EMDR and mindfulness. Eye movements and attentional breathing tax working memory and reduce vividness and emotionality of aversive ideation

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ABSTRACT

Background and objectives: Eye Movement Desensitization and Reprocessing (EMDR) and Mindfulness-Based Cognitive Therapy (MBCT) are effective in reducing the subjective impact of negative ideation. In both treatments, patients are encouraged to engage in a dual-task (eye movements (EM) in the case of EMDR and attentional breathing (AB) in the case of MBCT) while they experience negative thoughts or images. Working memory theory explains the effects of EM by suggesting that it taxes limited working memory resources, thus rendering the image less vivid and emotional. It was hypothesized that both AB and EM tax working memory and that both reduce vividness and emotionality of negative memories.
Methods: Working memory taxation by EM and AB was assessed in healthy volunteers by slowing down of reaction times. In a later session, participants retrieved negative memories during recall only, recall + EM and recall + AB (study 1). Under improved conditions the study was replicated (study 2).
Results: In both studies and to the same degree, attentional breathing and eye movements taxed working memory. Both interventions reduced emotionality of memory in study 1 but not in study 2 and reduced vividness in study 2 but not in study 1.
Limitations: EMDR is more than EM and MBCT is more than AB. Memory effects were assessed by self reports.
Conclusions: EMDR and MBCT may (partly) derive their beneficial effects from taxing working memory during recall of negative ideation.

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1. Introduction

Some 20 years ago, EMDR was introduced as treatment for posttraumatic stress disorder (PTSD), and meta-analyses of effect studies have concluded that the therapeutic claim was justified. EMDR appears to be as effective as cognitive behavior therapy (CBT) and the therapeutic effect is substantial, at least as large as those of other established treatments for other anxiety disorders (Bisson et al., 2007; Bradley, Greene, Russ, Dutra, & Westen, 2005; Seidler & Wagner, 2006). An early meta-analysis concluded that the eye movement component does not contribute to the effects of EMDR (Davidson & Parker, 2001). However, it has been criticized on methodological grounds (Lee & Cuijpers, submitted for publication), and a recent more encompassing and rigorous meta-analysis did

find significant additive effects for eye movements in clinical trials (Lee & Cuijpers, submitted for publication).

To explain EMDR effects, various authors have modeled EMDR, especially the eye movements (EM) component, experimentally. Typically, healthy participants are first asked to retrieve aversive autobiographical memories and rate their vividness and emotional valence. Then they are asked to recall the memories while making EM or doing no-dual-task (recall only). Finally, after recall + EM and recall only, participants are asked to recall the memories again, and to rate vividness and emotionality once more. Studies have shown that recall + EM reduces vividness and emotionality, but recall only does not (Andrade, Kavanagh, & Baddeley, 1997; van den Hout, Muris, Salemink, & Kindt, 2001; Kavanagh, Freese, Andrade, & May, 2001; Barrowcliff, Gray, Freeman, & MacCulloch, 2004; Kemps & Tiggemann, 2007; Maxfield, Melnyk, & Hayman, 2008; Gunter & Bodner, 2008). Apparently, the EM component of EMDR can be modeled under laboratory conditions, opening the door for the experimental dissection of the psychological mechanisms responsible for the treatment's therapeutic effects.

A fresh explanation of how EM might work has been derived from working memory theory (Andrade et al., 1997). The theory entails that retrieving a memory for an event requires limited-capacity working memory (WM) resources. If a secondary task is executed during retrieval that shares this dependence, fewer resources will be available for recalling the memory, and the latter will be experienced as less vivid and emotional. EM are held to serve as such a 'secondary' task that taxes WM, reduces vividness during memory recall and affects later recall (van den Hout et al., 2001; Kavanagh et al., 2001; Barrowcliff et al., 2004; Kemps & Tiggemann, 2007; Maxfield et al., 2008; Gunter & Bodner, 2008). The notion that the vividness of future recollections can be affected by the nature of earlier recollections is not new. If individuals concentrate on mental imagery, vividness of future recollections increases substantially (e.g., Hyman & Pentland, 1996). While such concentrated mental imagery creates "imagination inflation", cognitive taxing during recall seems to do the opposite and deflates the vividness and emotionality of future recollections. EMDR seems to therapeutically exploit the fact that memories become labile during recall and that reconsolidation is affected by the nature of the recall (Baddeley, 1998).

This WM account of the EM component of EMDR comfortably fits with experimental data. Non-taxing secondary tasks, like simple finger tapping, do not have beneficial effects (van den Hout et al., 2001), while more complex tapping does (Andrade et al., 1997). During EMDR eyes are typically moved horizontally. In line with a WM account, moving eyes vertically is just as effective (Gunter & Bodner, 2008). Crucially, the same effects occur if WM is taxed during memory recall with non-EM secondary tasks, like auditory shadowing (Gunter & Bodner, 2008), drawing a complex figure (Gunter & Bodner, 2008), doing arithmetic (Kemps & Tiggemann, 2007; van den Hout et al., 2010; Engelhard, van den Hout, & Smeets, 2011), or playing the computer game 'Tetris' (Engelhard, van Uijen, & van den Hout, 2010b). In these studies, participants deliberately recalled the negative memory during the dual-task. In two studies, participants played Tetris for 10 min following an interval of 30 min (Holmes, James, Coode-Bate, & Deeprose, 2009) or 4 h (Holmes, James, Kilford & Deeprose, 2010) after seeing a film of traumatic content. Before playing Tetris, they had a reminder of the film. Both experiments showed that, relative to the control condition, playing Tetris reduced the number of intrusions in the week after seeing the film. The beneficial effect of EM maintains when the negative memories pertain to loss and grief (Hornsveld, Landwehr, Stein, Stomp, Smeets & van den Hout, 2010).

EMDR is used for traumatic memories (flashbacks). Individuals may, however, also have prospective memories that may take the form of intrusive images about future events ("flashforwards"). In line with the WM account, vividness and emotionality of flashforwards are reduced when they are retrieved while making EM (Engelhard, van den Hout, Janssen, & van der Beek, 2010a). Individuals differ in working span capacity and in the capacity of dual-tasking. For individuals with relatively poor working span, the impact of a dual-task during recall should be relatively large. Consequently, WM theory predicts that people with relatively poor multi-tasking abilities show relatively large benefits from dual-tasks during recall of aversive memories. This has indeed been observed (Gunter & Bodner, 2008; van den Hout et al., 2010). In sum, laboratory data suggest that EMDR and related procedures derive their effects from WM taxing during recall of aversive memories (Holmes et al., 2009; Gunter & Bodner, 2008; Maxfield et al., 2008; van den Hout et al., 2010; Engelhard et al., 2010a).

WM is typically held to consist of three subsystems (Baddeley, 1998). The "central executive" (CE) allocates and divides attention between tasks, selects retrieval strategies, activates memories, and inhibits distractors. Furthermore, two "slave systems" are

postulated: the visuospatial sketchpad (VSSP), involved in the processing of visuospatial information, and the phonological loop (PL), that processes verbal information. The question ensues what component(s) of WM is (are) affected by the tasks mentioned above. The dominant theoretical perspective on this issue suggests modality specificity (e.g., Baddeley, 1998). Eye movements should load the VSSP and verbal tasks should load the PL. In line with the modality specificity view, it has been found that eye movements strongly interfere with WM for (sequences of) locations and much more than equivalent limb movement or covert attention shifts without eye movements (Pearson & Sahraie, 2003). With regards to autobiographical memory, Lilley, Andrade, Turpin, Sabin-Farrell, and Holmes (2009) asked 25 PTSD patients who awaited treatment to recall elements of the trauma under three conditions: recall + EM, recall + counting or recall only, with all treatments lasting 8×8 s. Trauma memories became (temporarily) less vivid and less emotional during recall + EM but not during the other treatments, and the authors interpret their findings "as showing that the eye-movements task reduced image vividness by temporarily disrupting active maintenance and manipulation of traumatic images in the VSSP of working memory" (p. 317). There is no reason to doubt that EM load the VSSP, but they also load the CE (see below), and it is unclear to what degree the effects reported by Lilley et al. were due to CE effects or VSSP effects. The verbal condition (counting aloud from one upward) may have required less overall cognitive load than making the eye movements. If so, results may also be explained in terms of more CE effects by EM. Gunter and Bodner (2008; experiment 3) reported that effects of auditory shadowing were as strong as effects of EM on reductions of vividness/emotionality. While, obviously, this argues for a general (CE) account, Gunter and Bodner add that their findings do "not completely rule out the possibility that some of the benefit is due to taxing the VSSP" (2008, p. 927). Alternatively, the fact that, in contrast to Gunter and Bodner (2008), Lilley, Andrade, Turpin, Sabin-Farell, and Holmes (2009) found that EM were superior to counting and that, again in contrast to Gunter & Bodner, effects of EM disappeared after one week, may be explained by differences between participants in these studies: PTSD patients (Lilley et al.) and healthy volunteers (Gunter & Bodner). This stresses the need for direct patient-control studies. Finally, Kemps and Tiggemann (2007) found that, compared to recall + counting, recall + EM reduced vividness and emotionality of visual images to a greater degree than vividness/emotionality of auditory images, whereas recall + counting had larger effects on auditory images. The authors suggest that memory disruption by dual-tasks during recall is modality-specific. Still, inspection of their data (experiment II) shows that the largest effect was a general one. Compared to recall-only, recall + EM and recall + counting reduced vividness/emotionality of visual and auditory memories. Modality-specific effects were present, but they were superimposed on a much larger general, non-specific effect.

In sum then, laboratory data suggest that EMDR and related procedures derive their effects from the taxing of WM during recall of aversive memories (Engelhard et al., 2010b, 2011; Gunter & Bodner, 2008; Holmes et al., 2009, van den Hout et al., 2010; Maxfield et al., 2008). The data suggest that procedures like EM and counting have memory effects that are general, affecting the CE component of WM, as well as modality specific, affecting visuo-spatial or phonological aspects of memory.

Over the last decade, a new treatment evolved that intended to prevent the recurrence of depression: "mindfulness-based cognitive therapy" (MBCT; Segal, Williams, & Teasdale, 2002). Several trials have confirmed that MBCT, compared to treatment as usual, reduces relapse rates for depression (for a review see Coelho, Canter, & Ernst, 2007), and reduces depression severity (Barnhofer et al., 2009;

Crane et al., 2008; Kingston, Dooley, Bates, Lawlor, & Malone, 2007). Studies in recovered depressed patients found that MBCT reduces self-discrepancies (Crane et al., 2008) and over general autobiographical memory (Williams, Teasdale, Segal, & Soulsby, 2000), which are both associated with the maintenance of depression. In 2004, the National Institute of Clinical Excellence recommended MBCT as treatment of choice for patients who have experienced multiple depressive episodes (NICE, 2004).

MBCT was developed to counteract downward spirals between low mood and self-devaluating thinking cycles. Recovered patients learn to identify depression-related thoughts and feelings at times of a potential relapse. To practice this state of sensitive awareness, or mindfulness, patients engage in attentional breathing (AB) in which they sit down and try to focus their attention on the present experience, which is typically awareness of the breath. When attention wanders, patients are encouraged to be aware of this in a nonjudgmental manner, and to reestablish attention on the breath. Crucial in the present context is that after four weekly sessions, patients are instructed to apply this exercise when they become aware of low mood or negative thinking (Segal et al., 2002, p. 209–211). Patients appear to perceive the breathing exercise as particularly helpful: "Many of those who have participated in the program have singled this practice out as the most useful feature of the whole course" (Williams, Teasdale, Segal, & Kabat-Zinn, 2007, p. 182).

Obviously, there are many differences between EMDR and MBCT in terms of theoretical rationale, clinical indication, et cetera, but, procedurally, there seems to be an interesting parallel that may have a bearing on the mechanism by which therapeutic change is brought about. Gunter and Bodner (2008) also noted this parallel. In both treatments, negative thoughts or images are retrieved while the patient simultaneously carries out a thematically unrelated dual-task: EM in the case of EMDR and AB in the case of MBCT. Given the evidence that such dual-tasking is crucial to EMDR, one wonders if mindfulness may operate in a comparable way. Would engaging in AB when a negative thought or image comes to mind serve as taxing WM, much like EM does in EMDR? Somewhat in passing, the developers of MBCT hinted at this option. AB was held to involve "intentional deployment of conscious awareness", which requires limited attentional resources so that "fewer of those resources are available for the establishment and maintenance of the depression-related processing configurations reactivated in dysphoria" (Segal, Teasdale, & Williams, 2004).

The first aim of the current studies was to test if, and to what degree, AB taxes WM. Reaction Time Tasks (RTTs) were used in which participants were asked to respond as fast as possible to auditory stimuli presented during AB (RTT + AB) or during a control condition (RTT only). To the degree that AB taxes WM, responses in the RTT + AB condition should be slower than during the RTT only. An earlier study showed that EM increases RT (van den Hout et al., submitted for publication). Effects of RTT + AB were compared with RTT only and with RTT + EM.

The second aim was to test in healthy participants if vividness and emotionality of negative memories are reduced if the retrieval of such memories is accompanied by EM and AB. Again, there were three conditions: Recall only, Recall + AB and Recall + EM.

Finally, results of the RTT and retrieval sessions were combined. Individuals differ in their multi-tasking ability: some individuals will be less distracted by, e.g., EM may slow down only little in an RTT + EM condition. The WM account of EMDR predicts that such individuals will benefit less from making EM during retrieval. Indeed, negative correlations have been found between 'multi-tasking' ability and the effects of EM and other dual-tasks during memory retrieval (Gunter & Bodner, 2008; van den Hout et al., 2010; Engelhard et al., 2010b). Thus, a third goal was to test whether the hypothesized slowing down in the RTT + EM and

RTT + AB conditions would predict the hypothesized decline in vividness/emotionality in the (later) Recall + EM and Recall + AB conditions.

The first experiment yielded promising results. To establish the robustness of the findings and test whether they would survive methodological changes, a second experiment was carried out. It tested the same hypotheses, but under slightly different conditions.

2. Experiment 1

Experiment 1 involved two sessions: assessment of WM taxing induced by EM and AB (session 1) and the subsequent test of the effects of recall + EM and recall + AB on memory vividness and emotionality (session 2). A valid way to assess the presence and severity of WM taxing of a task is to perform the task while simultaneously carrying out a reaction time task (RTT) in which two stimuli have to be discriminated (Bower & Clapper, 1989). Using such discrimination RTT, in which participants discriminate between high and low tones, earlier research showed that, compared to RTT only, individuals slow down when they simultaneously do mental arithmetic (van den Hout et al., 2010) or make EM (van den Hout et al., 2011; Engelhard et al., 2010b). In session 1 of the current experiment, a comparable RTT was used to assess WM taxing induced by RTT + AB, relative to RTT only and RTT + EM. In session 2, the same participants recollected three aversive memories and scored them in terms of vividness and emotionality. After that, memories were recalled in one of three conditions: Recall only, Recall + AB and Recall + EM, and then they were scored again on the same dimensions.

2.1. Method

2.1.1 Participants

Thirty-six undergraduates (mean age 22 years, $SD = 2.1$; 27 females) participated in exchange for remuneration or course credits.

2.1.2. Procedure and assessments

In session 1, degree of WM taxing was assessed with a stimulus discrimination RTT using two auditory cues. Participants wore headphones and sat in front of a computer screen that displayed the instructions. They were asked to press the left arrow key after a low tone (200 Hz) and the right arrow key after a high tone (300 Hz). They were told to respond as quickly and accurately as possible. All beeps were administered in both ears at a clearly detectable, constant volume. Each tone was presented for 500 ms, and the inter-stimulus interval was randomized and ranged between 2.7 s and 3.5 s (3.1 s average). Participants started with a practice task, and carried out the RTT in three conditions: 1) RTT only (baseline), 2) RTT + EM and 3) RTT + AB. The order of condition 2 and 3 was counterbalanced. In the baseline condition, participants performed the RTT without any secondary task. In the RTT + EM condition, participants performed the same RTT while making EM. The experimenter induced EM by sitting in front of the participant, and moving her hand across the participant's visual field, approximately 30 cm from the face, with a distance between the right and left of about 40 cm, at a rate of approximately 1 cycle per s. During RTT + AB, participants were instructed to close their eyes, place their non-dominant hand on their belly, breath slightly deeper than normal and observe their breathing. Dependent variables of the RTT were RT and error rate (failure to respond in time to the stimulus). All three conditions consisted of 3 sets that each lasted 24 s, leaving 21 RTs to be recorded in each of the three conditions. The RT task was programmed in E-Prime® 2.0.

Session 2 started 5 min after session 1; it also had a within-groups design and followed a protocol described earlier (van den Hout et al., 2001; Gunter & Bodner, 2008; Engelhard et al., 2010a, b). Participants were asked to choose three autobiographical memories (one for each condition) that still had a negative emotional impact on them at the time of the study, and to label these memories by writing keywords on a sheet of paper. During this assignment, the experimenter was absent for a few min, and participants were asked to alert the experimenter when they were finished. After ranking these memories from least to most emotional (their order was counterbalanced later to prevent sequence effects), the experiment started. There were three conditions: Recall only, Recall + EM and Recall + AB (the latter two tasks were identical to those used in the RTT experiment described above). Each participant completed all three conditions, and the order of the conditions was counterbalanced. In each condition, there were three stages. In the first stage, participants were given one of the three labels containing the memory keywords, and were instructed to think of the situation as vividly and completely as possible. After doing this for 10 s, they were asked to rate memory vividness (0 = not at all vivid, 100 = extremely vivid) and emotionality (0 = not at all unpleasant, 100 = extremely unpleasant) using 10 cm visual analogue scales (VAS). The second stage included the crucial manipulation, in which participants were again asked to recall the same memory used in the first stage, while at the same time doing either 1) nothing else (Recall only), 2) making eye movements (Recall + EM), or 3) attentional breathing (Recall + AB), depending on the condition. This process of recalling the memory (with or without a dual-task) lasted for 24 s, followed by a 10 s break in which participants were instructed to think of something else, and was repeated four times. The third stage was identical to the first stage, and resulted in a post-measurement of vividness and emotionality. Thus, the post-measurement did not relate to the experience during the stage 2 interventions, but to a new recollection of the pertinent memory.

2.2. Results

2.2.1. Session 1: taxing of working memory by EM and AB

A repeated-measures ANOVA showed that RT varied across conditions: $F(2,70) = 5.52$, $p < .01$, $\eta_p^2 = .14$. Paired t-tests showed that AB during the RTT yielded increased RT compared to no-dual-task: $t(35) = 3.44$, $p < .05$, one-tailed. A similar increase was found for EM: $t(35) = 2.60$, $p < .05$, one-tailed. Increases in RT due to AB did not differ from increases due to making EM, $t(35) = .06$, $p = .95$, two-tailed (see Table 1).

The number of errors did not differ between the conditions, $F(2.70) = 2.2$, $p = .12$, and was small in all conditions (Recall only: $M = .55$; $SD = 1.2$; Recall + AB: $M = .42$; $SD = 0.7$; Recall + EM: $M = .8$; $SD = 1.5$).

2.2.2. Session 2: effects of EM and AB on vividness and emotionality of memory

Fig. 1 shows pre and post-test values of vividness and emotionality in the three conditions. Effects were tested with

a 2×3 ANOVA with Time (pre-test vs. post-test) and Condition (Recall only vs. Recall + EM vs. Recall + AB) as within-group factors.

2.2.3. Vividness

For vividness, there was no significant main effect for Time, $F(1,35) = 1.40$, $p = .24$, $\eta_p^2 = .04$, or Condition, $F(2,70) = 1.6$, $p = .21$. The crucial Condition × Time interaction was significant, $F(2,70) = 4.62$, $p < .05$, $\eta_p^2 = .12$. Paired t-tests showed that the decreases in vividness in the Recall + AB condition did not differ from those in Recall only, $t(35) = .91$, $p = .18$, one-tailed. There was, however, a greater decrease in vividness in the Recall + EM condition relative to Recall only, $t(35) = 3.10$, $p < .01$, one-tailed. The decrease in vividness did not differ between the two dual-task conditions, $t(33) = 1.19$, $p = .24$.

2.2.4. Emotionality

For emotionality, there was a significant main effect for Time, $F(1,35) = 5.95$, $p = .02$, $\eta_p^2 = .15$, but not for Condition, $F(2,70) = .01$, $p = .91$. The Condition × Time interaction was significant, $F(2,70) = 5.16$, $p < .01$, $\eta_p^2 = .13$. Paired t-tests showed that the decrease in emotionality in the Recall + AB condition was greater relative to Recall only, $t(35) = 2.53$, $p < .05$, one-tailed. There was also a greater decrease in emotionality in the Recall + EM condition relative to Recall only, $t(35) = 3.14$, $p < .001$, one-tailed. The decrease in emotionality did not differ between the two dual-task conditions, $t(33) = .71$, $p = .48$.

2.2.5. Correlational analyses

As mentioned, WM theory predicts that larger increases in RT during dual-tasks predict larger decrease in vividness and emotionality due to dual-tasks. As an index of individual differences in taxing WM by EM, we calculated the increases in RT in the RTT + EM condition relative to the RTT only condition. This index was then correlated with the changes in vividness and emotionality during Recall + EM relative to Recall only. The same analysis was carried out for AB. None of the correlations were significant (all rs < 0.1; ps > .36).

2.3. Discussion Experiment 1 and introduction to Experiment 2

In session 1, we found that EM increased RT, which replicates the observations reported by van den Hout et al (2011) and Engelhard et al. (2010b). Crucially, a comparable increase in RT was observed due to AB. Apparently, EM and AB tax WM to a comparable degree.

In session 2, we observed that, relative to Recall only, emotionality of aversive memories was reduced by both EM and AB. The effects of EM replicated earlier findings reported by various authors (see general introduction). The current effects of AB on aversive memories are novel, and suggest that AB might obtain (some of) its effects by taxing WM, similar to EM. For vividness, the pattern was less straightforward. While the crucial Condition by Time interaction was significant, pair-wise comparisons showed that only EM had a significant effect relative to Recall only. Still, the drop in vividness scores due to AB was not significantly smaller compared to EM. It may be premature to speculate why EM affected vividness and emotionality, while AB only affected the latter. Earlier studies have shown that EM and other dual-tasks usually affect vividness and emotionality, but sometimes only one of these parameters is affected and chance fluctuations may be involved. Replication of these findings should first increase their robustness before any conclusions can be drawn.

Earlier studies found that individual differences in multi-tasking ability predict decreases in vividness and emotionality due to EM (Engelhard et al., 2010b; Gunter & Bodner, 2008) or to counting during recall (van den Hout et al., 2010).): the better this ability, the
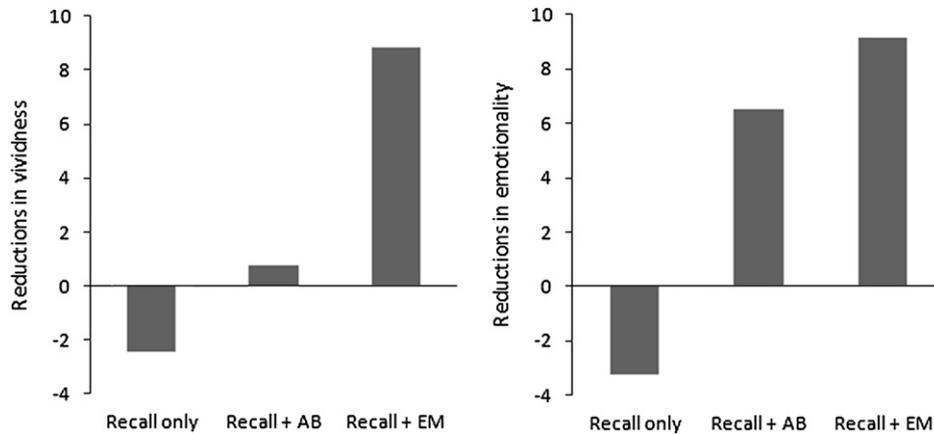
Table 1
Average reaction times in the conditions RTT only, RTT + AB, and RTT + EM.

Condition	Average reaction time (SD)
RTT only	535.6 (128.8)
RTT + AB	579.7 (138.0)
RTT + EM	578.7 (115.8)

Fig. 1. Changes in vividness (left panel) and emotionality (right panel) during Recall only, Recall + EM and RTT + AB (Experiment 1). Positive scores mean the memories became less vivid or emotional.

less vividness and emotionality decrease. In the current study, however, no such correlations emerged for EM or AB. This is at odds with earlier findings. Peculiarities of the RTT used may be responsible.

To test the robustness of the findings of the first experiment, a second (improved) experiment was carried out with a different RTT and slight alterations in the selection of participants, the AB task, and the EM task. These alterations are discussed below.

2.3.1. Reaction time task

The RTT was changed for a number of reasons. First, session 1 of Experiment 1 started with an RTT only, followed either by RTT + AB and RTT + EM, or vice versa. The increased RT in the AB and EM conditions may have reflected a fatigue effect rather than WM taxing. Therefore, in Experiment 2, the order of the RTT was optimized by making it fully balanced. Second, the RTT in the first experiment required participants to discriminate between two stimuli. Vandierendonck, De Vooght, and Van der Goten (1998) showed that RT to auditory cues presented at random intervals (without the requirement to discriminate), provides a valid and highly sensitive measure of WM taxation. RT in such a simple task are substantially shorter compared to discrimination tasks, which leaves more room for detecting subtle task-differences in WM taxing. Therefore, Experiment 2 used a simple auditory RTT instead of a stimulus-discrimination RTT. Third, participants in Experiment 1 were asked to respond as fast and accurately as possible. This instruction may have resulted in a shift in their speed-accuracy trait-off curve towards slow but accurate responses. The low error rate found in Experiment 1 is in line with this conjecture. A fast response strategy might be more sensitive for differences in taxing of working memory. Therefore, the instruction in Experiment 2 was changed to "respond as quickly as possible". Fourth, only 21 RT-trials per condition were presented in the Experiment 1. To increase the reliability of the RTT, the number of trials was increased in Experiment 2.

2.3.2. Selection of participants

In Experiment 1, participants who were familiar with EMDR and/or MBCT were not excluded. Effects on the RT and recall tasks might have been affected by prior knowledge. Therefore, in Experiment 2, familiarity with EMDR or MBCT served as exclusion criterion.

2.3.3. Attentional breathing task

During AB in Experiment 1, participants were instructed to close their eyes, place their non-dominant hand on their belly, breathe slightly deeper than normal, and observe their breathing.

In the other conditions, however, eyes were not shut and no hand was put on the belly. Though possibly unlikely, it cannot be ruled out that any (lack of) difference between the AB condition and other conditions was due to the eyes closed/hand on belly instruction. Therefore, in the AB conditions of Experiment 2, participants were instructed to keep their eyes open, and no instruction was given to follow the breathing with the hand on the belly. Furthermore, the AB instruction in Experiment 1 followed the MBCT protocol somewhat loosely. In Experiment 2, participants were trained in AB at the beginning of the study, and care was taken that the protocol as described in Segal et al. (2002) was followed.

2.3.4. Eye movement and recall only task Task

Experiment 1 did not ensure that eyes were stationary in the recall only condition. Therefore, participants in the recall only condition in Experiment 2 were asked to look at a stationary circle on the computer screen. Furthermore, in experiment 1, participants made EM by visually following horizontal hand movements made by the experimenter. To rule out that any effects of EM were due to non-specific aspects of this procedure (e.g. being distracted not only by the EM but also by other features of the experimenter), participants in Experiment 2 made EM by following a small circle that moved horizontally across a PC screen.

2.3.5. Compliance check

In Experiment I, participants were not asked about the degree to which they complied with the instructions. Such questions were added to Experiment II.

3.Experiment 2

3.1. Method

3.1.1. Participants

Thirty-six undergraduates (mean age 21.7, $SD = 2.1$; 21 females) participated in exchange for remuneration or course credit. Individuals familiar with mindfulness or EMDR were excluded.

3.1.2. Procedure and assessment

Prior to the main experiment, participants completed a training session to familiarize them with AB, EM, and the RTT. For the AB training, which took about 10 min, the breathing space exercise from the MBCT handbook (Segal et al., 2002) was translated into Dutch and adapted somewhat for use with participants unfamiliar with mindfulness. For the EM training, participants were seated

approximately 30 cm in front of a 17″ computer monitor that showed a 1 cm white circle moving horizontally at a rate of 1 left-right-left cycle per s. Additionally, a sinusoidal movement was implemented to make the task less straining for the eyes and to resemble a therapist's hand movements more closely (i.e., the horizontally moving circle slowed down upon approaching the edges and accelerated again towards the center). Lastly, in the RTT training, participants responded as quickly as possible to several 200 Hz beeps by pressing a button on the keyboard. All beeps were administered to both ears using headphones and a clearly detectable, constant volume. Stimulus duration was 50 ms. The inter-stimulus interval was quasi-random 900 or 1500 ms, with the restriction of no more than four of the same intervals in a row. This training lasted about 20 s. Dependent variables were RT and error rate (failure to respond in time to the stimulus). The RT task and EM task were programmed in E-Prime® 2.0.

In session 1, after the training session, the RTTs were administered. In all conditions, participants were seated in front of a computer screen in a soundproof laboratory. In the RTT only condition, participants were asked to respond to the beeps as quickly as possible while looking at a stationary white circle in the middle of the computer screen. In the RTT + AB condition, the RTT was performed while carrying out AB. Participants looked at the words "…breathe mindfully…" shown in the middle of the screen. In the RTT + EM condition, participants did the RTT while tracking the horizontally moving circle with their eyes. The three conditions were completed by each participant, and their order was counterbalanced.

In session 2, the effects of AB and EM on vividness and emotionality of memories were tested using the same protocol as described for Experiment 1. Again, there were three conditions (Recall only, Recall + AB and Recall + EM), and the instructions for AB and EM were identical to those in RTT + AB and RTT + EM. Each participant completed all conditions, and the order of the conditions was counterbalanced. After each of the three treatments, participants reported the degree to which they 1) directed attention to the breath and 2) made horizontal eye movements. Answers were given on 100 mm VASs. The assessment of vividness and emotionality followed Experiment 1.

3.2. Results

3.2.1. Data preparation

The upper limit for half of the trials was 900 ms (ISI 900), and RTs over 900 ms were deleted for the 1500 ms ISI trials. Two hundred RTs (1.3% of the total) were removed. To establish a lower bound cut-off point, the RTs of the fastest five participants were plotted in the order of magnitude. Visual inspection showed a smooth trend of rising RTs from 130 ms and higher (as opposed to randomly distributed RTs in the 0–130 ms part) and therefore, all RTs below 130 ms were discarded.

Data from three participants were removed. The first participant did not properly understand the AB instruction during the training, the second had an average RT in the RTT only condition with a z score of 4.37 (average RT = 507 ms compared to $M = 253$, $SD = 58$, for the other participants). The third made EM in the Recall + AB condition. Other outliers ($-3.29 < z < 3.29$) were replaced by scores deviating 3.29 SDs from the mean.

3.2.1.1. Session 1: taxing of working memory by EM and AB
3.2.1.1.1. Reaction times. A repeated-measures ANOVA showed that RTs varied across conditions, $F(2,68) = 39.34$, $p < .001$, $\eta_p^2 = .54$. RTT + AB yielded slower RTs compared to RTT only, $t(33) = 6.75$, $p < .001$. The same applied to RTT + EM, $t(33) = 8.97$,

$p < .001$. The difference between RTT + AB and RTT + EM was not significant, $t(34) = 1.02$, $p = .31$. See Table 2 for mean RTs.

A repeated-measures ANOVA showed that the number of errors in the RTT differed across conditions, $F(2, 68) = 12.69$, $p < .001$, $\eta_p^2 = .27$. Relative to RTT only, there were significantly more errors in the RTT + AB condition, $t(33) = 3.39$, $p < .01$, and in the RTT + EM condition, $t(33) = 4.57$, $p < .001$. The RTT + AB and RTT + EM conditions did not differ, $t(34) = 1.31$, $p = .26$. The mean number of errors per condition is presented in Table 2.

3.2.1.1.2. Task compliance. Scores on the VAS that assessed compliance with AB instructions were different across conditions: $F(2,64) = 114.64$, $p < .001$, $\eta_p^2 = .84$. Paired t-tests showed more attentional breathing in the RTT + AB condition ($M = 75$, $SD = 18$) relative to RTT only ($M = 19$, $SD = 22$; $t(32) = 10.89$, $p < .001$, one-tailed), or RTT + EM ($M = 9$, $SD = 15$; $t(34) = 13.53$, $p < .001$, one-tailed). For the VAS scores on EM, Mauchly's test showed that the assumption of sphericity had been violated ($\chi^2(2) = 8.79$, $p = .012$), and degrees of freedom were corrected using the Huynh-Feldt estimates of sphericity ($\varepsilon = .84$). Conditions differed significantly: $F(1.68,53.62) = 315.77$, $p < .001$, $\eta_p^2 = .91$. Paired t-tests showed that scores were higher after RTT + EM ($M = 80$, $SD = 16$) than after RTT only ($M = 6$, $SD = 6$; $t(32) = 24.72$, $p < .001$, one-tailed), or RTT + AB ($M = 9$, $SD = 15$; $t(34) = 18.38$, $p < .001$, one-tailed).

3.2.1.2. Session 2: effects of EM and AB on vividness and emotionality of memory
3.2.1.2.1. Vividness. Effects were tested with the same 2 × 3 repeated-measures ANOVA reported in Experiment 1. Mauchly's test indicated that the assumption of sphericity had been violated for the main effect of Condition, $\chi^2(2) = 6.74$, $p = .03$. Therefore, degrees of freedom were corrected using the Huynh-Feldt estimates of sphericity ($\varepsilon = .88$). There was a significant main effect for Time $F(1,33) = 9.38$, $p < .01$, $\eta_p^2 = .22$, but not for Condition, $F(1.75,57.82) = 2.12$, $p = .24$. The crucial Condition × Time interaction was significant, $F(2,66) = 4.18$, $p < .05$, $\eta_p^2 = .11$. Paired t-tests showed a greater decrease in vividness in the Recall + AB condition compared to Recall only, $t(33) = 1.72$, $p < .05$. Likewise, there was a greater decrease in the Recall + EM condition relative to Recall only, $t(33) = 3.15$, $p < .01$. The decrease in vividness did not differ between the two dual-task conditions, $t(33) = 1.19$, $p = .24$. Fig. 2 (left panel) shows the changes in vividness.

3.2.1.2.2. Emotionality. Mauchly's test indicated that the assumption of sphericity had been violated for the Condition × Time interaction, $\chi^2(2) = 7.01$, $p = .03$. Therefore, degrees of freedom were corrected using the Huynh-Feldt estimates of sphericity ($\varepsilon = .88$). Fig. 2 (right panel) shows the mean emotionality scores. There were no significant main effects for Time, $F(1,34) = 3.35$, $p = .08$, or Condition, $F(2,68) = 1.03$, $p = .36$, and the Condition × Time interaction was also not significant, $F(1.75,59.65) = 0.05$, $p = .93$.

3.2.1.2.3. Task compliance. For the VAS scores on AB, Mauchly's test indicated that the assumption of sphericity had been violated, $\chi^2(2) = 6.27$, $p = .043$, and degrees of freedom were corrected using the Huynh-Feldt estimates of sphericity ($\varepsilon = .89$). Conditions differed significantly: $F(1.79, 60.72) = 200.98$, $p < .001$, $\eta_p^2 = .86$. Paired t-tests showed that AB scores were higher after the Recall + AB condition ($M = 80$, $SD = 18$) compared to Recall only

Table 2
Reaction times in milliseconds and error rates.

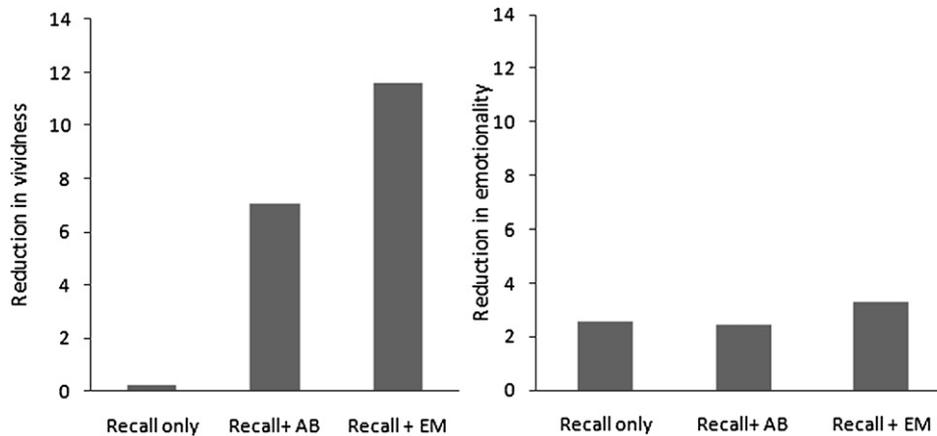| Condition	Average reaction time (SD)	Average number of errors (SD)
RTT only	250.1 (50.0)	4.83 (6.1)
RTT + AB	325.6 (76.6)	11.43 (14.4)
RTT + EM	336.7 (64.3)	13.54 (14.2)

Fig. 2. Changes in vividness (left panel)and emotionality (right panel) during Recall only, Recall + EM and RTT + AB (Experiment 2). Positive scores mean the memories became less vivid or emotional).

($M = 18$, $SD = 20$; $t(34) = 13.84$, $p < .001$, one-tailed), and greater than during Recall + EM ($M = 12$, $SD = 15$; $t(34) = 19.46$, $p < .001$, one-tailed). For the VAS measuring EM compliance, conditions differed: $F(2,68) = 877.33$, $p < .001$, $\eta_p^2 = .96$. Paired t-tests indicated that EM compliance during Recall + EM ($M = 90$, $SD = 10$) was greater than MB compliance during Recall only ($M = 7$, $SD = 10$; $t(34) = 34.33$, $p < .001$, one-tailed), and during Recall + AB ($M = 7$, $SD = 10$; $t(34) = 32.21$, $p < .001$, one-tailed).

3.2.1.2.4. Correlation analyses. Degree of WM taxing by AB and EM was determined, and differences were calculated between the number of errors in the RTT only condition and the other conditions, as described for Experiment 1. Correlations were calculated between these differences in RTs and number of errors on the one hand and changes in vividness on the other. No average reductions in emotionality were observed. Therefore, this variable was left out of the analyses.

Larger RTs due to EM in session 1 predicted larger reductions in vividness during session 2, $r = -.29$, $p < .05$; one-tailed. Similarly, more errors due to EM predicted larger reductions in vividness, $r = -.50$, $p < .001$, one-tailed. In contrast, larger RTs due to AB were not related to changes in vividness, $r = .03$, $p = .43$; one-tailed, and the number of errors due to AB did not predict drops in vividness, $r = .27$, $p = 0.12$, two-tailed.

3.3. Discussion Experiment 2

Experiment 2 differed in several ways from Experiment 1, but, by and large, the experimental effects survived these alterations. With an arguably more sensitive RTT, EM and AB, again, increased RTs, and the same pattern was found for the number of errors. The effects of AB and EM on RTs and errors did not differ. Both interventions reduced vividness of memories to a similar degree. The degree to which EM taxed WM, as evidenced by both RTs and error rates in session 1, predicted the later decline in vividness of memories. No such effect occurred for AB. On the RTTs and on memory tasks, participants reported good compliance with the instructions.

4. General discussion

In Experiment 1 and 2, different RTTs were used, but comparable effects were observed. In both experiments, RTs slowed down during AB and EM, and the rate of slowing down was identical in both conditions. In Experiment 1, neither of the interventions increased error rates, but in Experiment 2, both interventions did. It

is unclear to what degree differences in instruction (focus on both speed and accuracy in Experiment 1 and just on speed in Experiment 2) or the task itself (stimulus discrimination in Experiment 1 and simple RTT in Experiment 2) was responsible. Both experiments clearly show that both AB and EM tax WM to a surprisingly similar degree.

Regarding memories, the two experiments showed partly comparable and complementary effects. In Experiment 1, EM and AB affected emotionality to a similar degree, but in Experiment 2, they did not outperform recall only. As to memory vividness, Experiment 1 showed that only EM had larger effects than recall only, but EM and AB did not differ. In Experiment 2, both interventions reduced vividness to a same degree. It is hard to explain why emotionality was reduced in the first experiment and not the second, as the procedures were nearly identical. Using one way ANOVAs, we checked whether chance differences in initial ratings were involved. However, there were no significant initial differences in emotionality or vividness of the memories in Experiment I, $Fs\ (2,70) < 1$; $ps > .4$, or Experiment II, $Fs\ (2,66) < 2.04$; $ps > .13$. Note that each of the treatments (Recall + EM; Recall + AB; Recall only) was given as the first, second, or third treatment, with the order being balanced. To check whether the order of the treatment may have played a role, we tested whether drops in scores differed for the first, second or third position (independently from condition). There were no order-effects in Experiment 1 or 2 for vividness or emotionality. As mentioned, it is not uncommon in experimental research on EM that effects do not materialize on vividness or emotionality. This may be a matter of statistical power and more robust measures of the experiential quality of memories should be welcomed.

In Experiment 2, we found that increased RTs due to EM predicted the memory effects of Recall + EM on later trials. This replicates the observation that slowing down during RTT + Counting predicts the effects of Recall + Counting on later recollections (van den Hout et al., 2010). They are also are nicely in line with findings that a measure of the cognitive span predicts beneficial effects of EM, verbal shadowing, and drawing a figure during memory recall (Gunter & Bodner, 2008). However, these effects were not found for AB. It is unclear why RTT + EM predicted later effects of Recall + EM while RTT + AB did not. Possibly, AB taxes WM and affects memories, but the latter may not be mediated by the former.

Just like EM and related dual-tasks are central to EMDR (Shapiro, 2001), AB is held to be a crucial ingredient of MBCT (Segal et al., 2002). WM theory has a good track record in surviving tests to

explain the effects of EM (see introduction). Although there is more to MBCT than AB, and there may be more to AB than the taxing of WM, it is tempting to speculate that WM theory may explain (parts of) the effects of AB. In favor of such a hunch is the observation that AB taxes WM, which confirms incidental speculations by the developers of MBCT (Segal et al., 2004). Also, AB as "dual-task" affects memory vividness and emotionality, which is, by and large, comparable to other dual-tasks that have been tested earlier, like verbal shadowing and drawing complex figures (Gunter & Bodner, 2008), or counting (Kemps & Tiggemann, 2007; van den Hout et al., 2010; Engelhard et al., 2011). In this context, it is interesting that the degree of WM taxing and subsequent rating benefits seem independent of whether the AB task consists of the simple instruction to concentrate on the breath (Experiment 1) or if, in addition, the task emphasizes typical mindfulness elements, such as nonjudgmental awareness if attention wanders and the instruction not to influence the breathing process (Experiment 2). Finally, as to the comparison of EMDR and MBCT, one may note that in EMDR, clients are not encouraged to practice EM outside of therapy sessions. In MBCT, patients are stimulated to practice AB before going to sleep, after leaving bed, and during daytime. Given that EM is only practiced in therapy sessions, it seems unlikely that EM gets automated. With regards to AB, it is unclear what to predict about automation. On the one hand, the repeated practice will produce automation, and AB will take less effort as practice continues. On the other hand, patients are encouraged to keep allocating attentional resources to the breath; thus AB may be a skill that is related to resisting automation. It would be interesting to document the development of the degree to which AB requires cognitive resources.

In sum, following the WM explanation of EMDR effects, it was argued that AB in MBCT may function as EM in EMDR. The prediction that both interventions tax WM, as indexed by slowing of RTs, was confirmed. Likewise, we confirmed that both AB and EM during memory recall affect the vividness/emotionality of later recollections. There was some evidence (Experiment 2 only) that individual differences in the impact of EM on RTs predict EM effects on memory. Experiment 1 and 2 both showed that the AB effects on the RTT task did not predict AB effects on the memory task. Power problems may be involved here. EMDR and MBCT have become popular treatments. Explanations of the precise mechanisms by which therapeutic gains are achieved have crucial implications for (contra) indications and technical 'how-to-do-it' aspects for both EMDR and MBCT. Insights from recent WM/EMDR studies may be helpful to understand how MBCT works. There is room for fresh, exciting, and clinically important studies.

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