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Making eye movements during imaginal exposure leads to short-lived memory effects compared to imaginal exposure alone

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ABSTRACT

Background and objectives: A plethora of eye movement desensitization and reprocessing (EMDR) analogue studies has shown that, in the short term, making eye movements (EM) during brief imaginal exposure (“recall + EM”) blurs memories more than just imaginal exposure (“recall only”). Yet, results of the few studies that included a follow-up test are inconsistent. We improved this paradigm's ecological validity by including an extended intervention phase and multiple assessments per phase. We hypothesized that recall + EM results in larger immediate and 24 h reductions in memory vividness, negative valence, and distress than recall alone. We explored the persistence of the effects, as well as the predictive value of memory characteristics and individual differences.

Methods: Students ($N = 100$) selected a negative autobiographical memory and were randomized to recall + EM or recall alone; both interventions lasted 32 intervals of 24s. During the interventions they rated the memory after every four intervals.

Results: After 4 × 24s intervention, recall + EM resulted in memory deflation, while recall only caused memory inflation. After the full intervention (i.e., 32 × 24s), both conditions resulted in immediate and 24 h reductions on all outcome measures. Crucially, memory effects in the recall + EM condition partially relapsed 24 h later, while the effects in the recall only condition persisted. Change patterns were hardly explained by predictive variables.

Limitations: We used a non-clinical sample; replication in clinical samples is warranted.

Conclusion: Making EM during imaginal exposure leads to short-lived effects compared to imaginal exposure alone. However, EM may offer a response aid for those who avoid imaginal exposure.

1. Introduction

In clinical guidelines, eye movement desensitization and reprocessing (EMDR) therapy is recommended or suggested as a treatment for posttraumatic stress disorder (PTSD; e.g., American Psychiatric Association, 2017; National Institute for Health and Care Excellence, 2005). Meta-analyses indicate large effect sizes for EMDR in reducing PTSD symptom severity compared to a waiting list and care as usual (e.g., Bisson, Roberts, Andrew, Cooper, & Lewis, 2013; Cusack et al., 2016), and no significant differences with alternative treatments for PTSD such as cognitive behavioral therapy (e.g., Bisson et al., 2013; Watts et al., 2013). Nevertheless, a substantial minority of patients with PTSD does not show clinically significant improvement after EMDR treatment (e.g., about 20% in treatment completers; Sack et al., 2016) and, so far, no strong predictors of treatment outcome have been identified.

In EMDR, the therapist guides the patient towards the memory “hotspot” (i.e., the moment with the greatest emotional impact) and induces rapid horizontal eye movements (EM). Because focusing on the memory hotspot is also a core element of imaginal exposure, scientists have questioned whether the EM have additional value (e.g., Herbert et al., 2000). This has led to dismantling studies in which the EM component was isolated. Some of these studies used the complete EMDR protocol with or without EM in clinical or non-clinical samples (e.g., Devilly, Spence, & Rapee, 1998). However, the majority of EMDR studies have used an analogue paradigm. In this paradigm, healthy

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individuals recall highly aversive autobiographical (yet not traumatic) memories while making EM ("recall + EM") or not ("recall only"), and rate each memory before and after the intervention on vividness and/or emotionality (see van den Hout & Engelhard, 2012). The recall + EM condition is a lab analogue model of EMDR, while the recall only condition is a lab analogue model of imaginal exposure. Lee and Cuijpers (2013) conducted two meta-analyses and showed that EM resulted in a large superior effect in the analogue studies and a small to medium beneficial effect in the full protocol studies.

Why would making EM during memory recall produce beneficial effects? Attentional control over two relatively complex tasks loads the limited capacity of the working memory (WM), leading to poorer performance of both tasks, compared to single task execution (Baddeley, 2007). Recalling an aversive autobiographical memory loads WM (van Veen, Engelhard, & van den Hout, 2016), as does making EM (e.g., Engelhard, van Uijen, & van den Hout, 2010). As such, if an individual recalls an emotional memory and simultaneously performs EM (or another task that loads the WM), this should impair the recollection of that memory. Next, it is hypothesized that the impaired memory is restored in long-term memory (van den Hout & Engelhard, 2012) or induces other cognitive processes, such as reappraisal (Gunter & Bodner, 2008). A plethora of experimental studies have shown that dual tasks that sufficiently load the WM (e.g., backwards counting, playing Tetris, attentional breathing; see van den Hout & Engelhard, 2012) indeed produce greater immediate decreases in vividness and emotionality than the mere recall of the memory. The WM explanation is further supported by the finding that dual tasks with a higher WM load produced greater reductions in vividness and/or emotionality than those with a lower WM load (e.g., fast versus slow EM, van Veen et al., 2015; van Schie, van Veen, Engelhard, Klugkist, & van den Hout, 2016; EM versus listening to tones, de Jongh, Ernst, Marquez, & Hornsveld, 2013; van den Hout et al., 2011; 2012), although some studies did not find this effect (Mertens et al., 2019). While beneficial effects of such dual attention tasks commonly appear at an immediate post-test, it is unclear whether these effects survive the passage of time.

Thus far, only seven published EMDR analogue studies comparing recall + EM with recall only have included a follow-up test at least one day later. From pre-test to follow-up, two studies found no reductions of vividness and/or emotionality ratings in both conditions (Kavanagh, Freese, Andrade, & May 2001; Lilley, Andrade, Turpin, Sarbin-Farrell, & Holmes, 2009), another two found memory reductions in both conditions but no between-group differences (Littel et al., 2017; Schubert, Lee, & Drummond, 2011), and three studies found that recall + EM reduced vividness and emotionality *more* than recall only (Gunter & Bodner, 2008, exp. 2; Schubert et al., 2011; Leer, Engelhard, & van den Hout, 2014). The method of these studies differed in intervention duration (i.e., from 64 s to 45 min) and time between the intervention and follow-up (i.e., 24 h or 1 week). There is no clear effect of intervention duration on memory effects. Furthermore, while some studies found that reduced memory scores in the recall + EM condition returned to baseline at the follow-up test (Kavanagh et al., 2001; Lilley, Andrade, Turpin, Sabin-Farrel, & Holmes, 2009), others found that effects persisted over 1-week (Gunter & Bodner, 2008; Lee & Drummond, 2008). To summarize, studies that included delayed and persistence effects of dual-task procedures are limited and the findings are inconsistent.

The first aim of this study was to measure the immediate (i.e., pre-test to post-test), delayed (i.e., pre-test to follow-up) and persistence (i.e., post-test to follow-up) effects of recall + EM versus recall only on negative autobiographical memories in a non-clinical sample. To improve the ecological validity of the paradigm, we extended the intervention duration from the typical 4–6 × 24s (see van den Hout & Engelhard, 2012; van Schie et al., 2016; van Veen et al., 2015) to 32 × 24s intervention. Outcome measures were vividness and negative valence of the memory (i.e., stimulus aspects) and distress of recalling the memory (i.e., response). We hypothesized that, compared to recall only, recall + EM would result in larger immediate and delayed reductions on all outcome measures. We had no explicit expectations regarding the persistence effects. To gain insight into individual trajectories of change, we calculated the minimal clinical change and classified individuals as "improved", "no change" or "worsened".

The second aim of this study was to identify predictors of change (i.e., memory characteristics and individual differences) into the recall + EM and recall only condition. In terms of memory features, we included associated emotions and threat classification of the memory hotspot (i.e., physical versus psychological threat; see Grey & Holmes, 2008; Holmes, Grey, & Young, 2005). In terms of individual differences, while some dual task studies found a negative correlation between WM span and reductions of vividness and/or emotionality ratings (Engelhard et al., 2010; Gunter & Bodner, 2008; van den Hout et al., 2010, 2011), a recent study with two distinguishable WM span groups did not find differences in memory effects (van Schie et al., 2016). We tried to further explore this relationship by including WM span and attentional control (i.e., task focusing and task shifting). Lastly, because recall of memories requires mental imagery (Pearson, Deeprose, Wallace-Hadrill, Heyes, & Holmes, 2013), we also included imagery ability as a predictor.

2. Methods

2.1. Participants

Participants were 100 students ($M_{\text{age}} = 21$, $SD = 2.27$; 27 male, 73 female) recruited through flyers and advertisements. We excluded individuals who had participated in similar studies from our group, had prior knowledge of EMDR, or reported being diagnosed with a current psychiatric disorder, visual problems, or medication use that affects memory or concentration. Participants received course credit or financial reimbursement (€14) for their participation. The study was approved by the Ethics Committee of the Faculty of Social and Behavioral Sciences of Utrecht University (FETC15-080).

2.2. Design

The experiment consisted of two sessions, approximately 24 h apart. Participants were randomly assigned to either the recall + EM ($n = 50$) or recall only ($n = 50$) intervention. They rated the target memory on vividness, negative valence, and distress before and after the intervention, as well as one day later. For each rating phase, they completed three assessments that were spaced by a filler task (i.e., recalling a second, *other* negative autobiographical memory). A previous laboratory study has shown that activation of a negative filler memory does not affect the ratings of the target memory over time (van Veen et al., 2016). To gain insight into memory changes during the intervention phase, participants additionally rated the target memory on vividness, negative valence and distress after each of the eight intervention blocks. In total, the design consisted of 16 repeated measures, see Fig. 1.

2.3. Measures

Vividness, negative valence, and distress ratings. Vividness (0 = *not at all vivid*, 100 = *very vivid*) and negative valence (0 = *not at all negative or neutral*, 100 = *very negative*) of the memory hotspot, as well as the distress experienced during recall of that hotspot (0 = *not at all distressed*, 100 = *very distressed*) were all rated on digital Visual Analog Scales (VASs).

Emotions associated with the memory hotspot. Fear, anger, sadness, helplessness, guilt, shame, and surprise associated with the memory hotspot were rated on separate VASs (0 = *not at all*, 100 = *a lot*). These emotions mirror the most frequently reported emotions of memory hotspots in patients with PTSD (Grey & Holmes, 2008).

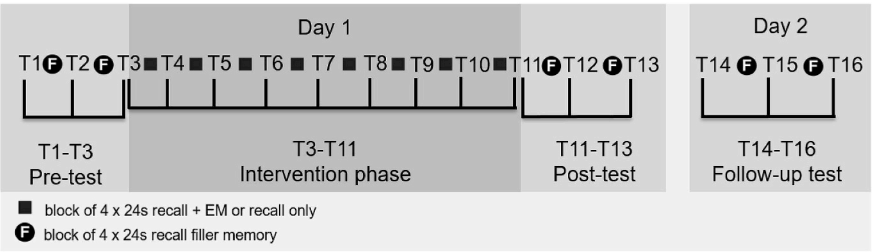

Fig. 1. Timeline of experimental design. Participants assessed the target memory 16 times (T1-16) on memory vividness, negative valence, and distress. In between the assessments of the pre-test, post-test and 24 h follow-up test they recalled the filler (F) memory for 4 × 24s.

Cognitive themes in memory hotspot. We audio recorded participants' descriptions of their memory storyline and memory hotspot, and two independent raters categorized the cognitive themes in the hotspot following the procedures of Holmes et al. (2005). The seven cognitive themes were: *uncertain threat*, *general threat of injury and death*, *control and reasoning*, *consequences*, *abandonment*, *esteem*, and *cognitive avoidance*. The first two themes are classified as threat to physical integrity, while the others relate to psychological threat (Holmes et al., 2005). Both raters selected the main cognitive theme for each memory (i.e., the theme that best matched the descriptions of the participant). The first author allocated ratings when disagreements between raters arose. The inter-rater reliability for the main cognitive theme was good, Cohen's kappa = .79.

Spontaneous Use of Imagery Scale (SUIS). The Dutch version of the SUIS (Nelis, Holmes, Griffith, & Raes, 2014; Reisberg, Pearson, & Kosslyn, 2003) was used to measure the tendency and ease of forming visual images in daily life. The SUIS is a self-report measure that contains 12 descriptions of daily life situations, rated on a 5-point scale (1 = *never appropriate*, 5 = *always completely appropriate*). Its internal consistency was acceptable in a prior study ($\alpha = 0.72–0.76$; Nelis et al., 2014), but it was questionable in this study ($\alpha = 0.60$).

Attentional Control Scale (ACS). The ACS was used to measure individual differences in attentional regulation (Derryberry & Reed, 2002). This self-report measure contains 20 items, rated on a 4-point scale (1 = *almost never true*, 4 = *always true*). We used both subscales of the ACS (Ólafsson et al., 2011): attentional shifting (10 items) and attentional focusing (9 items). The internal consistency was good for focusing ($\alpha = 0.78$) and poor for shifting ($\alpha = 0.53$), and the subscales were correlated, $r = 0.31$, $p = .002$.

Automated reading span. The automatic reading span was used to measure individual differences in working memory span (Conway et al., 2005; Daneman & Carpenter, 1980). Participants rated the meaningfulness of 75 sentences (three sets of 3–7 sentences) by clicking a TRUE or FALSE box. After each sentence, participants viewed a single letter on the screen for 1s. Participants had to recall the letters in a 4 × 3 letter matrix, in the order in which they were presented. The proportion of correctly recalled letters within a trial was averaged over all trials and is an indication of WM span (i.e., partial credit unit scoring). This measure of WM span shows good internal consistency ($\alpha = 0.86–0.88$; Conway et al., 2005; Redick et al., 2012). For an extensive description of the procedures of this task, see van Schie et al. (2016).

Intervention. Participants recalled their memory hotspot in 8 blocks of 4 × 24s, while making EM or not. They made EM by following a 1 cm white dot moving horizontally with a speed of 1.2 Hz (i.e., 1.2 left-right-left cycle per second; van Veen et al., 2015). All participants sat at approximately 60 cm from the computer screen and the moving distance of the dot was 45 cm, which creates a visual angle of 41°. Participants in the recall only condition looked at a black screen. We did not use a fixation point in this condition, to minimize WM load.

Manipulation check. Participants indicated on VASs (1) how well they followed the instructions during the experiment (0 = *not at all*, 100 = *very well*), (2) to what extent they were able to constantly recall the target memory during the intervention (0 = *not at all*, 100 = *very well*), and (3) to which degree the two memories (i.e., target and filler) got mixed up during the intervention (0 = *not at all*, 100 = *a lot*).

2.4. Procedure

On day 1, participants selected two negative autobiographical memories of specific, unrelated events that happened more than one week ago and still evoked feelings of distress. We included memories rated 60 or higher on the vividness and distress scales. The memory rated highest on distress was used as the *target* memory and the lowest memory as the *filler* memory. Participants described the global story line of the target and filler memory (order of the memories was counterbalanced). Next, participants briefly recalled the memory and selected an image that still evoked the most distress here and now (i.e., memory “hotspot”). Participants wrote down a label for that hotspot. These instructions were almost identical to the Dutch EMDR protocol (de Jongh & ten Broeke, 2012). The same procedure was followed for the other memory. Participants then filled out the emotion ratings of the target memory and received extended instructions for interpretation of the vividness, negative valence, and distress ratings.

Participants sat behind a computer and underwent three phases: pre-test, intervention, and post-test. All instructions and stimuli were programmed in OpenSesame 2.8.3 (Mathôt, Schreij, & Theeuwes, 2012). Each assessment started with a 10s recall of the target memory cued with their personalized label, followed by the vividness, negative valence, and distress ratings. In between the three pre-test and post-test assessments, participants were instructed to recall the memory hotspot of the *filler* memory as vividly as possible (i.e., for 132s: equal to the duration of one intervention block). The intervention phase consisted of nine assessments and eight intervention blocks of 4 × 24s with 10s breaks in between. Each 24s cycle started with instructions to recall the memory hotspot as vividly as possible. The experimenter sat behind a screen and observed the participant's face via a webcam and, if necessary, briefly reminded them of the instructions (e.g. “follow the dot”).

On day 2, participants first underwent the follow-up test, which mirrored the assessment procedure as used in the pre and post-test. Next, they completed the SUIS, ACS and reading span task. Finally, they answered the manipulation check questions and were debriefed.

2.5. Data preparation and analysis

We calculated pre-test (T1-3), post-test (T11-13) and follow-up test (T14-16) mean scores averaging over waves; see Table 1. We used these scores to calculate difference scores: pre-test minus post-test, pre-test minus follow-up test, post-test minus follow-up test. We used: (1) one-sample *t*-tests to test if these difference scores differed from zero per condition, (2) independent samples *t*-tests to test if these difference scores differed between conditions, (3) Bayesian piece-wise latent growth model (LGM) to analyze the differences in slopes within the five phases (i.e., pre-test denoted by S1 in Fig. 2, intervention – S2, post-test – S3, change overnight – S1, follow-up – S5) and between the conditions using all data points (see the note in Table 2 for model specifications),

Table 1
Means and Standard Deviations for vividness, negative valence, and distress at pre-test, post-test and follow-up (FU) test for recall + EM and recall only.

	Recall + EM		
	Vividness	Negative valence	Distress
	M (SD)	M (SD)	M (SD)
Pre-test	72.33 (*19.33*)	69.87 (*21.87*)	74.97 (*22.79*)
Post-test	51.92 (*30.59*)	45.56 (*29.73*)	45.71 (*34.31*)
FU test	60.60 (*21.30*)	52.93 (*24.79*)	54.26 (*30.75*)
	Recall only Vividness	Negative valence	Distress
	M (*SD*)	M (*SD*)	M (*SD*)
Pre-test	72.41 (*17.47*)	68.40 (*22.30*)	69.60 (*23.96*)
Post-test	57.67 (*27.39*)	50.47 (*28.77*)	46.16 (*28.65*)
FU test	56.21 (*21.91*)	49.27 (*27.29*)	45.42 (*29.29*)

and (4) a distribution based method (i.e., one-half of the SD of the difference score) to calculate the minimal clinically important difference (MCID; Copay, Subach, Glassman, Polly, & Schuler, 2007). Based on the MCID scores, we classified participants as "improved", "no change" or "worsened". Furthermore, we defined relapse as participants who were classified as "worsened" from post-test to follow-up test. Lastly, we used (5) logistic regression analyses with a backward selection method to test the predictive value of the memory characteristics (i.e., physical vs. psychological threat, emotions associated with hotspot) and individual differences (i.e., WM span, attentional shifting and focusing, imagery ability) on MCID scores of participants who improved versus those who did not (i.e., pre-test to post-test), and of participants in which memory effects persisted versus those in which the effects relapsed (i.e., post-test to follow-up test) in the separate conditions. We only tested the predictive value on distress, because this is the most clinically relevant variable. All supplementary materials of the results section (e.g., syntax, output, tables) are available on the Open Science Framework via https://osf.io/3yqcw/.

3. Results

3.1. Manipulation check

Participants indicated that they followed the instructions very well during the experiment ($M = 87.82$, $SD = 11.14$). The recall only condition was more able to constantly recall the target memory during the intervention ($M = 56.46$, $SD = 23.35$) than the recall + EM condition ($M = 43.65$, $SD = 23.21$, $t\,(97) = 2.74$, $p = .007$), which was expected. The degree to which the two memories (i.e., target and filler) got mixed up, was reasonable (Day 1: $M = 31.20$, $SD = 23.63$; Day 2: $M = 34.24$, $SD = 26.40$).

3.2. Randomization check

In the piecewise model, see Table 2, the intercepts for the three outcome measures are not different between conditions (i.e., overlapping 95% CI intervals). The slope of the first phase (S1) is stable for vividness and negative valence in both conditions, but is already decreasing for distress in the recall + EM condition.

3.3. Emotions while retrieving hotspots at baseline

The two strongest emotions while retrieving the memory hotspot at baseline were helplessness ($M = 80.29$, $SD = 20.61$) and sadness ($M = 75.62$, $SD = 22.60$). Anger ($M = 57.45$, $SD = 34.72$), fear ($M = 54.13$, $SD = 29.93$) and surprise ($M = 49.02$, $SD = 31.71$) were moderately experienced, while shame ($M = 30.26$, $SD = 32.56$) and guilt ($M = 27.21$, $SD = 30.90$) were the weakest emotions during recall.

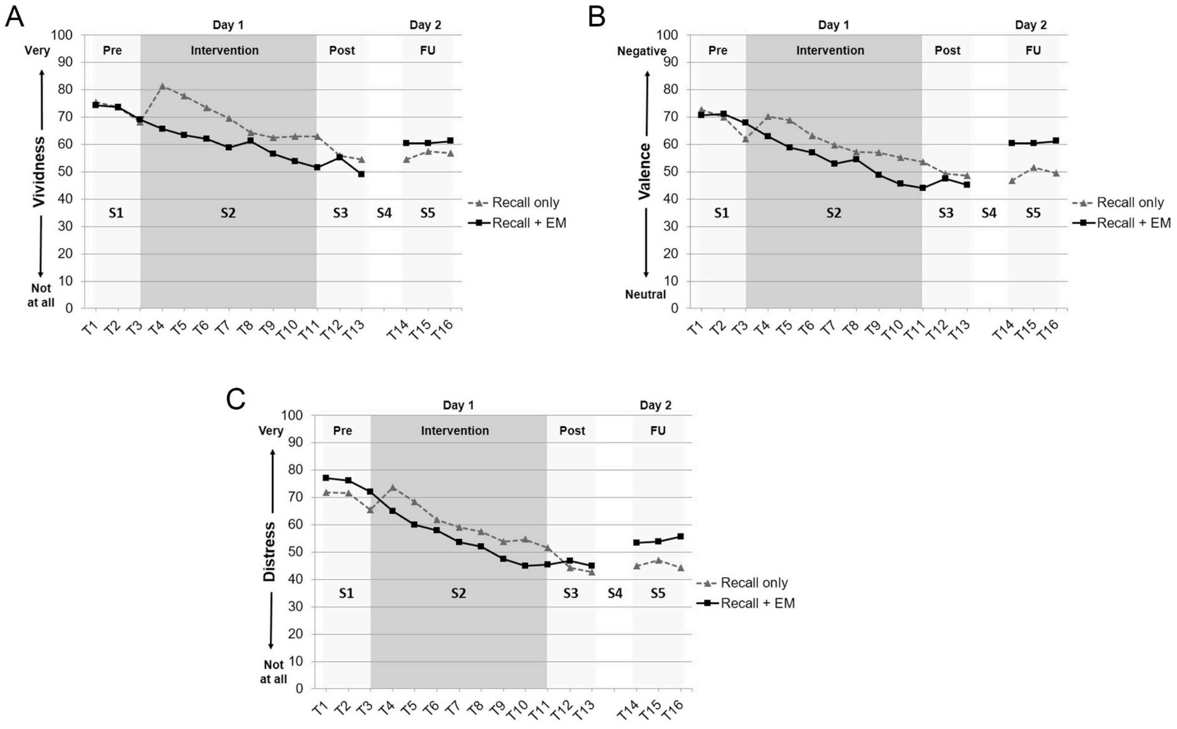

Fig. 2. a-c. Timeline of vividness, negative valence, and distress scores during pre-test (T1-3; S1), intervention (T3-11; S2), post-test (T11-13; S3), change overnight (S4) and 24 h follow-up test (T14-16; S5) for recall only and recall + EM.

Table 2
Bayesian posterior results for the piecewise latent growth model for the two conditions and the difference in estimates between the conditions.

	Recall + EM		
	Vividness	Negative valence	Distress
	M (95% CI)	M (95% CI)	M (95% CI)
Intercept	**74.45*** (69.14–79.83)	**70.88*** (64.66–77.24)	**76.44*** (69.82–83.00)
S1	−2.90 (−5.75–0.068)	−2.35 (−5.00–0.31)	**−4.06*** (−6.97 to −1.07)
S2	**−1.90*** (−2.79 to −1.00)	**−2.65*** (−3.48 to −1.77)	**−2.90*** (−3.75 to −2.04)
S3	−0.90 (−3.10–1.23)	0.64 (−0.76–2.14)	0.82 (−1.17–2.86)
S4	**3.83*** (0.95–6.70)	**2.73*** (0.34–5.13)	**3.28*** (0.76–5.81)
S5	0.72 (−1.53–3.01)	1.56 (−0.37–3.49)	1.21 (−0.69–3.18)
	Recall only		
	Vividness	Negative valence	Distress
	M (95% CI)	M (95% CI)	M (95% CI)
Intercept	**73.76*** (68.28–79.00)	**72.35*** (66.12–78.68)	**71.53*** (64.94–78.09)
S1	2.55 (−0.40–5.51)	−1.37 (−4.00–1.32)	−0.34 (−3.29–2.56)
S2	**−2.39*** (−3.32 to −1.50)	**−2.01*** (−2.86 to −1.15)	**−2.51*** (−3.37 to −1.67)
S3	**−2.84*** (−4.95 to −0.71)	**−2.13*** (−3.60 to −0.70)	**−3.59*** (−5.57 to −1.58)
S4	0.75 (−2.11–3.60)	0.17 (−2.19–2.58)	1.53 (−0.95–4.06)
S5	0.77 (−1.52–3.04)	0.73 (−1.25–2.69)	−0.43 (−2.40–1.50)

Note. M = median of the posterior distribution; 95% CI = 95% higher posterior density interval. Each model was estimated using the Gibbs sampler in Mplus v8.2 with 4 chains and 30.000 iterations with thinning set at 100 (to reduce auto-correlation) and conservative priors on the slopes (normal distributions with prior means of 0 and prior variances of 10) and weakly-informative priors on the intercept (normal distributions with prior means of 70 and a prior variances of 100). For all iterations post-burnin (the first 50% of each chain was omitted) the potential scale reduction factor was always < 1.01. To reduce model complexity, we set all correlations between intercept and slope parameters at zero and forced (residual) variance to be equal across groups. The difference scores were obtained by introducing a set of new parameters in each iteration of the Gibbs Sampler.
* median of posterior falls outside 95% CI.

3.4. *Cognitive themes in hotspots*

The most common themes of the memory hotspots (n = 99) were general threat (33.3%) and control and reasoning (18.2%). Examples of hotspot situations as described by participants include: getting robbed in a taxi, seeing a family member have a heart attack, and break-up with a loved one. Based on the main cognitive theme, hotspots were categorized as physical (46.5%) or psychological (53.5%) threat.

3.5. *Immediate effects (pre-test to post-test)*

In Fig. 2 the scores for each wave are shown. One-sample t-tests revealed that, compared to the average across pre-test scores, participants in both conditions rated the memories as less vivid and negative, and reported less distress while recalling the memories at post-test ($ps < .001$; ds = 0.60-0.82 for recall only; ds = 0.87–1.21 for recall + EM). Independent samples t-tests showed that these difference scores did not differ between the two conditions ($ps > .223$; ds = 0.22-0.24). The results of the piecewise model showed that the slopes of the intervention phase (S2) significantly decreased on all three outcome measures, see Table 2, with no differences between the two conditions. So, both conditions produced immediate memory effects and, in contrast to our expectations, these effects were not larger in the recall + EM condition than in the recall only condition.

3.6. *Delayed effects (pre-test to follow-up test)*

One-sample t-tests showed that, relative to the pre-test, vividness, negative valence and distress reduced in both conditions at the 24-h follow-up test ($ps < .001$; ds = 0.79-0.89 for recall only; ds = 0.75–1.14 for recall + EM). Although independent samples t-tests revealed that there was *no evidence* for a difference between the conditions ($ps > .209$; ds = 0.10-0.25), the piecewise model results suggest that the effects for the recall only condition kept on decreasing, see the results for S3 in Table 2. This suggests that both interventions caused 24 h memory reductions and that, contrary to our expectations, these reductions were not larger in the recall + EM condition than in the recall only condition.

3.7. *Persistence effects (post-test to follow-up test)*

One-sample t-tests revealed that in the recall only condition, scores on all outcome measures did not change from post-test to 24 h follow-up test ($ps > .610$; ds = 0.04-0.07). However, in the recall + EM condition, scores *increased* from post-test to 24 h follow-up test for vividness, t (49) = −3.05, p = .004, d = 0.43, negative valence, t (49) = −3.25, p = .002, d = 0.46, and distress, t (49) = −3.70, p = .001, d = 0.52. Independent samples t-tests confirmed that difference scores of vividness (t (98) = 2.45, p = .016, d = 0.49), negative valence (t (98) = 2.63, p = .010, d = 0.53), and distress (t (98) = 2.71, p = .008, d = 0.54) differed between the conditions. The piecewise model results showed similar effects: from the last assessment on day 1 (T13) to the first assessment of day 2 (T14), the slope (denoted by S4 in Table 2) in the recall + EM condition significantly increased, which did not occur in the recall only condition. This indicates that the acquired effects during the intervention persisted after 24 h in the recall only condition, while the beneficial effects of the recall + EM intervention partially relapsed one day later.

3.8. *Explorative analysis: first intervention block*

Because most previous EMDR analogue studies used 4–6 x 24s intervention, as mentioned earlier, we calculated difference scores from T3 to T4 (i.e., 4 × 24s). Independent samples t-tests showed that conditions differed on all outcome measures from T3 to T4 ($ps < .001$, ds = 0.79-0.89). This difference was caused by an increase on all outcome measures in the recall only condition ($ps < .016$, ds = 0.36-0.71), as well as a decrease in negative valence (t (98) = 2.18, p = .034,

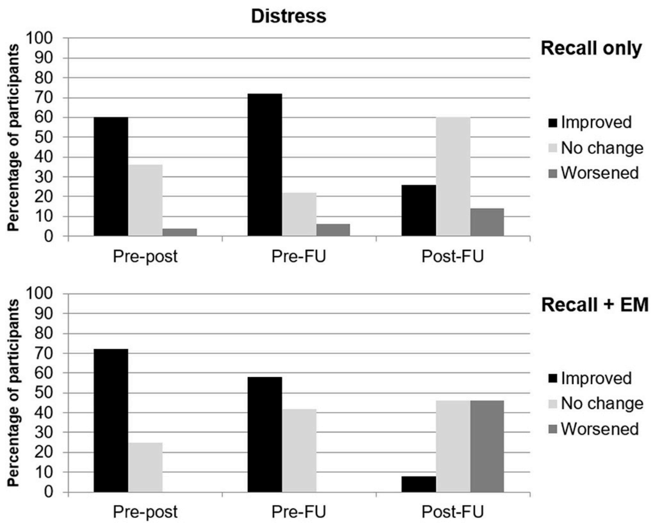

Fig. 3. Overview of the percentage of participants who improved (i.e., scores decreased), worsened (i.e., scores increased) or showed no change from pre-test to post-test, pre-test to follow-up test, and post-test to follow-up test on distress for the recall only and recall + EM condition. The categories represent clinical relevant change.

$d = 0.31$) and distress (t (98) = 3.44, $p = .001$, $d = 0.49$), but not in vividness (t (98) = 1.32, $p = .192$, $d = 0.19$) in the recall + EM condition.

3.9. Clinical relevant change

The three outcome measures showed comparable patterns in participants who improved, showed no change or worsened. A complete overview can be found on the Open Science Framework. We displayed the results for distress in Fig. 3. A notable pattern is that 46% of participants in the recall + EM condition showed an increase in distress from day 1 to day 2, compared to 14% of participants in the recall only condition. A chi-square test showed that this difference was significant (χ^2 (1, $N = 100$) = 12.19, $p < .001$). This indicates that the relapse effects in the recall + EM condition are not driven by a small subsample, but are found in a substantial number of participants in this condition.

3.10. Predictors of change: improvement and relapse

For both conditions, none of the variables in the final model significantly predicted immediate improvement on distress. In terms of relapse, only the SUIS score was a significant predictor in the recall only condition: $\beta = 0.27$, Wald χ^2 (1, $N = 50$) = 7.20, $p = .007$, OR = 1.30. For recall + EM, only the emotion surprise predicted no relapse: $\beta = 0.02$, Wald χ^2 (1, $N = 50$) = 4.75, $p = .029$, OR = 1.02. This suggests that relapse after recall only is higher among those with a better ability to use imagery in daily life, and that relapse after the dual task intervention is lower when the memory is associated with more surprise at baseline.

4. Discussion

Analogue studies of EMDR have often shown that recall of aversive autobiographical memories while making EM reduces the vividness and emotional intensity of these memories more than recall only (Lee & Cuijpers, 2013; van den Hout & Engelhard, 2012). However, studies with follow-up tests are scant and their findings are inconsistent. We improved the ecological validity of this paradigm and found that both conditions resulted in immediate and 24 h reductions in vividness and negative valence of the memory, as well as distress experienced during recall of the memory. Unexpectedly, we did not find that recall + EM led to larger reductions in memory ratings than recall only: the memory effects in the recall + EM condition partially relapsed from day 1 to day 2, while those in the recall only condition persisted.

Most laboratory studies that found the beneficial effects of performing a dual task during recall used relatively brief intervention durations (4-6 × 24s; e.g., Littel, van Schie, & van den Hout, 2017; van den Hout & Engelhard, 2012; van Schie et al., 2016; van Veen et al., 2015). Interestingly, for some studies, the beneficial effects were (partially) driven by an increase in ratings in the recall only condition (e.g., Engelhard et al., 2010; Leer et al., 2014). We observed a similar pattern in our data: after the first block of the intervention (i.e., 4 × 24s), we found an inflation of scores in the recall only condition, while the dual task intervention resulted in an immediate reduction of negative valence and distress. van Veen et al. (2016) found that intervention duration was positively related to memory effects: the discrepancy in memory reductions between recall + EM and recall only became larger after 16 × 24s than after 8 × 24s intervention. In this study, we provided 32 × 24s intervention, but found no differences between the conditions at post-test. This would suggest that initially active working mechanism(s) in the recall + EM condition became less active over time, or that working mechanism(s) in the recall only condition showed a delay in effectiveness.

A decreasing impact of the recall + EM condition may have occurred because the WM load of making EM gradually reduced during the intervention. Fundamental studies on dual task procedures have shown that if one of the tasks is very easy or has become automated, it has minimal impairment on the execution of the other task (e.g., Baddeley, Grant; Wight, & Thomson, 1973; Quinn & McConnell, 1996). We used EM on a constant speed of 1.2 Hz, which loads the WM in the short term (van Veen et al., 2015). It is unclear if a longer period of making EM on this speed still produces the same WM load. However, the slope of the intervention phase in the recall + EM condition shows a linear pattern on all outcome variables, which does not support this decay hypothesis.

The lack of differentiation between the conditions at post-test may also be explained by active working mechanism(s) in the recall only condition that require some time. Recall only can be considered a lab analogue of imaginal or prolonged exposure therapy, which is an effective treatment for PTSD (Foa, Keane, Friedman, & Cohen, 2008). Several clinical studies have shown that prolonged exposure to the traumatic memory leads to change in trauma-related negative cognitions and that these changes precede PTSD symptom reduction (e.g., McLean, Yeh, Rosenfield, & Foa, 2015; Zalta et al., 2014). Arguably, cognitive change may appear after substantial treatment duration, reflected in PTSD reduction. Clapp, Kemp, Cox, and Tuerk (2016) found three response patterns in a group of veterans diagnosed with PTSD who received prolonged exposure: 18.3% rapid responders, 40.4% linear responders and 41.3% delayed responders. Although we used process measures instead of clinical measures, slower activation of working mechanisms in the recall only condition could explain why previous analogue studies that involved a brief duration showed beneficial effects of making EM during recall, while we found no differences between the conditions. Furthermore, it is still unknown whether cognitive change also mediates the effects between dual tasks and reductions in distress during the session or PTSD symptoms over time (Engelhard, McNally, & van Schie, 2019; Gunter & Bodner, 2008).

A remarkable finding of this study is that the memory reductions were short-lived only after EM during recall. One explanation for this finding might be that making EM functions as safety behavior during exposure. Safety behavior may lead to a misattribution of safety to the behavior instead of to the stimulus (Salkovskis, 1991). Translated to our study, participants might have argued: "I felt less distress, *because* I was distracted". When safety behavior is no longer available, threat perceptions may increase (Engelhard, van Uijen, van Seters, & Velu, 2015). Another explanation is that performance of dual tasks reduces memory accessibility and that part of this accessibility restores over time. Indeed, after recall + EM but not recall only, participants reported that memories are more difficult to retrieve than before the intervention (van Veen et al., 2015) and they typically show poorer performance on tasks that measure memory recognition (Houben, Otgaar, Roelofs, & Merckelbach, 2018; Leer et al., 2017; van den Hout, Bartelski, & Engelhard, 2013; but see van Schie, Engelhard, & van den Hout, 2015). However, since these studies lack follow-up measurement, it is unclear whether the reduced accessibility is permanent or restores over time. Nevertheless, the finding that memory effects after recall + EM condition partially relapsed after one day is not in line with the hypothesis that the intervention changes the actual memory (van den Hout & Engelhard, 2012).

The results of this study should be interpreted within the context of study's strengths and limitations. A first strength of the study is that we reduced demand characteristics by recruitment of a sample with no prior knowledge of EMDR, by the use of standardized instructions on the computer and by placing the experimenter out of sight of the participant. A second strength is that we reduced the error of memory fluctuations by including multiple assessments per phase. A first limitation of this study is that we found a poor internal consistency for the scale “attentional shifting” of the ACS. Future studies could assess attentional control with a computer-based task, such as the Attention Network Test (Fan, McCandliss, Sommer, Raz, & Posner, 2002). A second limitation is that we used a non-clinical sample. The study should be replicated in a clinical sample and involve outcome measures (e.g., PTSD symptom severity) besides process measures (i.e., stimulus, response, and meaning of the memory). Moreover, the study could be replicated with images of feared future events (i.e., “flashforwards”; Engelhard, van den Hout, Janssen, & van der Beek, 2010), to test if the same patterns occur.

From a clinical perspective, dual task procedures (e.g., EMDR) could be a preferred intervention for patients who are too anxious to start with imaginal exposure treatment (Andrade, Kavanagh, & Baddeley, 1997). Making EM immediately deflates the stimulus and response aspects of the memory and prevents confrontation with an inflated memory. Allowing such distraction fits with the empirical finding that approach-supportive safety behavior may facilitate expectancy violation and may therefore contribute to positive effects of exposure therapy (e.g., Milosevic & Radomsky, 2008, 2013). A possible solution to the counter-productive effects of EM found in this study might be to remove the EM after the first stage of the intervention, similar to the elimination of safety behavior during exposure therapy (e.g., Craske, Treanor, Conway, Zbozinek, & Vervliet, 2014). Furthermore, a longer period of recall only (e.g., 2 min) after dual task procedures could be considered a behavioral approach test and may form a new assessment tool in clinical or analogue EMDR studies. Last, future studies could include measures of cognitive change and memory accessibility to gain a better understanding of memory and cognitive processes that take place during imaginal exposure and dual task interventions.

Author contributions

SCvV developed the study concept. All authors contributed to the study design. SvV was responsible for the data collection. SCvV and RvdS performed the data analyses. SCvV drafted the manuscript. All authors provided critical revisions.

Conflict of interest

There is no conflict of interest in the present study for any of the authors. This work was supported by a TOP grant (dossier number: 40-00812-98-12030) from the Netherlands Organization for Health Research and Development (ZonMw) awarded to MAvdH and IME. IME is supported with a Vici grant (grant number: 453-15-005) from the Netherlands Organization for Scientific Research (NWO).

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jbtep.2019.03.001 and at the Open Science Framework (https://osf.io/3yqcw/).

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