Journal of Anxiety Disorders 25 (2011) 1–11

Contents lists available at ScienceDirect

Journal of Anxiety Disorders

# The efficacy and psychophysiological correlates of dual-attention tasks in eye movement desensitization and reprocessing (EMDR)

Sarah J. Schubert*, Christopher W. Lee, Peter D. Drummond

*Murdoch University, School of Psychology, South Street, Murdoch, Western Australia 6150, Australia*

ARTICLE INFO

*Article history:*
Received 23 March 2010
Received in revised form 28 June 2010
Accepted 28 June 2010

*Keywords:*
EMDR
Eye movements
Autobiographical memory
Psychophysiology
Orienting response

ABSTRACT

This study aimed to investigate the psychophysiological correlates and the effectiveness of different dual-attention tasks used during eye movement desensitization and reprocessing (EMDR). Sixty-two non-clinical participants with negative autobiographical memories received a single session of EMDR without eye movements, or EMDR that included eye movements of either varied or fixed rate of speed. Subjective units of distress and vividness of the memory were recorded at pre-treatment, post-treatment, and 1 week follow-up. EMDR-with eye movements led to greater reduction in distress than EMDR-without eye movements. Heart rate decreased significantly when eye movements began; skin conductance decreased during eye movement sets; heart rate variability and respiration rate increased significantly as eye movements continued; and orienting responses were more frequent in the eye movement than no-eye movement condition at the start of exposure. Findings indicate that the eye movement component in EMDR is beneficial, and is coupled with distinct psychophysiological changes that may aid in processing negative memories.

© 2010 Elsevier Ltd. All rights reserved.

## 1. Introduction

An extensive body of literature has demonstrated efficacy of eye movement desensitization and reprocessing (EMDR) for the treatment of posttraumatic stress disorder (PTSD). Meta-analyses that have examined efficacy of EMDR have concluded that it is as effective as traditional exposure therapy (Bisson et al., 2007; Bradley, Greene, Russ, Dutra, & Westen, 2005), and many international clinical practice guidelines recommend both therapies for the treatment of PTSD (Foa, Keane, Friedman, & Cohen, 2009; National Institute for Clinical Excellence, 2005). However, processes that operate in EMDR remain unclear. In particular, a longstanding debate continues in the literature about whether processes in EMDR are different from those of traditional exposure, and controversy still remains about the role of the eye movements in EMDR.

EMDR is a complex therapy with many elements (Solomon & Shapiro, 2008). Processes identified in EMDR include mindfulness, somatic awareness, free association, cognitive restructuring, and conditioning. These processes may interact to create the positive effects achieved through EMDR (Gunter & Bodner, 2009; Solomon & Shapiro, 2008). However, the mechanism of change in EMDR that has received most attention in the scientific literature is the eye movements (EMs) and other bilateral stimulation (i.e., tones and tapping) that are used as a dual-attention task within the procedure. To date, research that has examined the effect of the EMs in EMDR has resulted in mixed and inconsistent findings. It has been demonstrated that a single session of EMDR-with EMs leads to greater reductions in distress compared to EMDR-without EMs (Lee & Drummond, 2008; Wilson, Silver, Covi, & Foster, 1996). However, other researchers have reported that EMDR-with or -without EMs led to significant positive, but equivalent treatment effects (Pitman et al., 1996; Renfrey & Spates, 1994). Davidson and Parker (2001) employed meta-analysis to examine the impact of the EMs in EMDR, but found only marginally significant effects of the EMs in clinical populations. Thus, at present the contribution that EMs make to overall clinical effectiveness remains unclear.

A separate, expansive body of literature demonstrates that EMs have various effects on cognitive, neurological, and physiological processes that aid in memory processing. Laboratory research on non-clinical samples has demonstrated that when negative memories are recalled induced EMs decrease the emotionality and degree of vividness associated with them (Andrade, Kavanagh, & Baddeley, 1997; Barrowcliff, Gray, Freeman, & MacCulloch, 2004; Gunter & Bodner, 2008; Kavanagh, Freese, Andrade, & May, 2001; Maxfield, Melnyk, & Hayman, 2008; van den Hout, Muris, Salemink, & Kindt, 2001). Induced saccadic EMs have also been shown to affect cognitive processes such that they enhance episodic memory retrieval (Christman, Garvey, Propper, & Phaneuf, 2003; Christman, Propper,

* Corresponding author. Tel.: +61 408 483460; fax: +61 8 9360 6492.
*E-mail addresses:* s.schubert@murdoch.edu.au (S.J. Schubert), chris.lee@murdoch.edu.au (C.W. Lee), p.drummond@murdoch.edu.au (P.D. Drummond).

0887-6185/$ – see front matter © 2010 Elsevier Ltd. All rights reserved.
doi:10.1016/j.janxdis.2010.06.024

& Dion, 2004; Propper & Christman, 2008), increase the accuracy of memories recalled (Christman et al., 2004; Lyle, Logan, & Roediger, 2008; Parker, Relph, & Dagnall, 2008), induce cognitive and semantic flexibility, and facilitate attentional orienting (Kuiken et al., 2001–2002). Research investigating the neurological effects of EMs has demonstrated that saccadic EMs create changes in brain activation that enhance memory processing (Christman et al., 2003; Christman et al., 2004; Christman, Propper, & Brown, 2006).

While neurological changes created by EMs is a relatively new field of research, the physiological effects of induced EMs have been reported for many years, not only in laboratory studies but also more recently in treatment studies with PTSD patients (Elofsson, von Schèele, Theorell, & Söndergaard, 2008; Sack et al., 2008). EMs produce distinct psychophysiological effects, with most studies suggesting that they are associated with psychophysiological dearousal (for a review, see Söndergaard & Elofsson, 2008). For example, Barrowcliff et al. (2004) found that when participants brought-to-mind negative autobiographical memories EMs, compared to an eyes stationary condition, consistently reduced physiological arousal as indicated by significantly lower skin conductance. They concluded that their findings offer support for the orienting response theory of EMDR (MacCulloch and Feldman, 1996).

The orienting response (OR) was first described by Pavlov (1927) as "a "what-is-it" reflex which brings about the immediate response in man and animals to the slightest change in the world around them, so that they immediately orientate their appropriate receptor organ in accordance with the perceptible quality in the agent bringing about the change, making full investigation of it" (p. 12). Russian physiologist Eugene Sokolov (1963) proposed that the OR has two distinct phases: first, an alerting reaction in response to a novel stimulus in the environment; and second, habituation that leads to a reduction of the OR with repeated stimulus presentations in the face of no danger or threat. The OR is a well defined reflex and it is one of the most heavily investigated topics in psychophysiology (Sokolov & Cacioppo, 1997). The psychophysiological profile of the OR is characterized by an increase in parasympathetic tone (reflected by bradycardia and increased heart rate variability), decreases in respiration rate, and an increase in sympathetic tone (reflected by skin conductance increases and skin temperature reductions) (Öhman, Hamm, & Hugdahl, 2000). This reaction is a short-term (less than 10 s) response that habituates quickly. Shapiro (1995) has proposed that desensitization of trauma memories occurs in EMDR through possible mechanisms such as the orienting response, and other mechanisms such as disruptions in working memory and reciprocal inhibition.

The EM component in EMDR is thought to aid in the processing of memories by taxing working memory (Maxfield et al., 2008). Working memory theories of EMDR are based on Baddeley and Hitch's (1974) model that states that working memory is a capacity limited system that is responsible for consciously maintaining information in the face of ongoing information processing and/or distraction. Working memory theory proposes that targeted memories are held in working memory during EMDR. Concurrently engaging in EMs during EMDR overloads working memory capacity and, in turn, the memories held in mind become less vivid. Working memory theory predicts that the more complex the dual-attention task in EMDR, the greater the reductions in vividness and distress associated with negative memories.

A third account of EMDR proposes that counter-conditioning through reciprocal inhibition (Wolpe, 1991) is a mechanism underlying EMDR. The theory of reciprocal inhibition posits that two incongruent responses (relaxation and anxiety) cannot coexist. Research suggests that the EMs in EMDR, through inducing ORs that dissipate, create a state of physiological dearousal while patients simultaneously think about the traumatic memory (Wilson et al., 1996). Thus, a relaxation response is paired with the distress associated with the traumatic memory and, in turn, the association between the traumatic memory and the distress response weakens. Studies using EMDR have found that psychophysiological dearousal occurs from before to after successful treatment (Aubert-Khalfa, Roques, & Blin, 2008; Forbeset al., 1994; Sack, Lempa, & Lamprecht, 2007). Surprisingly, however, very little empirical research has examined psychophysiological changes *during* treatment sessions in patients with PTSD.

The first published study to have examined the mechanisms of EMDR by investigating the autonomic responses during EMDR was by Wilson et al. (1996). Eighteen subjects with distressing memories of traumatic events were treated with a single session of either EMDR-with EMs or two comparison treatments (EMDR-with tapping, or EMDR-with no EMs). EMDR-with EMs, but neither of the comparison conditions, led to significant physiological dearousal from before to after treatment. Onset of the EMs was associated with a relaxation response, suggesting that reciprocal inhibition is at least one of the mechanisms underlying EMDR.

More recently similar autonomic changes have been reported during EMDR intervention in naturalistic treatment settings with PTSD clients (Elofsson et al., 2008; Sack, Lempa, Steinmetz, Lamprecht, & Hofmann, 2008). Both studies provide support for a dearousal model of EMDR, as the authors demonstrated that EMDR resulted in significant physiological dearousal across the treatment session, reflected by a shift in autonomic balance as indicated by lowered heart rate (HR), respiration rate (RR), skin conductance (SC), and increased heart rate variability (HRV). Analysis of the within session physiological processes also indicated that the EM component in EMDR was associated with certain physiological changes. When the EMs began HR significantly decreased within the first 10 s, and HRV increased, together indicating decreased sympathetic and increased parasympathetic activity respectively. Although RR decreased across sessions, both Sack and Elofsson found that EM sets were associated with a significant increase in RR. Elofsson and colleagues also demonstrated that EMs were associated with a trend towards a decrease in SC. Sack and colleagues concluded that there was a clear association between the onset of redirecting the focus of awareness and following the therapist's moving hand with one's eyes and the elicitation an orienting response with psychophysiological de-arousal. A limitation of these findings was that neither study included a control group; therefore, the causal relationship between the onset of the EMs and the observed psychophysiological changes remains unclear.

The primary aim of this study was to investigate the psychophysiological correlates of the EM component in EMDR during a single treatment session by comparing findings to an EMDR condition with the eye movements omitted from the procedure. The study therefore also assessed the necessity of the EMs in EMDR. A further aim was to examine the effectiveness and psychophysiological correlates of two different types of eye movements commonly used in EMDR: fixed rate versus varied rate.

It was hypothesized that EM conditions would be more effective than the no-EM condition at reducing distress associated with negative memories. A further hypothesis was that the varied EM condition, assumed to be more taxing on working memory, would be more effective than the fixed EM condition and would generate more orienting responses. It was also hypothesized that physiological arousal would decrease within treatment sessions, and that different physiological responses would be noted for the EM conditions compared to the no-EM condition. Finally, it was expected that the physiological patterns of an orienting response would occur at the beginning of stimulation sets for the EM conditions.

## 2. Method and materials

### 2.1. Participants

Sixty-four psychology students from an Australian university were recruited, and two were excluded. An inclusion criterion was that the participants had a memory of a stressful experience that still created a level of distress. One participant was excluded due to scoring above 30 on the Dissociative Experiences Scale (DES-II: Carlson & Putnam, 1993) and the other participant's rate of distress at pre-test was too low to warrant treatment. The 51 females (82.3%) and 11 males (17.7%) who completed treatment had an average age of 24.74 years (SD = 9.671, range = 18–58 years). Eighty-five percent of the participants were Caucasian and 15% were Asian. The majority (86%) of participants received course credit for participating. After receiving information about the aims of the study, all participants gave their written consent. The University Human Research Ethics committee approved the study.

### 2.2. Design

This experiment had one between participants independent variable with three levels: 1. fixed eye movements (EM-fixed), 2. varied eye movements (EM-varied), and 3. a no eye movement control (no-EM). In all conditions participants received EMDR treatment that differed only in the type of dual-attention task used during stimulation sets. Participants in the EM-fixed condition engaged in eye movements that were fixed in width and were a constant rate of one back and forth per second. Participants in the EM-varied condition received eye movements that varied in speed and width. The induced EMs were thus pursuit EMs that involved catch-up and/or anticipatory saccadic intrusions (Collewijn & Tamminga, 1984; Kapoula, Yang, Bonnet, Bourtoire, & Sandretto, 2010), however the extent of saccadic intrusions were not measured. In the no-EM, exposure only control, the eye movements were removed from the EMDR procedure. Instead, during each set participants closed their eyes for the average period of a set (approximately 24 s).

### 2.3. Procedure and measures

Before any discussion of trauma memories participants completed the Dissociative Experiences Scale (DES: Bernstein & Putnam, 1986). This is a commonly used, standardized test of dissociation for non-clinical and clinical samples. In college samples high scorers have been identified as those scoring above 30 (Zingrone & Alvarado, 2001); thus to avoid including participants with dissociative tendencies those who scored above 30 were excluded.

Participants were asked to recall a stressful or traumatic experience that had happened to them in the past that still created distress when they thought of the experience in the present. Participants were introduced to the Subjective Units of Distress Scale (SUDs: Wolpe, 1991), which is an 11-point self-report scale (0 = no disturbance or distress; 10 = the highest distress possible) routinely used to assess the intensity of distress associated with a specific experience. The validity of the SUDs scale has been demonstrated (Kaplan, Smith, & Coons, 1995; Kim, Bae, & Park, 2008), and the scale has been shown to correlate with several physiological measures of stress (Thyer, Papsdorf, Davis, & Vallecorsa, 1984).

Participants were asked to recall an incident that was associated with a score of approximately 6 on the SUDs scale. Participants described the incident and identified the most distressing moment. This moment became the target memory. Participants were asked to rate the vividness of the target memory by holding it in mind for 10 s and indicating on a 10 cm visual analogue scale the degree to which the image appeared vivid from “not at all clear” (extreme left) to “very clear” (extreme right). This measure has been used in previous studies to rate vividness (Lee & Drummond, 2008; van den Hout et al., 2001). Following this, participants completed an Impact of Events Scale (IES: Horowitz, Wilmer, & Alvarez, 1979) for the incident. Treatment was then administered.

Treatment in all conditions followed Shapiro's (2001) EMDR protocol and included six phases: 1. Preparation, 2. Target assessment, 3. Desensitization, 4. Installation of a positive cognition, 5. Body scan, and 6. Closure. After the preparation phase the therapist allocated participants to a condition by drawing the top unmarked instruction package from a shuffled pile. Treatment rationales were given as per the instructions for the particular assigned condition. After this, participants completed an expectancy scale that was designed to assess the degree to which they expected their assigned condition to be successful at reducing the distress associated with their target memory. The 10-point expectancy scale was based on expectancy items used in previous research (Borkovec & Nau, 1972; Feske & Goldstein, 1997; Lee & Drummond, 2008).

Once desensitization began treatment continued for a maximum of 45 min. This controlled for the amount of treatment participants received, but meant that the session length did not always allow for the installation phase and body scan to be completed. If SUDs did not decrease significantly, a relaxation or safe place procedure was administered after all physiological measures had been recorded, but before closing the session. Participants were followed up 1 week later via telephone to attain a SUDs and vividness (VAS) rating relating to the target memory.

Treatment was administered by the first author, a post-graduate clinical psychology student with level II EMDR training (accredited by the international EMDR association). After treatment participants rated their response to the question “how confident do you believe the therapist was that the type of procedure used to process the emotional memory would help you?” on an 11-point scale (0 = not confident, 10 = extremely confident). Treatment sessions were videotaped. The second author randomly selected 6 tapes from the EM conditions and 6 from the no-EM condition and rated the sessions according to a fidelity checklist provided from EMDR training. The checklist used a 7-point scale to rate the implementation of the EMDR treatment procedures (1 = poor, 4 = fair, and 7 = excellent). For ratings of treatment fidelity, a mean overall integrity rating of 6.27 (SD = 0.14) was assigned to the therapy sessions in the EM conditions, and 6.18 (SD = 0.15) to the sessions in the no-EM condition. These means were not significantly different, $t_{10} = 1.02$, $p = .33$.

### 2.4. Psychophysiological assessment

Physiological variables measured were HR, HRV, RR, and SC. These variables were chosen because they could be measured non-invasively, without interference to treatment, and because they are commonly used as indices for de-arousal and are assumed to be involved in the physiological pathways operating in working models of EMDR. Prior to participants providing a description of their distressing experience, electrodes and sensors were placed and the physiological variables were allowed to stabilize for a 5 min adaptation period. Data acquisition took place throughout the whole session.

Electrocardiogram (ECG) data was recorded using a standard three-lead configuration where Ag-AgCl-electrodes were placed on the inner aspect of both forearms and the right ankle. SC was measured using a Galvanic Skin Response Amplifier GSR100C (Biopac Systems Inc.), and was recorded by means of constant voltage (0.5 V, set to a Gain of 2 μS per volt) using a pair of Ag/AgCl-electrodes (8 mm internal diameter) filled with electrode gel (Johnson and Johnson KY Jelly as recommended by Edelberg, 1967). Electrodes were attached to the second phalanx of the middle and ring fingers on participant's non-dominant hand. RR was acquired using a flexible respiration belt that detected changes in thoracic circumference. Signals were sampled 1000 times/second via a Biopac MP100 data acquisition system and data was stored and averaged using Acknowledge software 3.9.0 (Biopac Systems Inc.).

### 2.5. Psychophysiological signals processing

Physiological measures were monitored during the recording and visually inspected offline. Recording artifacts were manually identified and corrected by interpolation if less than 10% of any measurement period needed correction; otherwise, measurement periods were discarded (resulting in differing degrees of freedom throughout the analysis).

To calculate HR and HRV a time series waveform of interbeat intervals was generated from the ECG data. From this the average heart beat per minute was calculated for each measurement period. Due to the nature of the EMDR protocol, with relatively short stimulation sets, and the short measurement periods examined in this study, HRV was calculated using the square root of the mean squared differences (RMSSD) between successive interbeat intervals. RMSSD is the most commonly used method for calculating HRV from interval differences between heartbeats (Thayer, Hansen, & Johnson, 2008). It has been documented that HRV from short recordings can assess cardiac autonomic activity (Task Force of the European Society of Cardiology and the North American Society of Pacing and Electrophysiology, 1996). There is growing evidence that RMSSD is a suitable means to assess parasympathetic nervous system activity, with reduced activity (i.e. low RMSSD values) indicating a stress response. In addition, research by Schroeder et al. (2004) demonstrated that RMSSD calculated from 10 s of data showed the same reproducibility as those obtained from 6 min; thus the HRV parameters in this data set should be accurate in assessing cardiac autonomic activity.

As the interval generated from raw respiratory data was markedly influenced by artifact, RR was determined by manually counting and averaging the number of breaths over each measurement period, and was expressed in breaths per minute. SC was measured and expressed in μS, and was determined by averaging responses over each measurement period. The number of skin conductance responses (SCRs) was also examined. A significant SCR was defined as a trough-to-peak increase of at least 0.04 μS. Thus, any response greater than this was tallied and averaged for each measurement period. SCRs were expressed in responses per minute when comparing the number in the first three stimulation sets compared to the last three sets. SCRs within sets were expressed as the number occurring per 10 s. The amplitude of SCRs was also recorded, averaged for each measurement period, and analysed.

### 2.6. Data reduction and statistical analyses

Self-report within session trends across conditions were investigated using a repeated measures ANOVA to examine the effect of time. Specific hypotheses about the changes in self-reported measures for each condition were examined using contrast analysis by conducting oneway ANOVAs that compared changes in the EM-fixed condition to the EM-varied condition, and also changes in the EM conditions combined to the no-EM condition.

To assess psychophysiological changes within sessions the following measurement periods were defined: first, a 30 s baseline period immediately prior to commencing the desensitization phase and another immediately after EMDR treatment ended; second, the mean of the physiological variables was calculated within the first 3 and last 3 sets of the session. To assess the physiological changes during EM or no-EM/exposure periods the following measurement periods were defined: A: 10 s interval prior to stimulation (pre-stimulation); B: first 10 s of ongoing stimulation; C: middle period of stimulation. This period was defined as the difference between the first and final 10 s of each set. D: final 10 s of stimulation. Data were not included if any measurement period was less than 10 s.

Significant effects were examined using a repeated measures ANOVA, with the treatment condition as a between participants factor and time as the repeated factor. Post hoc analyses used paired samples *t*-tests for within condition comparisons and independent *t*-tests for between condition comparisons. Bonferroni corrections were used with all *t*-tests, and an overall significance level was set at an alpha level of .05. To report the magnitude of statistically significant effects partial eta squared ($\eta_p^2$) is used to report effect sizes for repeated measures ANOVAs and Cohen's *d* for oneway ANOVAs and *t*-tests. Data were analyzed using SPSS 17.

## 3. Results

### 3.1. Preliminary analysis

Prior to the main analysis, appropriate tests were conducted to determine whether groups were equivalent in terms of stimulation periods received during treatment, baseline data associated with the target memory, and expectancies of treatment. Within EMDR sessions the mean number of stimulation periods (with SD in parentheses) for all treatment conditions were: EM-fixed = 24.43 (7.58), EM-varied = 25.95 (7.41), no-EM = 27.95 (9.14). A oneway ANOVA revealed that these means were not significantly different, $F_{2,\ 59} = .98$, $p = .38$. Oneway ANOVAs were also used to investigate differences between treatment groups on pre-treatment measures. No differences were found for the IES, $F_{2,\ 59} = .53$, $p = .59$, DES-II, $F_{2,\ 59} = .50$, $p = .61$, SUDs, $F_{2,\ 59} = .62$, $p = .54$, or VAS ratings, $F_{2,\ 59} = .09$, $p = .92$. The associated scores on the IES ($M = 30.92$, SD = 11.62) and the pre-treatment SUDs ratings ($M = 6.92$, SD = 1.24) indicated that the majority of participants chose memories associated with a medium level of trauma symptomatology and a moderate degree of distress. No differences were found between treatment conditions on treatment expectancy ratings, $F_{2,\ 59} = .09$, $p = .41$, or the participant's perception of the therapist's confidence in the treatment process, $F_{2,\ 24} = .10$, $p = .91$. Thus, random assignment appears to have resulted in each condition being equivalent prior to the intervention, and there is no evidence that expectancy or therapist confidence in the treatment conditions played a part in treatment effects.

### 3.2. Self-report within session trends

A repeated measures ANOVA revealed that SUDs decreased significantly in all treatment conditions over time, $F_{2,\ 118} = 256.21$, $p < .0005$, $\eta_p^2 = .81$ (see Fig. 1). The rate of improvement across treatment conditions was investigated with oneway ANOVAs to compare the EM conditions combined to the no-EM condition, and also to compare the EM-Fixed to the EM-varied condition. When comparing the EM to the no-EM condition the analysis revealed that participants in the EM condition had significantly lower SUDs ratings than those in the no-EM condition at both post-treatment, $F_{1,\ 60} = 3.72$, $p = .03$, $d = .46$ (one-tailed), and at follow-up, $F_{1,\ 60} = 5.59$, $p = .01$, $d = .61$, (one-tailed). In contrast to what was hypothesized, no significant differences were found in reported SUDs ratings of participants in the EM-fixed condition compared to the EM-varied condition at either post-treatment or follow-up, $F_{1,\ 40} = 2.06$, $p = .16$, $d = .45$ and $F_{1,\ 40} = 2.44$, $p = .13$, $d = .49$ respectively.

A repeated measures ANOVA revealed that VAS ratings decreased significantly in all treatment conditions over time, $F_{2,\ 118} = 68.49$, $p < .0005$, $\eta_p^2 = .54$ (see Fig. 2).

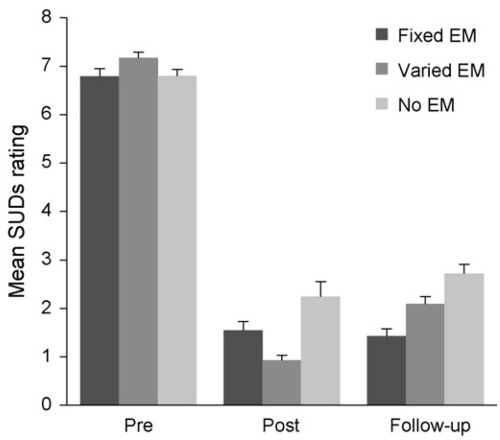


**Fig. 1.** Mean SUDs ratings for each condition at pre- and post-treatment, and at follow-up. Error bars represent standard error of the mean (SEM).

The reduction in VAS ratings across treatment conditions was investigated with oneway ANOVAs using planned contrasts. Although there was a trend towards the reductions in VAS ratings being greater in the EM conditions compared to the no-EM condition at post-treatment no significant differences were found between the EM and no-EM conditions, or between the EM-fixed and EM-varied condition at any time point.

### *3.3. Psychophysiological trends from before to after EMDR treatment*

First, trends in physiological data were examined using repeated measures ANOVAs, and significant effects were examined based on hypotheses using oneway ANOVAs with planned contrasts at each time point. With the exception of an elevation in the EM-fixed over the EM-varied condition in the size of skin conductance responses in the first 10 s of the first three sets of the EMDR session, no significant differences were found between changes in autonomic responses for the EM-fixed and EM-varied conditions when examining trends from before to after treatment, during stimulation periods, or when examining the number of skin conductance responses within treatment. Therefore, to investigate the effect of the eye movement component in EMDR, the analysis from this point on compared the physiological changes in both EM conditions to responses in the no-EM condition.

Psychophysiological changes within treatment sessions were examined using repeated measures ANOVAs to investigate changes in each physiological variable from before to after treatment during the rest period measured immediately before and after the desensitization phase. The analysis revealed a significant decrease in HR, $F_{1,\ 60}$ = 10.38, $p$ = .002, $\eta_p^2 = .15$, and SC, $F_{1,\ 60}$ = 23.38, $p < .0005$, $\eta_p^2 = .28$, across the treatment session, and a significant increase in HRV, $F_{1,\ 57}$ = 5.48, $p$ = .02, $\eta_p^2 = .09$. Although RR appeared to decrease within the session, the reduction was not significant, $F_{1,\ 60}$ = 3.12, $p$ = .08, $\eta_p^2 = .05$. Overall, these findings indicate physiological dearousal from before to after treatment, consistent with the reduction in subjective ratings of distress (SUDs). Time by condition interactions were non-significant for SC, RR, or HRV measures, indicating that the changes in physiology were similar in the EM and no-EM conditions. However, for HR the time by condition interaction approached significance, $F_{1,\ 60}$ = 3.73, $p$ = .058, $\eta_p^2 = .06$. Post hoc analyses using paired $t$-tests revealed that the decrease in HR from before to after treatment was significant for the EM condition, $t_{41}$ = 4.61, $p < .0005$, $d$ = 1.44, but in the no-EM condition the decrease was not significant, $t_{19}$ = 0.76, $p$ = .46, $d$ = .35 (see Table 1).

Changes within treatment sessions were also examined by comparing the physiological variables during the first three stimulation periods to the last three stimulation periods of each session. Again, the analysis revealed a significant decrease in HR, $F_{1,\ 59}$ = 5.17, $p$ = .03, $\eta_p^2 = .08$, SC, $F_{1,\ 57}$ = 16.91, $p < .0005$, $\eta_p^2 = .23$, and RR, $F_{1,60}$ = 10.89, $p$ = .002, $\eta_p^2 = .15$, within the treatment session. However, there was no significant change in HRV, $F_{1,\ 52}$ = 0.30, $p$ = .86, $\eta_p^2 = .01$. A significant time by condition interaction was noted for changes in RR, $F_{1,\ 60}$ = 12.72, $p$ = .001, $\eta_p^2 = .18$. Post hoc analyses using paired $t$-tests revealed that there was a significant reduction in RR for the EM condition, $t_{41}$ = 6.25, $p < .0005$, $d$ = 1.02, but not in the no-EM condition, $t_{19}$ = −0.45, $p$ = .88, $d$ = −.20 (see Table 1).

These findings suggest that all EMDR conditions led to improvement in SUDs and physiological dearousal, but different processes occurred in EMDR when EMs were used compared to when EMs were omitted. To further explore this possibility, physiological correlates of the EM component in EMDR were examined during stimulation periods within the desensitization phase of EMDR.

### *3.4. Psychophysiological changes during stimulation within EMDR treatment sessions*

Applying repeated measures ANOVAs, significant time effects were noted for all physiological variables (see Table 2). Time by condition interactions were significant for RR, approached significance for HR, and were non-significant for SC and HRV. Main group effects and within-subject contrasts that compared pre-stimulation values (A) with during-stimulation phases (B, C, and D) revealed the following.

Changes in RR differed between conditions (see Table 2 and Fig. 3). The RR in the EM condition did not change significantly from pre-stimulation to the first 10 s during the set. However, as stimulation continued RR increased significantly. In contrast, when EMs were omitted from the EMDR procedure RR decreased significantly within the first 10 s of the set. RR then began to increase, but it remained lower than the pre-stimulation rate throughout the set. Although the RR in the EM condition suggests physiological arousal during stimulation, all other physiological variables indicate a dearousal response throughout EM sets.

In the EM condition HR decreased significantly during stimulation (see Table 2 and Fig. 4). However, in the no-EM condition the change in HR was not significant. In addition to this, and consistent with presence of an orienting response, a significantly large and pronounced decrease in HR occurred within the first 10 s after the eye movements began in the EM conditions. No significant change in HR occurred during this period when eye movements were omitted. Deceleration in HR in the EM conditions was accompanied by

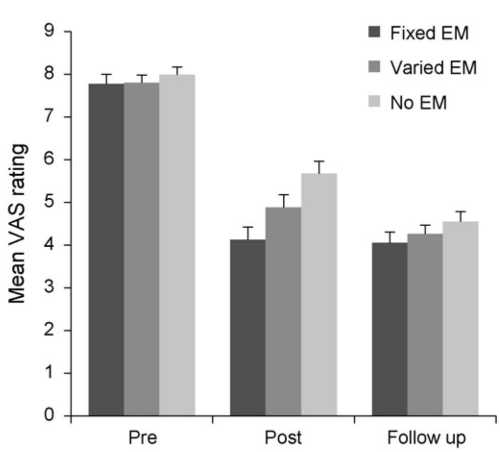


**Fig. 2.** Mean VAS ratings for each condition at preand post-treatment and at follow up. Error bars represent SEM.

**Table 1**
Means, standard deviations, and statistical comparisons for psycho-physiological measures for each condition pre- and post-treatment, and during the first three vs. last three stimulation periods of each treatment session.

| Measure | Condition | BL30[a] pre | | BL30 post | | Statistical comparison | EM1-3[b] first | | EM1-3 last | | Statistical comparison |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *M* | (SD) | *M* | (SD) | | *M* | (SD) | *M* | (SD) | |
| HR | EM | 75.33 | (10.51) | 70.94 | (9.14) | *** | 73.96 | (9.38) | 72.98 | (8.83) | ns |
| | No EM | 73.59 | (10.39) | 72.48 | (9.05) | ns | 74.91 | (10.08) | 73.35 | (9.45) | * |
| SC | EM | 2.06 | (1.61) | 1.58 | (1.25) | *** | 1.80 | (1.20) | 1.44 | (1.03) | *** |
| | No EM | 2.45 | (1.59) | 2.06 | (1.34) | ** | 2.19 | (1.24) | 1.94 | (0.99) | * |
| RR | EM | 15.17 | (5.29) | 13.13 | (3.38) | * | 17.31 | (3.96) | 14.85 | (2.87) | *** |
| | No EM | 15.19 | (3.73) | 14.93 | (3.58) | ns | 14.77 | (3.96) | 14.87 | (3.82) | ns |
| HRV | EM | 33.70 | (16.23) | 39.40 | (16.77) | ** | 34.03 | (13.88) | 34.39 | (13.40) | ns |
| | No EM | 47.06 | (30.80) | 50.19 | (24.12) | ns | 39.17 | (21.44) | 38.32 | (14.56) | ns |

*Note:* Statistical comparison used paired *t*-tests. *sig. at .05, **sig. at .01, ***sig at .001, ns = not significant.
[a] BL30 indicates the 30 s baseline measurement period immediately pre or post treatment.
[b] EM 1-3 indicates the measurement period where the mean of physiological variables were calculated within the first and last 3 sets of the treatment session.

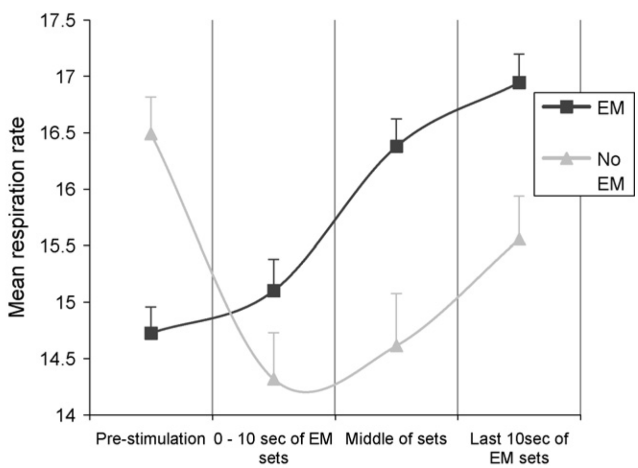


**Fig. 3.** Mean respiration rate of each condition prior to and during eye movements of the first and last three sets of each session. Error bars represent SEM.

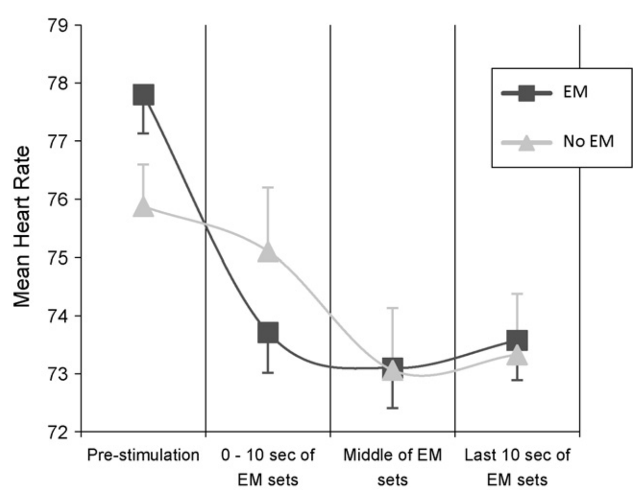


**Fig. 4.** Mean heart rate of each condition prior to and during eye movements of the first and last three sets of each session. Error bars represent SEM.

a significant increase in HRV, together indicating decreased physiological arousal and increased parasympathetic activity during stimulation. Although HRV also increased from pre-stimulation to the start of the stimulation period in the no-EM condition, none of the changes in HRV were significant.

Also indicating decreased arousal, SC during stimulation showed a pattern of significant decline both in the EM and no-EM conditions. Although the overall time by condition interaction was non-significant for SC, it is interesting to note that the average SC responses for participants in the EM conditions did not change significantly from pre-stimulation to the first 10 s of the set, whereas in the no-EM condition the decrease in SC was significant. Visual inspection of the data indicated that there were short bursts of increased SC within the first 10 s of stimulation sets. One of the main hypotheses about the working mechanisms of EMDR is that dual-attention stimulation created by eye movements in EMDR causes de-arousal by eliciting an OR (Elofsson et al., 2008; Sack et al., 2008). The spikes in SC within the first 10 s of stimulation indicate the presence of an OR, and thus warranted further examination.

### *3.5. Skin conductance responses in EMDR: Examining the presence of an orienting response*

#### *3.5.1. The number of skin conductance responses*

For each participant the SCRs were examined in the first and last three stimulation sets. Based on orienting response theory (Sokolov, 1963), and the knowledge that habituation is a hallmark distinguishing feature of the OR (Zimmer, 2006), if the spikes identified in the SC data represent the presence of an OR it is assumed that as the novel stimulus (the eye movements) continued, habituation to the EMs would occur across the treatment session and within each stimulation set. Thus, if the spikes in SC represent an orienting response there would be more SCRs at the beginning of the session than the end. This was found to be the case for the EM condition, but not for the no-EM condition. To compare the number of SCRs that occurred in the EM and no-EM conditions within the first 3 sets compared to the last 3 sets, a repeated measures ANOVA was used. Results indicated a non-significant effect of time, $F_{1,\ 60} = 1.19$, $p = .28$, $\eta_p^2 = .02$, and a time by condition interaction that approached significance, $F_{1,\ 60} = 3.73$, $p = .058$, $\eta_p^2 = .06$. When comparing the number of SCRs in the first 3 sets to the last 3 sets of the session it was found that for the EM conditions combined the number of SCRs decreased significantly from an average of 2.19 (SD = 2.23) responses per minute to 1.41 (SD = 1.36) responses per minute, $t_{41} = 2.41$, $p = .02$, $d = .75$. For the no-EM condition there was no significant difference in the number of SCRs within the first three sets ($M = 1.29$, SD = 1.15) compared to the last three sets ($M = 1.51$, SD = 1.55) of the session, $t_{19} = -.70$, $p = .49$.

If the SCRs represent the presence of an orienting response then the number of responses should also decrease within sets as participants habituate to the ongoing presence of the eye movement

**Table 2**
Physiological variables pre- and during-attentional stimulation periods.

| Variable | Cond. | Stimulation period | | | | | | | | Main effects: Time and interaction | | | | Main group effects: EM and no-EM | | | | Within-subject contrasts | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Pre. A: -13 to -3 s prior to set | | Start. B: 0-10 s of set | | Middle. C: between first and last 10 s of set | | End. D: final 10 s of set | | | | | | | | | | | | |
| | | M | (SD) | M | (SD) | M | (SD) | M | (SD) | F | (d.f.) | p | $\eta_p^2$ | F | (d.f.) | p | $\eta_p^2$ | A/B | A/C | A/D |
| HR | EM | 77.80 | (8.70) | 73.71 | (8.98) | 73.10 | (8.91) | 73.58 | (8.85) | T:21.12 | (1.56,93.60) | .000 | 0.251 | 45.02 | (1.85,75.75) | .000 | 0.523 | *** | *** | *** |
| | NoEM | 75.87 | (6.43) | 75.10 | (9.79) | 73.06 | (9.57) | 73.33 | (9.38) | I:3.25 | (1.56,93.60) | .055 | 0.051 | 2.54 | (1.4,26.61) | .113 | 0.118 | ns | ns | ns |
| SC | EM | 1.72 | (1.15) | 1.69 | (1.12) | 1.61 | (1.05) | 1.54 | (1.02) | T:42.26 | (1.46,87.42) | .000 | 0.413 | 32.06 | (1.45,59.52) | .000 | 0.439 | ns | *** | *** |
| | NoEM | 2.22 | (1.14) | 2.12 | (1.09) | 2.05 | (1.04) | 2.00 | (1.03) | I:1.13 | (1.46,87.42) | .313 | 0.018 | 14.89 | (1.45,27.55) | .000 | 0.439 | ** | *** | *** |
| RR | EM | 14.73 | (3.03) | 15.10 | (3.59) | 16.38 | (3.15) | 16.95 | (3.27) | T:8.09 | (2.55,152.96) | .000 | 0.119 | 16.18 | (2.48,101.67) | .000 | 0.283 | ns | *** | *** |
| | NoEM | 16.49 | (2.91) | 14.32 | (3.67) | 14.61 | (4.12) | 15.56 | (3.42) | I:12.76 | (2.55,152.96) | .000 | 0.175 | 8.29 | (2.41,45.87) | .000 | 0.304 | *** | ** | ns |
| HRV | EM | 31.25 | (10.96) | 35.57 | (15.13) | 36.43 | (15.91) | 37.66 | (20.28) | T:4.83 | (2.62,144.14) | .005 | 0.081 | 5.10 | (2.32,88.21) | .006 | 0.118 | * | ** | * |
| | NoEM | 36.76 | (15.03) | 42.21 | (22.02) | 41.65 | (20.78) | 40.40 | (20.73) | I:0.53 | (2.62,144.14) | .526 | 0.009 | 1.50 | (2.34,39.83) | .234 | 0.081 | ns | ns | ns |

*Note.* Main effects analysis used repeated measures ANOVAs. As the assumption of sphericity was violated, results reported use Huynh-Feldt. T = main effect of time. I = main effect of the time by condition interaction. Within-subject contrasts (Bonferroni corrected for multiple testing): ns = non significant, *$p<.05$, **$p<.01$, ***$p<.001$.

stimulus. To examine this, number of SCRs per 10 s was calculated for each measurement period (i.e. the beginning, middle, and end of each set) within the first three sets of EMDR for both the EM and no-EM condition. The ANOVA revealed a significant effect of time, $F_{2,\ 120} = 29.52$, $p < .0005$, $\eta_p^2 = .33$, and a significant time by condition interaction, $F_{2,\ 120} = 4.61$, $p = .012$, $\eta_p^2 = .07$.

Post hoc analysis using independent *t*-tests revealed that as predicted, there were significantly more SCRs in the EM conditions ($M = 0.68$, SD = 0.66) than the no-EM condition ($M = 0.37$, SD = 0.36) within the first 10 s of the set, $t_{58.90} = 2.38$, $p = .01$, $d = .62$ (one-tailed). There continued to be significantly more SCRs throughout the middle of the set for the EM conditions ($M = 0.23$, SD = 0.26) than the no-EM condition ($M = 0.08$, SD = 0.09), $t_{56.17} = 3.37$, $p = .001$, $d = .90$. As participants habituated to the novel eye movement stimulus, the spikes in SCR within the last 10 s of the set dropped in the EM condition ($M = 0.19$, SD = .30) to be no different from the number seen in the no-EM condition ($M = .20$, SD = .25), $t_{60} = -0.12$, $p = .90$. Post hoc analysis using paired-*t*-tests also revealed that the number of SCRs decreased significantly from the start to the end of the set for both the EM, $t_{41} = 6.08$, $p < .0005$, $d = 1.90$, and the no-EM, $t_{19} = 2.36$, $p = .029$, $d = 1.08$, conditions.

### 3.5.2. *The amplitude of skin conductance responses*

If the spiked SCRs represent the presence of an OR, the amplitude of the SCRs should also decrease across the session and within stimulation sets (Sokolov, 1963). To investigate this, the amplitude of SCRs in the EM and no-EM conditions was compared in the first and last 3 sets. Results indicated a non-significant effect of time, $F_{1,\ 60} = .001$, $p = .97$, $\eta_p^2 = .00$, and a non-significant interaction, $F_{1,\ 60} = 1.20$, $p = .28$, $\eta_p^2 = .02$. The size of the SCRs did not change significantly for the EM conditions from the first three sets ($M = .11$, SD = .12) to the last three sets ($M = .09$, SD = .12) of the session, $t_{41} = 1.03$, $p = .33$, $d = .32$. In the no-EM condition there was a non-significant increase in the size of the SCRs from the start ($M = .09$, SD = .12) to the end ($M = .11$, SD = .14) of the session, $t_{19} = -0.60$, $p = .55$, $d = .28$.

To further determine whether the amplitude of the SCRs decreased within stimulation periods the average size of the SCRs for each measurement period (i.e. the beginning, middle, and end of each set) was compared within the first three sets of each EMDR session for both conditions. The ANOVA revealed a significant effect of time, $F_{2,\ 120} = 4.54$, $p = .01$, $\eta_p^2 = .07$, and a significant time by condition interaction, $F_{2,\ 120} = 3.88$, $p = .02$, $\eta_p^2 = .06$. Post hoc analysis using independent *t*-tests indicated that the size of the SCRs were similar in the EM and the no-EM conditions at the start (EM: $M = .18$, SD = .19; no-EM: $M = .11$, SD = .15), $t_{60} = -1.38$, $p = .17$, middle (EM: $M = .12$, SD = .16; no-EM: $M = .06$, SD = .08), $t_{59.93} = -1.44$, $p = .08$, and end of the set (EM: $M = .04$, SD = .08; no-EM: $M = .10$, SD = .27), $t_{20.58} = 1.00$, $p = .33$. However, post hoc analysis using paired *t*-tests revealed that the amplitude of the SCRs decreased significantly from the start to the end of the set for the EM conditions, $t_{41} = 5.19$, $p < .0005$, $d = 1.62$, but the change in SCR amplitude in the no-EM condition was non-significant, $t_{19} = .15$, $p = .88$, $d = .07$.

## 4. Discussion

This study was designed to examine effectiveness and psychophysiological correlates of different dual-attention tasks used in EMDR. The study is unique as it used a single EMDR session, with either fixed or varied rate EMs, and compared results to a no-EM control, thus allowing for changes to be attributed to the effects of the eye movement component in EMDR. We found that a single EMDR session was effective at reducing the distress associated with negative autobiographical memories. We also found that the EM component in EMDR was beneficial, and was coupled with distinct psychophysiological changes that may aid in processing negative memories.

As hypothesized, when EMs were used in EMDR there was a greater reduction in distress associated with negative memories than when EMs were omitted from the procedure. In this study no difference in effectiveness was seen when either fixed or varied rate EMs were used in EMDR. This research demonstrated that EMDR is associated with significant physiological dearousal within treatment. This study also established that the EMs in EMDR are accompanied by a number of physiological changes: HR decreased significantly at the onset of the EMs; SC decreased during EM sets; HRV increased significantly; RR increased during EM sets; and orienting responses were more frequent in the EM conditions than in the no-EM condition at the start of exposure.

### 4.1. The effects of eye movements vs. no eye movements in EMDR

The finding that a single session of EMDR-with EMs reduced self-reported distress associated with negative memories is consistent with Shapiro's (1989) initial findings that introduced the procedure. Current results also support findings by Wilson et al. (1996) and Lee and Drummond (2008) who found that a single session of EMDR-with EMs leads to greater reductions in SUDs associated with distressing memories than EMDR-without EMs, and this effect was maintained at follow-up.

While several other treatment studies have compared EMDR-with EMs to EMDR-without EMs and found noticeable differences in within-session SUDs decreases (i.e. Boudewyns, Stwertka, & Hyer, 1993; Montgomery & Ayllon, 1994), findings of several studies contradict ours by demonstrating that EMDR-with or -without eye movements leads to significant positive, but equivalent treatment effects (Pitman et al., 1996; Renfrey & Spates, 1994; Sanderson & Carpenter, 1992). To date, research that has compared EMDR-with EMs to EMDR-without EMs has been difficult to interpret due to methodological issues. For example, Sanderson and Carpenter (1992) used a simplified version of the EMD procedure that removed cognitive aspects of the treatment, and asked participants to remain focused on the feared image. The therapy integrity level in Pitman et al. (1996) was low to moderately acceptable, and their no-EM condition had the therapist still administer hand movements while participants' eyes were open but fixed, and simultaneously engage in a tapping task. Similarly, other studies have replaced the EMs in no-EM analogue conditions with alternative dual-attention tasks, rather than simply including a comparison eyes closed, exposure only control. In addition, research has often used small sample sizes, and treatment dose has varied between conditions (i.e. Renfrey & Spates, 1994).

Whilst our findings of greater reductions in distress following EMDR-with EMs compared to EMDR-without EMs is consistent with some, but not all treatment studies, our findings are consistent with analogue studies that have examined the effects of only 8 to 96 s of eye movement on negative autographical memories of non-clinical participants. Greater reductions in distress for EM over no-EM conditions have been consistently found (Andrade et al., 1997; Barrowcliff et al., 2004; Kavanagh et al., 2001; van den Hout et al., 2001; Kemps & Tiggermann, 2007). These non-clinical studies also often reported that thinking of a negative memory and engaging in EMs led to significantly greater reductions in the vividness of memories than exposure with no-EMs. Recently, Lilley, Andrade, Turpin, Sabin-Farrell, and Holmes (2010) have replicated and extended the findings of analogue studies as they demonstrated that EMs, compared to no-EMs or a verbal task, reduced the distress and vividness of trauma images from a clinical population of PTSD patients awaiting treatment.

The rapid reduction of distress and vividness associated with negative memories using EMDR has also been noted by researchers who have used a single EMDR session to treat PTSD (Rogers et al., 1999). Despite EMDR being an effective intervention for rapidly reducing the intensity of negative memories, and that EMs appear to add to this effect, what remains unclear is what type of EMs work best in EMDR. This study showed no significant difference in effectiveness when the therapist used fixed or varied EMs. The only other research that has compared the effects of EMs of different rates on memory processing was by Maxfield et al. (2008). They found that compared to no-EMs, slow and fast EMs led to significantly decreased ratings of memory vividness and emotionality, and fast-EMs led to greater decreases than slow-EMs. Maxfield et al. (2008) concluded that her findings support the working memory model of EMDR. She argued that fast EMs are more difficult to perform and more taxing on the visual spatial sketchpad component of working memory. Further research is needed to examine why certain types of EMs, or other bilateral tasks, lead to different effects on memory processing. As yet, no study has measured how much dual-attention tasks in EMDR tax working memory, or to what degree certain tasks generate ORs. Research has also shown that saccadic EMs have greater effects on memory processing over smooth pursuit EMs (Christman et al., 2003), but research is yet to examine to what extent different EM tasks create saccadic movements during EMDR. Future research should also examine how much these aspects of dual-attention tasks relate to EMDR treatment outcome.

### 4.2. The physiological effects of EMDR and correlates of the EM component within sessions

Evident from this research is that EMDR is associated with significant dearousal within sessions, and that the EM component in EMDR evokes physiological changes that may aid in processing negative memories. This study demonstrated that EMDR led to dearousal from before to after treatment on all physiological variables examined (HR, HRV, SC, and RR), and the reductions in HR and RR were greater for the EM compared to the no-EM condition. Thus, the findings support previous research (Aubert-Khalfa et al., 2008; Sack et al., 2007; Wilson et al., 1996) that reported physiological dearousal within EMDR sessions.

Surprisingly, empirical research that has examined the processes that occur *during* treatment of PTSD patients is scarce. This study demonstrates that onset of the EM component was associated with an immediate decrease in HR during EMDR treatment in a non-clinical sample. This was also observed by Sack et al. (2008) and Elofsson et al. (2008) who used EMDR to treat PTSD patients. However, these findings extend those of past research, as it can be concluded that the decrease in HR is a distinct feature of the EMs because in the no-EM condition HR did not decrease significantly at the onset of exposure sets. In this study, HR continued to decrease slightly across the set when EMs were used, then increased slightly towards the end of the set. This is also in accordance with past findings (Elofsson et al., 2008; Sack et al., 2008). Like Elofsson and Sack, we attribute the changes in HR at the beginning of EM sets as concomitants of an orienting response (Obrist, 1981; Öhman et al., 2000; McCulloch and Feldman, 1996).

Consistent with an OR, the dearousal at the onset of the EMs, as indicated by reduced HR, was coupled with an increase in HRV, which for both EM and no-EM conditions continued to rise, indicating an increase in parasympathetic tone within EM/exposure sets. In an orienting response SC should increase but habituate quickly. In this study SC decreased from the start to the end of EM/exposure sets for both conditions. Although there was no significant interaction between the EM and no-EM conditions in relation to SC changes, an interesting difference was that within the first 10 s of the set the decrease in SC in the EM condition was non-significant and less than the significant decrease in the no-EM condition. Also, within the SC data, short, sharp increases of

SC that resolved quickly were recorded. The OR is characterized by short increases in SC that habituate quickly, while simultaneously sympathetic activity decreases (reflected by decreased HR) and parasympathetic tone increases (reflected by increased HRV). This was seen in our data; however, if the observed bursts in SC were ORs, then, according to OR theory (Sokolov, 1963; Zimmer, 2006) the number and amplitude of the SCRs should habituate both across the EMDR session and within EM/exposure sets.

We found that the number of SCRs decreased significantly from the start to the end of EMDR sessions for the EM condition, but not for the no-EM condition. Also at the start of treatment the number of SCRs was greater at the beginning of sets for the EM compared to the no-EM condition, but by the end of the sets the number of SCRs decreased in the EM condition to be the same as in the no-EM condition. In addition, at the start of treatment the amplitude of the SCRs decreased significantly within the stimulation sets only for the EM condition. This pattern of response is consistent with habituation to the eye movement stimulus both across the treatment session and within each stimulation set. However, contrary to OR theory, the amplitude of the SCRs did not decrease significantly from the start to the end of treatment for the EM condition. Although SC is the most sensitive and commonly used measure of the OR, the low novelty value of the EMs may not have created ORs large enough to allow for the detection of changes in SCR amplitude across the session.

Reduction seen in the number of SCRs within EM sets and EMDR sessions indicates the presence of ORs. However, as this is the first study to examine the number and amplitude of SCRs during EMDR, further investigation of SC activity is required. It is important for future research to examine specific changes in SC as opposed to just examining mean SC responses during measurement periods of interest within EMDR sessions, as mean SC responses do not provide information about the presence of brief orienting responses and the role that they may play in the EMDR process.

In this study and past EMDR treatment studies (Sack et al., 2008; Elofsson et al., 2008), the physiological changes associated with EMs were consistent with the presence of a relaxation response. At the onset of EMs there was a clear decrease in sympathetic indices and an increase in parasympathetic tone. However, in contrast to the other physiological trends, the EMs were also associated with an increase in RR. In this study the increase in RR was not significant within the first 10 s of the EMs, but RR increased significantly by the end of EM sets. Increased RR is distinct to the EMs in EMDR as when the EMs were omitted from the procedure RR decreased significantly at the onset of exposure sets, and remained significantly lower than the pre-stimulation phase throughout the exposure set.

The increase in RR associated with the EMs in EMDR remains unexplained. Wilson et al. (1996, p. 224) noted that the "respiration tracked and matched the rhythm of the eye movements in a shallow regular pattern." Sack et al. (2008) argued that the physiological correlates of the EMs were a result of a biphasic reaction in which an OR was first dominant but during ongoing exposure a stress-related psychophysiological response emerged. Based on Stickgold's (2002) theory of EMDR, Elofsson et al. (2008) suggested that the increase in RR maybe the result of the EMDR procedure inducing a REM- like state, as the EMs in REM-sleep are associated with rapid shallow breathing. Stickgold proposed that repeated EMs during EMDR creates constant redirecting of attention which evokes ORs and induces a neurobiological state similar to REM-sleep which facilitates memory processing. REM-sleep is a complex state without a well defined autonomic profile, and patients are awake in EMDR, thus it cannot be expected that physiological responses in EMDR be identical to those seen in REM-sleep (Stickgold, 2002). In our data, the increase in RR may represent the presence of an induced state similar to REM-sleep. However, our SC data show a difference between pure REM-sleep and EMDR as ORs were present and tended to show a pattern of habituation. A consistent finding has been that ORs in electrodermal measures are rare during REM-sleep (Johnson & Lubin, 1967; McDonald & Carpenter, 1975), and when they occur they do not tend to habituate (Johnson & Lubin, 1967; Johnson, Townsend, & Wilson, 1975).

EMDR is a complex therapy with a number of underlying processes simultaneously at play. We argue that the psychophysiological changes associated with the EMs in EMDR are primarily the result of two overlapping yet distinct influences: first, an OR as the EM component begins; and second, as the OR habituates to repeated EM stimulation the physiological profile becomes mixed with a stress, or defense response due to continued exposure to stressful memories. Like Sack and colleagues (2008) we propose dual-attention tasks in EMDR create ORs and short-term dearousal which may aid in the processing and integration of trauma memories. Also, through the process of reciprocal inhibition, in which a relaxation response is paired with exposure to distressing memories, negative appraisals of distressing memories weaken, and avoidance of trauma memory processing decreases. Eye movements, as a dual-attention task, may also reduce distress to a tolerable level and create a cognitive and physiological state in which effective processing of trauma information can occur. The relaxation response associated with EMs in EMDR is clinically meaningful as it may serve to moderate arousal throughout treatment sessions. Thus, EMDR may be particularly suitable for patients who cannot tolerate the high stress associated with exposure.

### 4.3. Limitations

This study compared EMDR-with EMs to EMDR-without EMs in a non-clinical sample. The extent to which these findings apply to a clinical population is yet to be tested. However, the physiological changes seen during EMDR in this study were similar to the changes seen in past EMDR treatment research with PTSD patients (Elofsson et al., 2008; Sack et al., 2008; Wilson et al., 1996). A further limitation was that the therapeutic procedures were administered by the researcher. However, measures were taken to assess experimenter biases and treatment expectancies. No difference was found between conditions in how much participants expected the treatment to reduce the distress associated with their chosen memory. Nor was there any difference in how confident participants perceived the therapist to be in the treatment they received. In addition, reductions in physiological arousal corroborated reductions in self-reported distress.

Although research is now beginning to further explore the specific processes and the physiological changes that occur in EMDR, research is yet to examine the physiological changes that occur during treatment of PTSD patients with EMDR versus behavioral exposure therapy. More research is also required to understand the precise role of the EMs and other forms of dual-attention stimulation used in EMDR. The physiological correlates of alternate bilateral stimulation (i.e., tones and tapping) have yet to be examined, and further investigation is needed to ascertain why certain dual-attention tasks are more effective than others.

Despite EMDR being an efficacious treatment for PTSD, and research indicating that the EM component in EMDR is beneficial, our understanding of the mechanisms that underlie effective therapy remains incomplete. An understanding of treatment mechanisms that underlie EMDR may lead to refinements in the therapeutic procedure, and also enhance our understanding of processes involved in development and resolution of trauma.

## Acknowledgements

The research presented in this paper was conducted as part of the Master of Psychology (clinical)/Doctor of Philosophy degree of the first author under the supervision of the other authors. Parts of this article were presented at the 10th EMDR European Conference, 5–7th June 2009, in Amsterdam, Netherlands.

## References

Andrade, J., Kavanagh, D., & Baddeley, A. D. (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.

Aubert-Khalfa, S., Roques, J., & Blin, O. (2008). Evidence of a decrease in heart rate and skin conductance responses in PTSD patients after a single EMDR session. *Journal of EMDR Practice and Research*, *2*, 51–56.

Baddeley, A., & Hitch, G. (1974). Working Memory. In: G. H. Bower (Ed.), *The psychology of learning and motivation* (Vol. 8, pp. 47–89). New York: Academic Press.

Barrowcliff, A. L., Gray, N. S., Freeman, T. C. A., & MacCulloch, M. J. (2004). Eye-movements reduce the vividness, emotional valence and electrodermal arousal associated with negative autobiographical memories. *Journal of Forensic Psychiatry and Psychology*, *15*, 325–345.

Bernstein, E. M., & Putnam, F. W. (1986). Development, reliability, and validity of a dissociation scale. *Journal of Nervous and Mental Disease*, *174*, 727–735.

Bisson, J. I., Ehlers, A., Matthews, R., Pilling, S., Richards, D., & Turner, S. (2007). Psychological treatments for chronic post-traumatic stress disorder. *British Journal of Psychiatry*, *190*, 97–104.

Borkovec, T. D., & Nau, S. D. (1972). Credibility of analogue therapy rationales. *Journal of Behavior Therapy & Experimental Psychiatry*, *3*, 257–260.

Boudewyns, P. A., Stwertka, S. A., & Hyer, L. A. (1993). Eye movement desensitization for PTSD of Combat: A treatment outcome pilot study. *Behavior Therapist*, *16*, 29–33.

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.

Carlson, E. B., & Putnam, F. W. (1993). An update on the dissociative experiences scale. *Dissociation*, *6*, 16–27.

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., & Brown, T. J. (2006). Increased interhemispheric interaction is associated with earlier offset of childhood amnesia. *Neuropsychology*, *20*, 336–345.

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.

Collewijn, H., & Tamminga, E. (1984). Human smooth and saccadic eye movements during voluntary pursuit of different target motions on different backgrounds. *Journal of Physiology*, *251*, 217–250.

Davidson, P. R., & Parker, K. C. H. (2001). Eye movement desensitization and reprocessing (EMDR): A meta-analysis. *Journal of Consulting and Clinical Psychology*, *69*, 305–316.

Edelberg, R. (1967). Electrical properties of the skin. In: C. C. Brown (Ed.), *Methods in psychophysiology*. Baltimore, MD: Williams & Wilkins.

Elofsson, U. O. E., von Schèele, B., Theorell, T. R., & Söndergaard, H. P. (2008). Physiological correlates of eye movement desensitization and reprocessing. *Journal of Anxiety Disorders*, *22*, 622–634.

Feske, U., & Goldstein, A. J. (1997). Eye movement desensitization and reprocessing treatment for panic disorder: A controlled outcome and partial dismantling study. *Journal of Consulting & Clinical Psychology*, *65*, 1026–1035.

Foa, E. B., Keane, T. M., Friedman, M. J., & Cohen, J. A. (Eds.). (2009). *Effective treatments for PTSD: practice guidelines from the International Society for Traumatic Stress Studies* (2nd ed.). New York: Guilford Press.

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.

Gunter, R. W., & Bodner, G. E. (2009). EMDR works . . . But How? Recent progress in the search for treatment mechanisms. *Journal of EMDR Practice and Research*, *3*, 161–168.

Horowitz, M., Wilmer, N., & Alvarez, W. (1979). Impact of event scale: A measure of subjective stress. *Psychosomatic Medicine*, *41*, 209–218.

Johnson, L. C., & Lubin, A. (1967). The orienting reflex during waking and sleeping. *Electroencephalography & Clinical Neurophysiology*, *22*, 11–21.

Johnson, L. C., Townsend, R. E., & Wilson, M. R. (1975). Habituation during sleeping and waking. *Psychophysiology*, *12*, 574–584.

Kapoula, Z., Yang, Q., Bonnet, A., Bourtoire, P., & Sandretto, J. (2010). EMDR effects on pursuit eye movements. *PLoS One, 5*. Retrieved from http://www.plosone.org/article/info%3Adoi%2F10.1371%2Fjournal.pone.0010762.

Kaplan, D. M., Smith, T., & Coons, J. (1995). A validity study of the subjective unit of discomfort (SUD) score. *Measurement and Evaluation in Counseling and Development*, *27*, 195–199.

Kavanagh, D. J., Freese, S., Andrade, J., & May, J. (2001). Effects of visuospatial tasks on desensitization to emotive memories. *British Journal of Clinical Psychology*, *40*, 267–280.

Kemps, E., & Tiggermann, M. (2007). Reducing the vividness and emotional impact of distressing autobiographical memories: The importance of modality-specific interference. *Memory*, *15*, 412–422.

Kim, E., Bae, H., & Park, Y. C. (2008). Validity of the Subjective Units of Disturbance Scale (SUDS) in EMDR. *Journal of EMDR Practice and Research*, *1*, 67–72.

Kuiken, D., Bears, M., Miall, D., & Smith, L. (2001–2002). Eye movement desensitization reprocessing facilitates attentional orienting. *Imagination, Cognition and Personality*, *21*, 3–20.

Lee, C. W., & Drummond, P. D. (2008). Effects of eye movement versus therapist instructions on the processing of distressing memories. *Journal of Anxiety Disorders*, *22*, 801–808.

Lilley, S. A., Andrade, J., Turpin, G., Sabin-Farrell, R., & Holmes, E. (2010). Visuospatial working memory interference with recollections of trauma. *British Journal of Clinical Psychology*, *48*, 309–321.

Lyle, K. B., Logan, J. M., & Roediger, H. L., III. (2008). Eye movements enhance memory for individuals who are strongly right-handed and harm it for individuals who are not. *Psychonomic Bulletin & Review*, *15*, 515–520.

MacCulloch, M. J., & Feldman, P. (1996). Eye movement desensitisation treatment utilises the positive visceral element of the investigatory reflex to inhibit the memories of post- traumatic stress disorder: A theoretical analysis. *British Journal of Psychiatry*, *169*, 571–579.

Maxfield, L., Melnyk, W. T., & Hayman, C. A. G. (2008). A working memory explanation for the effects of eye movements in EMDR. *Journal of EMDR Practice and Research*, *2*, 247–261.

McDonald, D. G., & Carpenter, F. A. (1975). Habituation of orienting response in sleep. *Psychophysiology*, *12*, 618–623.

Montgomery, R. W., & Ayllon, T. (1994). Eye movement desensitization across subjects: Subjective and physiological measures of treatment efficacy. *Journal of Anxiety Disorders*, *25*, 217–230.

National Institute for Clinical Excellence (NICE). (2005). *Post traumatic stress disorder (PTSD): the management of adults and children in primary and secondary care.* London: NICE Guidelines. http://guidance.nice.org.uk/CG26.

Obrist, P. A. (1981). *Cardiovascular psychophysiology*. New York: Plenum.

Öhman, A., Hamm, A., & Hugdahl, K. (2000). Cognition and the autonomic nervous system. Orienting, anticipation, and conditioning. In: J. Cacioppo, L. Tassinary, & G. Berntson (Eds.), *Handbook of psychophysiology*. Cambridge: Cambridge University Press.

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.

Pavlov, I. P. (1927). Lecture 1. *Conditioned Reflexes: an investigation of the physiological activity of the cerebral cortex*. Oxford University Press. Translated by O.V. Anrep. Republished by Dover Publications Inc. New York. (1960).

Pitman, R. K., Orr, S. P., Altman, B., Longpre, R. E., Poire, R. E., & Macklin, M. L. (1996). Emotional processing during eye movement desensitization and reprocessing therapy of Vietnam veterans with chronic posttraumatic stress disorder. *Comprehensive Psychiatry*, *37*, 419–429.

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

Renfrey, G., & Spates, C. R. (1994). Eye movement desensitization: A partial dismantling study. *Journal of Behavior Therapy & Experimental Psychiatry*, *25*, 231–239.

Rogers, S., Silver, S., Goss, J., Obenchain, J., Willis, A., & Whitney, R. (1999). A single session, group study of exposure and eye movement desensitization and reprocessing in treating posttraumatic stress disorder among Vietnam War Veterans: Preliminary data. *Journal of Anxiety Disorders*, *13*, 119–130.

Sack, M., Lempa, W., & Lamprecht, F. (2007). Assessment of psychophysiological stress reactions during a traumatic reminder in patients treated with EMDR. *Journal of EMDR Practice and Research*, *1*, 15–23.

Sack, M., Lempa, W., Steinmetz, A., Lamprecht, F., & Hofmann, A. (2008). Alterations in autonomic tone during trauma exposure using eye movement Desensitisation. *Journal of Anxiety Disorders*, *22*, 1264–1271.

Sanderson, A. S., & Carpenter, R. (1992). Eye movement desensitization versus image confrontation: A single-session crossover study of 58 phobic subjects. *Journal of Behavior Therapy & Experimental Psychiatry*, *23*, 269–275.

Schroeder, E. B., Whitsel, E. A., Evans, G. W., Prineas, R. J., Chambless, L. E., & Heiss, G. (2004). Repeatability of heart rate variability measures. *Journal of Electrocardiology*, *37*, 163–172.

Shapiro, F. (1989). Efficacy of the eye movement desensitization processing in the treatment of traumatic memories. *Journal of Traumatic Stress*, *2*, 199–223.

Shapiro, F. (1995). *Eye movement desensitization and reprocessing: basic principles, protocols, and procedures*. New York: Guilford Press.

Shapiro, F. (2001). *Eye movement desensitization and reprocessing: basic principles, protocols, and procedures* (2nd ed.). New York: Guilford Press.

Sokolov, E. N. (1963). *Perception and the conditioned reflex* (S. W. Waydenfeld, Trans.). Pergamon Press, Oxford (Original work published 1958).

Sokolov, E. N., & Cacioppo, J. T. (1997). Orienting and defense reflexes: Vector coding and the cardiac response. In: P. J. Lang, R. F. Simons, & M. Balaban, *Attention and orienting. Sensory and motivational processes.* Lawrence Erlbaum Associates, Publishers: London.

Solomon, R. M., & Shapiro, F. (2008). EMDR and the adaptive information processing model. *Journal of EMDR Practice and Research*, *2*, 315–325.

Söndergaard, H. P., & Elofsson, U. (2008). Psychophysiological studies of EMDR. *The Journal of EMDR Practice and Research*, *2*, 282–288.

Stickgold, R. (2002). EMDR: A putative neurobiological mechanism of action. *Journal of Clinical Psychology*, *58*, 61–75.

Task Force of the European Society of Cardiology the North American Society of Pacing Electrophysiology (1996). Heart rate variability: Standards of measurement, physiological interpretation, and clinical use. *Circulation, 93*, 1043–1065.

Thayer, J. F., Hansen, A. L., & Johnson, B. H. (2008). Noninvasive assessment of autonomic influences on the heart. In L. L. Luecken & L. C. Gallo (Eds.), *Handbook of physiological research methods in health psychology* (pp. 183–209). Los Angeles: Sage Publications.

Thyer, B. A., Papsdorf, J. D., Davis, R., & Vallecorsa, S. (1984). Autonomic correlates of the subjective anxiety scale. *Journal of Behavior Therapy and Experimental Psychiatry*, *15*, 3–7.

van den Hout, M., 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.

Wolpe, J. (1991). *The practice of behavior therapy* (4th ed.). New York: Pergamon Press.

Wilson, D. L., Silver, S. M., Covi, W. G., & Foster, S. (1996). Eye movement desensitization and reprocessing: Effectiveness and autonomic correlates. *Journal of Behavior Therapy and Experimental Psychiatry*, *27*, 219–229.

Zimmer, H. (2006). Habituation of the orienting response as reflected by the skin conductance response and by endogenous event-related brain potentials. *International Journal of Psychophysiology*, *60*, 44–58.

Zingrone, N. L., & Alvarado, C. S. (2001). The dissociative experiences scale-II: Descriptive statistics, factor analysis, and frequency of experiences. *Imagination, Cognition & Personality*, *2*, 145–157.