined in this study the largest effect was found for the VOC scale and then the SUDS measure. However even after excluding these measures, there was still significant effect for eye movement. It can be argued that SUDS is both an outcome and process measure. In trauma focused cognitive behaviour therapy, SUDS is used during the session to assess how the habituation process is proceeding and to help ascertain 'hot spots' which are the subject of further attention by the therapist. However SUDS can also be an outcome measure. At the conclusion of treatment if this process is successful then there should be no

hot spots. SUDS is also used in EMDR to check the current degree of distress to the memory. An important outcome of any PTSD treatment is that recovery should be evident by reduced frequency of avoidance and intrusive symptoms and that when a person is reminded of the trauma that the memory it is not accompanied by hyperarousal. SUDS recorded at the end of treatment (as used in the current analysis) can help assess this and is therefore also an outcome measure.

The finding of a significant effect for eye movements in both treatment and laboratory contexts is important in terms of understanding the underlying active processes in EMDR. One account for the effect of eye movements is provided by working memory theories of EMDR (Andrade et al. 1997; Gunter & Bodner, 2008; Maxfield et al. 2008; van den Hout et al., 2011). Researchers have noted that emotional memories tend to have an episodic form and are rich in sensory detail, and trauma recovery is likely to occur when these memories lose their sensory richness (Stickgold, 2002). Consistent with hypotheses from a working memory theory, holding an emotional memory in mind and performing another task such as eye movements disrupts the storage of this information and the episodic quality is reduced. Therefore the finding of a large effect size in the non-therapy studies for the specific measure of vividness is consistent with this working memory theory to explain treatment effects in EMDR. Another finding consistent with this model is that other complex visuospatial tasks can also produce a reduction in vividness and emotionality (Gunter & Bodner, 2008), although this is not always found (Kavanagh et al. 2001).

Another model to account for the possible role of eye movements that has some empirical support is that the eye movements elicit an orienting response (Barrowcliff et al. 2003; Sack et al. 2008; Schubert, Lee, & Drummond, 2011). According to orienting response theory the eye movements activate an “investigatory reflex” in which first, an alert response occurs, then, a reflexive pause produces dearousal in the face of no threat. This reflex results

in a state of heightened alertness and permits exploratory behaviour in which cognitive processes become more flexible and efficient (Kuiken et al. 2001). Some physiological changes associated with the eye movements do fit with the orienting response hypothesis such as changes in skin conductance and heart rate (Elofsson et al., 2008; Sack et al., 2008; Schubert et al, 2011). However other changes during EMDR treatment sessions are not consistent with an orienting response such as an increase in respiration (Schubert et al., 2011).

Whilst the effect of eye movements in the non-therapy studies might be accounted for by a working memory model or by the eye movements triggering an orienting response, the key processes in the therapy studies are likely to be more complex. In the non-therapy studies the amount of exposure to eye moment was always a single session and lasted between 8 and 96 seconds. In contrast, in the treatment studies the eye movements or no eye movement period involved one to several sessions and most studies included many phases of the EMDR protocol. EMDR has been described as a complex procedure and that even without eye movements involves processes such as mindfulness to the trauma (Lee et al. 2006), cognitive restructuring, an increased sense of personal mastery, and other processes associated with exposure that would create a therapeutic benefit (Solomon & Shapiro, 2008). Thus when the effects of eye movements in an EMDR therapy context are assessed they have to provide additional value to these other processes. Thus in comparison to the effect size difference in the non-therapy studies it is not surprising that the effect was less pronounced (moderate) and the heterogeneity greater. In the non-therapy studies, these other elements are absent so the comparison is not measuring the additive value of eye movements to other useful processes but a more direct assessment of its value.

Some of the data indicated that the additional effects of the eye movements may depend on the quality of the treatment delivery. The effect size for studies that cited use of an

EMDR treatment manual was higher than the effect size in studies that did not cite use of a treatment manual. This is consistent with a previous meta-analysis that found a significant correlation between effect size and treatment fidelity (Maxfield & Hyer, 2002). There was also a trend indicating that the difference between EMDR with and EMDR without eye movements was larger when the treatment was delivered by a fully trained EMDR therapist. However, because this difference was not significant at $p<0.05$, and because the number of studies was very small, such interpretations have to be considered with caution.

This study has several limitations. The most important one is that the quality of included studies was not optimal. This may have distorted the outcomes of the studies and our meta-analysis. Apart from ensuring adequate checks on treatment quality, there were other serious methodological problems with the studies in the therapy context. None of the studies described an adequate sequence generation, and only one study reported adequate concealment of allocation to respondents. There was an over reliance on self report measures and, in general, each study had an insufficient sample size to detect significant differences. In addition many of the laboratory studies included a within subjects design which can produce carry over effects. Furthermore, the total number of studies was small, especially the number of studies on brief experiments. This limited the possibilities to examine possible moderating variables. It also restricted some subgroup analysis. The total number of treatment studies that investigated the effect of eye movement and where participants had a DSM diagnosis was only 6. However the effect size of the difference between the conditions was moderate and significant.

Another possible limitation of this study is that we used standard methods to calculate the confidence intervals around our effect sizes. There are indications, however, that alternative methods to calculate confidence intervals are somewhat more conservative (Viechtbauer & Cheung, 2010; Sanchez-Meca & Marin Martinez, 2008). On the other hand,

the effects of these alternative methods on the confidence intervals have been found to be small (Viechtbauer & Cheung, 2010), and probably would not have led to very different outcomes.

Despite these limitations, it seems safe to conclude that the eye movements do have an additional value in EMDR treatments. There remains a need for research to be conducted on clinical populations with adequate attention to treatment fidelity and the above methodological issues. However the results from the studies to date suggest that eye movements do alter the processing of emotional memories.

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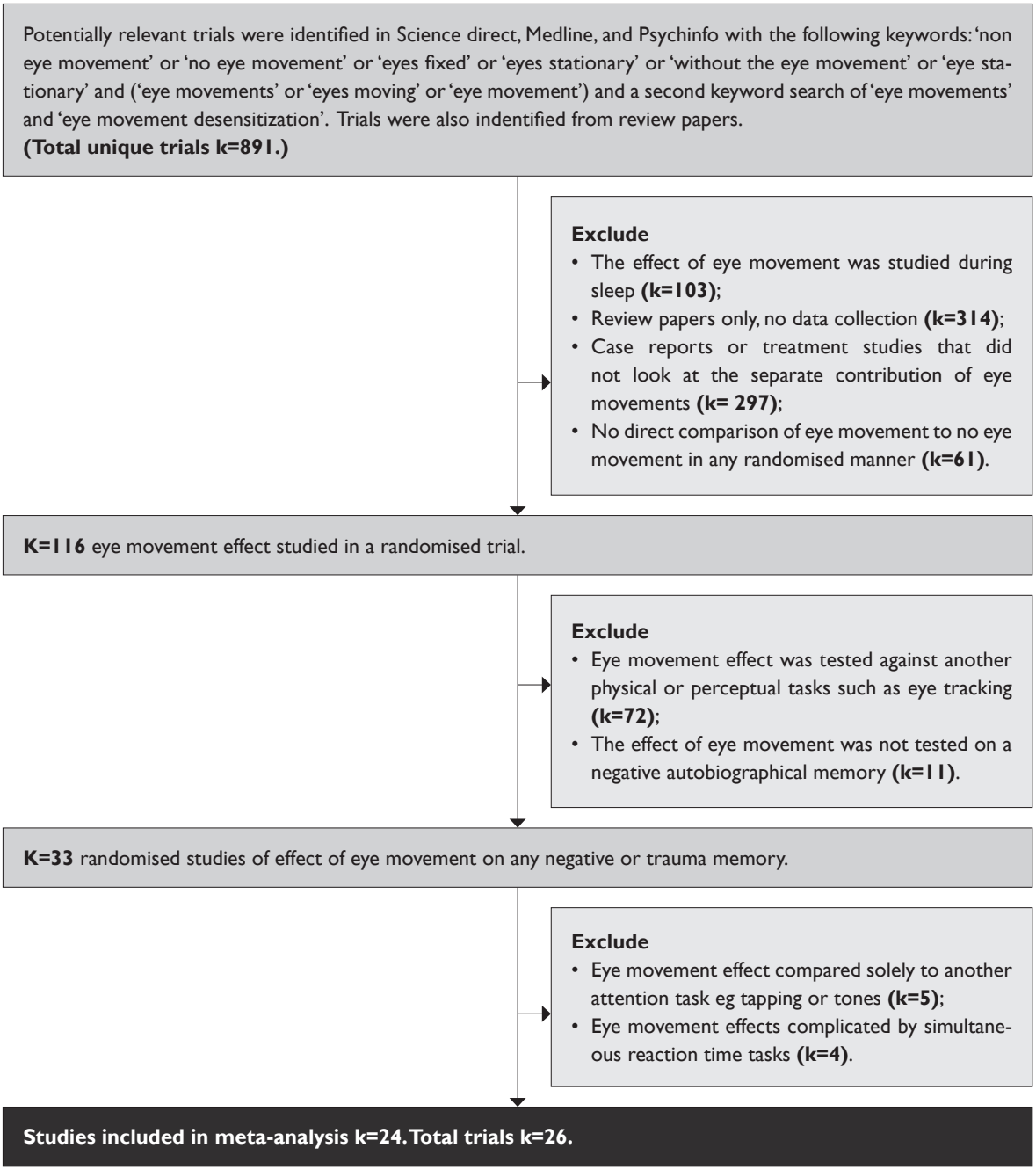
Figure(s)


Potentially relevant trials were identified in Science direct, Medline, and Psychinfo with the following keywords: 'non eye movement' or 'no eye movement' or 'eyes fixed' or 'eyes stationary' or 'without the eye movement' or 'eye stationary' and ('eye movements' or 'eyes moving' or 'eye movement') and a second keyword search of 'eye movements' and 'eye movement desensitization'. Trials were also indentified from review papers.
(Total unique trials k=891.)
Exclude
• The effect of eye movement was studied during sleep (k=103);
• Review papers only, no data collection (k=314);
• Case reports or treatment studies that did not look at the separate contribution of eye movements (k= 297);
• No direct comparison of eye movement to no eye movement in any randomised manner (k=61).
K=116 eye movement effect studied in a randomised trial.
Exclude
• Eye movement effect was tested against another physical or perceptual tasks such as eye tracking (k=72);
• The effect of eye movement was not tested on a negative autobiographical memory (k=11).
K=33 randomised studies of effect of eye movement on any negative or trauma memory.
Exclude
• Eye movement effect compared solely to another attention task eg tapping or tones (k=5);
• Eye movement effects complicated by simultaneous reaction time tasks (k=4).
Studies included in meta-analysis k=24. Total trials k=26.

Figure(s)

Figure 1. Consort flow diagram of meta-analysis study selection

Figure(s)

Study name	Outcome	Std diff in means	Lower limit	Upper limit	Z-Value	p-Value
Boudewyns, 1993	Combined	0.30	-0.74	1.35	0.57	0.57
Carrigan, 1999	SUDS	0.00	-0.65	0.65	0.00	1.00
Devilly, 1998	Combined	0.42	-0.38	1.22	1.04	0.30
Dunn, 1996	SUDS	0.43	-0.32	1.18	1.12	0.26
Feske, 1997	Combined	0.32	-0.34	0.99	0.96	0.34
Foley, 1995	Combined	0.00	-0.88	0.88	0.00	1.00
Gosselin, 1995	Combined	0.41	-0.20	1.02	1.30	0.19
Lee, 2007 Distancing	Combined	1.31	0.43	2.20	2.91	0.00
Lee, 2007 Reliving	Combined	0.47	-0.34	1.28	1.13	0.26
Lytle, 2002	Combined	-0.10	-0.83	0.62	-0.28	0.78
Renfrey, 1994	Combined	0.00	-1.01	1.01	0.00	1.00
Sanderson, 1992	Combined	-0.25	-0.80	0.29	-0.91	0.36
Schubert et al., 2011	Combined	0.44	-0.10	0.98	1.60	0.11
Shapiro, 1989	Combined	1.64	0.68	2.61	3.33	0.00
Wilson, 1996	Combined	2.65	1.10	4.20	3.35	0.00
		0.41	0.13	0.70	2.82	0.00

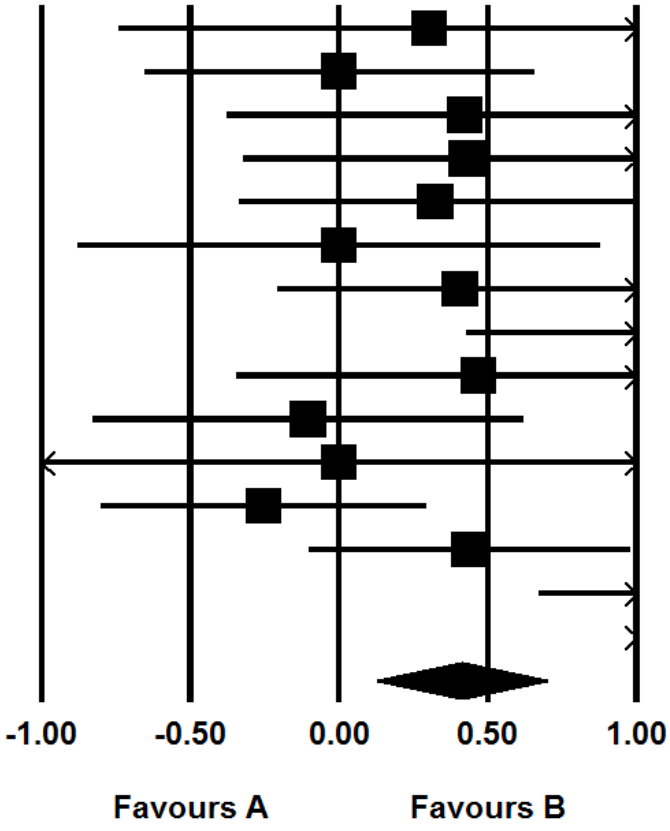


Figure 2. Eye movement versus no eye movement in full EMDR treatments: Standardized effect sizes.

Study name	Outcome	Statistics for each study				
		Std diff in means	Lower limit	Upper limit	Z-Value	p-Value
Andrade et al., 1997	Combined	0.86	0.45	1.28	4.05	0.00
Barrowcliff et al., 2004	Combined	0.27	-0.17	0.71	1.21	0.23
Christman et al., 2003	accuracy	0.54	-0.09	1.17	1.69	0.09
gunter & B exp1 2008	Combined	1.33	0.61	2.06	3.59	0.00
gunter & B exp2 2008	Combined	0.86	0.18	1.55	2.47	0.01
Kavanagh et al., 2001	Combined	1.05	0.36	1.75	2.96	0.00
Kemps et al., 2007	Combined	0.89	0.36	1.43	3.30	0.00
Kristjansdottir and Lee 2011	Combined	0.97	0.56	1.38	4.66	0.00
Lilley et al., 2009	Combined	0.55	0.05	1.05	2.18	0.03
smeets et al 2012	Combined	0.52	0.01	1.03	1.99	0.05
Van den Hout et al., 2001	Combined	0.69	0.17	1.21	2.59	0.01
		0.74	0.57	0.91	8.59	0.00

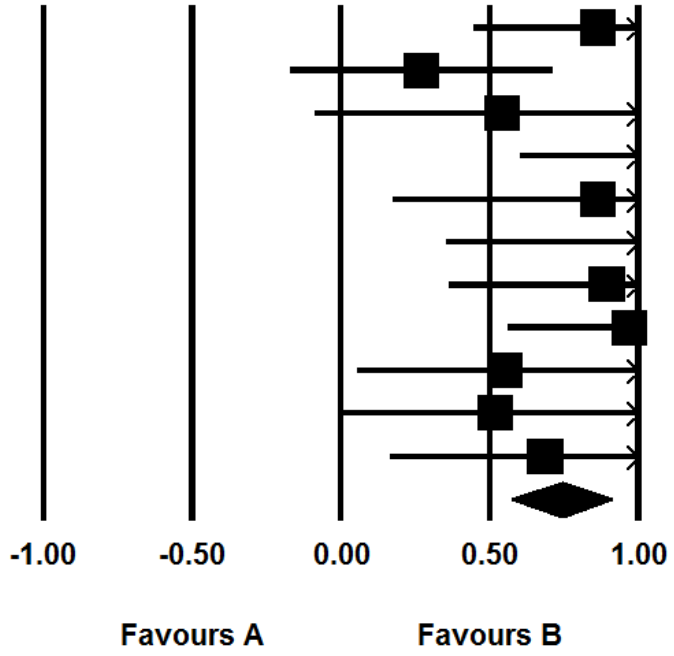


Figure 3. Eye movement versus no eye movement in brief experiments: Standardized effect sizes.

Table(s)

Table 1.

Study characteristics of investigations into EMDR with or without eye movements within a therapy context

Study	n	Disorder	Population	DSM criteria	EMDR training	Use of therapy manual	Outcome measures used in analysis
Boudewyns et al., 1993	16	PTSD	Clinical	+	−	-	CAPS, IES, SUDS, MSCRP
Carrigan & Levis, 1999	36	Public speaking anxiety	Students	−	−	-	SUDS
Devilly et al., 1998	25	PTSD	Clinical	+	+	+	SUDS, MSCRP, STAI
Dunn et al., 1996	28	distressing memory	Student	−	−	+	SUDS
Feske & Goldstein, 1997	36	panic disorder	Clinical	+	+	+	ACQ, BAI, BSQ, FP, FPA, MI, PAI
Foley & Spates, 1995	20	public speaking anxiety	Students	−	−	-	BASA, PRCA-24, PRPSA, SUDS, VOC
Gosselin & Mathews, 1995	42	anxiety	Students	−	+	+	SUDS, VOC
Lee & Drummond, 2008[a)]	48	distressing memory	Students	−	−	+	SUDS, vividness
Lytle et al., 2002	30	distressing memory	Students	−	−	+	IES, STAI, SUDS, Vividness, VOC
Renfrey & Spates, 1994	15	PTSD [b)]	Clinical [c)]	+	−	-	SUDS, VOC
Sanderson & Carpenter, 1992	62	Anxiety	Clinical	−	−	-	SUDS
Schubert et al., 2011	60	distressing memory	Students	-	+	+	SUDS, VOC
Shapiro, 1989	22	clinical trauma	Clinical	+	+	NA	SUDS, VOC
Wilson et al., 1996	12	PTSD	Clinical	+	+	+	SUDS, VOC

[a)] Included 2 comparisons, one with reliving instructions, one distancing.
[b)] More than 90% met DSM criteria for PTSD.
[c)] This was a student population, but they met criteria for a clinical population.

Abbreviations:
ACQ: Agoraphobic Cognitions Questionnaire; FP: Fear of Panic; STAI: State-Trait Anxiety Inventory; FPA: Fear of Panic Attacks; MI: Mobility Inventory for Agoraphobia; PAI: Panic Appraisal Inventory; BASA: Behavioral Assessment of Speech Anxiety; PRCA-24: Personal Report of Communication Anxiety; PRPSA: Personal Report of Public Speaking Anxiety; VOC: Validity of Cognition.

Table(s)

Table 2.
Meta-analyses of studies comparing the effects of eye movement with no eye movement during EMDR treatments

Study		N_{comp}	d	95% CI	Z	I^{2} [a]	p [b]
Effect sizes at post-test							
• All comparisons		15	0.41	0.13~0.70	2.82 **	48.59 *	
• Two possible outliers removed [c]		13	0.27	0.07~0.47	2.70 **	0	
• One effect size per study (highest) [d]		14	0.43	0.13~0.73	2.83 **	52.14 *	
• One effect size per study (lowest) [d]		14	0.36	0.09~0.63	2.64 **	42.47 *	
Specific outcomes							
• SUDS only		14	0.53	0.20~0.85	3.14 **	59.12 **	
• VOC only		6	0.72	0.13~1.32	2.37 *	65.47 *	
• SUDS and VOC excluded		8	0.33	0.07~0.60	2.48 *	0	
Subgroup analyses							
• Population	– Clinical sample	7	0.50	0.05~0.95	2.17 *	70.76 **	0.72
	– Students	8	0.39	0.01~0.77	2.00 *	0	
• DSM diagnosis	– Yes	6	0.32	-0.15~0.79	1.34	61.12 *	0.57
	– No	9	0.49	0.14~0.85	2.73 **	37.91	
• Aimed at posttraumatic stress	– Yes	4	0.60	-0.05~1.25	1.80 o	64.58 *	0.58
	– No	11	0.39	0.08~0.71	2.42 *	45.34 *	
• Manual cited	– Yes	9	0.56	0.22~0.90	3.21 **	32.47	0.03*
	– No	5	-0.05	-0.43~0.34	-.24	57.27	
• Fully trained EMDR therapist	– Yes	6	0.70	0.28~1.11	3.25 **	60.81 *	0.09o
	– No	9	0.23	-0.11~0.58	1.33	22.01	

o: $p < 0.10$; *: $p < 0.05$; **: $p < 0.01$; ***: $p < 0.001$.

[a] The p-values in this column indicate whether the Q-statistic is significant (the $\mathbf{I^2}$ statistics does not include a test of significance).
[b] The p-values in this column indicate whether the difference between the effect sizes in the subgroups is significant.
[c] Wilson et al., 1996 and Shapiro et al., 1989.
[d] In these analyses only one comparison from each study was used.

Table(s)

Table 3.

Study characteristics of investigations into memory processing with or without eye movements not in a therapy context.

Study	Number	Type of memory	Measures
Andrade et al., 1997	48	distressing memory	subjective distress, vividness
Barrowcliff et al., 2004	80	distressing memory	subjective distress, vividness
Christman et al., 2003	40	autobiographical memories	accuracy of memory recall
Gunter & Bodner, 2008	36	distressing memory	subjective distress, vividness, completeness
Kavanagh et al., 2001	18	distressing memory	subjective distress, vividness
Kemp 2007	30	distressing memory	subjective distress, vividness
Kristjánsdóttir & Lee 2011	36	distressing memory	subjective distress, vividness
Lilley et al., 2009	18	distressing memory	subjective distress, vividness
Smeets et al., 2012	61	distressing memory	subjective distress, vividness
Van den Hout et al., 2001	30	distressing memory	subjective distress, vividness

Table(s)

Table 4.
Meta-analyses of studies comparing the effects of Eye movement versus no eye movement in brief experiments at post-test

Study		N_{comp}	d	95% CI	Z	I^2
All comparisons		11	0.74	0.57~0.91	8.61 ***	12.15
Specific outcomes	Emotion	10	0.66	0.47~0.85	6.73 ***	28.85
	Vividness	10	0.91	0.65~1.16	6.94 ***	56.03 *

*: $p<0.05$