

Reducing vividness and emotional intensity of recurrent “flashforwards” by taxing working memory: An analogue study

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ABSTRACT

Several studies have found that making eye movements while retrieving visual images about past negative events reduces their vividness and emotional intensity. A working memory account states that eye movements tax working memory and interfere with visual imagery, thus degrading images. This study examined whether eye movements also affect recurrent, intrusive visual images about potential future catastrophes (“flashforwards”) in a sample of female undergraduates who had indicated on a screening-scale that they suffer from such intrusions. They were asked to recall two intrusive images with or without making eye movements. Before and after each condition, participants retrieved the image, and rated its vividness and emotionality. Results showed that vividness of intrusive images was lower after recall with eye movement, relative to recall only, and there was a similar trend for emotionality. Potential implications are discussed.

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On February 24, 2010, bobsledder pilot Edwin van Calker withdrew his four-man team from the Olympics, citing diminished confidence in navigating the track. His coach said he was affected by the fatal crash of a Georgian luger there, his own training crash, and pressure from his family. His coach considered the course safe and less dangerous than others (Abrams, 2010), but van Calker said it was a miracle he had been speeding down the course with the sled upright (ANP, 2010). According to a columnist, he feared the sled turning upside down, and “.. was in the grip of catastrophic thoughts. He imagined himself entering the finish with three corpses behind him” (Wagendorp, 2010).

Fear of future danger is common after a threatening event, and may take the form of future-oriented mental images. These may appear like “flashforwards,” echoing “flashbacks” in posttraumatic stress disorder (PTSD), and possess sensory qualities, being vivid, compelling, and detailed (see Holmes, Crane, Fennell, & Williams, 2007). Although intrusive thoughts and images about impending doom are commonly reported by healthy people (Rachman & De Silva, 1978), they are also related to psychopathology (see Brewin, Gregory, Lipton, & Burgess, 2010), such as PTSD (Reynolds & Brewin, 1998), depression (Holmes et al., 2007), panic disorder (Ottaviani & Beck, 1987), health anxiety (Muse, McManus, Hackmann, Williams, & Williams, 2010; Wells & Hackmann, 1993), and obsessive compulsive disorder (OCD; Speckens, Hackmann, Ehlers, & Cuthbert,

2007). For instance, people with depression or PTSD may suffer from future-oriented images that represent an elaboration of a specific personal memory, like a person nursing a sick relative imagining that relative deteriorating further or dying, and a person who had a stroke imagining having another one (Reynolds & Brewin, 1998). Obsessional problems in OCD may involve recurring thoughts or images of impending doom (e.g., “I will go insane and end up in an institution”) (Rachman & De Silva, 1978). In a study of patients with health anxiety, Muse et al. (2010) found that over 78% of participants reported experiencing recurrent, distressing intrusive images, the majority of which were future orientated, and these were categorised into four themes: (1) being told ‘the bad news’ that you have a serious/life threatening-illness, (2) suffering from a serious or life-threatening illness, (3) death and dying due to illness, and (4) impact of own death or serious illness on loved ones. People may respond to experiencing intrusive images by engaging in avoidance, checking, reassurance seeking, distraction, and rumination (Muse et al., 2010), thus preventing disconfirmation of erroneous expectations, and rendering them self-perpetuating. How can the vivid and emotional details of such images be diminished?

Eye movement desensitization and reprocessing (EMDR) was developed to target traumatic memories. In short, EMDR uses a dual-task approach (Shapiro, 2001; see Maxfield, Melnyk, & Hayman, 2008), in which a person imagines the traumatic event, while simultaneously focusing on external stimulation. The latter typically involves tracking the therapist’s finger moving from side to side in front of the person, which induces horizontal eye

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movements. Sets of eye movements are repeated until the memory no longer evokes distress. EMDR has long been a controversial treatment, but meta-analyses have shown it is an effective treatment for PTSD (e.g., Bisson, Ehlers, Matthews, Pilling, Richards, & Turner, 2007), and comparisons of EMDR and trauma-focused cognitive behavior therapy (CBT) have revealed no significant differences regarding treatment outcome or the speed of therapeutic change (National Institute for Health & Clinical Excellence, 2005).

The controversy surrounding EMDR involves whether eye movements add to the treatment's effectiveness. A recent meta-analysis of clinical trials suggests that it does (Lee & Cuijpers, submitted for publication). This is substantiated by analogue experimental studies that found that horizontal eye movements during recall of unpleasant autobiographical memories decrease vividness and/or negative emotions associated with these memories, compared to recall only (e.g., Andrade, Kavanagh & Baddeley, 1997; Engelhard, van Uijen, & van den Hout, 2010b; Gunter & Bodner, 2008; Van den Hout, Muris, Salemink, & Kindt, 2001). Eye movements seem to work, but it has been unclear why.

A working memory account posits that eye movements and visual imagery both draw on limited-capacity visuospatial (Andrade et al., 1997) and central executive (Gunter & Bodner, 2008) working memory resources. This dual-task competition will impair imagery, such that images become less vivid and emotional. Horizontal eye movements indeed tax working memory (Engelhard et al., 2010b; Van den Hout et al., 2011). In line with the working memory account, analogue studies have found that other taxing tasks during recall also reduce vividness and/or emotionality of negative memories, like vertical eye movements, drawing a complex figure (Gunter & Bodner, 2008), verbal arithmetic (Kemps & Tiggemann, 2007), mental arithmetic (Engelhard, van den Hout, & Smeets, 2011; Van den Hout et al., 2010; but see a clinical study by Lilley, Andrade, Turpin, Sabin-Farrell, & Holmes, 2009), and playing the computer game Tetris (Engelhard et al., 2010b). Interestingly, Holmes, James, Coode-Bate, & Deerprouse (2009) found that playing Tetris shortly after viewing a film with traumatic content reduces flashbacks in the next week, which suggests that a taxing visuospatial task during memory consolidation may be an effective preventative intervention. Further support for the working memory theory comes from studies showing that people with less working memory capacity or more taxing of working memory show more benefits from dual-tasks during memory recall (Gunter & Bodner, 2008; Van den Hout et al., 2010).

EMDR has been promoted as a treatment of memories for traumatic events, but the working memory theory implies that taxing dual tasks also affect images for *positive* autobiographical memories. This is confirmed by experimental evidence (Engelhard et al., 2010b; Van den Hout et al., 2001). More importantly here, the theory implies that it is irrelevant whether mental images are related to the past or the future: demanding dual-tasks should not only affect images about past traumatic events, but also about potential future events. This is supported by preliminary evidence. Engelhard et al. (2010a) asked healthy undergraduates to imagine two negative visual images about events they feared might happen to them in the future, and had not already happened to them in the past. These images were distributed over two conditions: (1) recall with eye movements, in which participants were told to keep the image in mind and simultaneously follow a white circle as it moved from side to side across a computer screen, and (2) recall only, in which participants were told to keep the image in mind and focus on a stationary white circle on the screen. Both conditions consisted of 4 phases of 24-s each, with 10-s breaks in between. Before and after each condition, participants were asked to retrieve the image and to rate its vividness and emotional intensity. The results showed that the vividness and emotional intensity of the future-oriented

images decreased after recall with eye movements, relative to recall only.

The working memory theory and this preliminary evidence provide a sound rationale for using working memory taxing during mental imagery of feared future events. However, it is unclear whether the findings may be generalized to clinical populations. As a next step towards clinical research, the aim of this study was to replicate this prior finding and extend it to a pre-selected sample of female students who suffer from recurrent, distressing intrusive images that are future-oriented.

1. Method

1.1. Participants and procedure

A total of 625 undergraduates from Utrecht University and Hogeschool Utrecht (higher vocational school) was administered a 3-item screening-scale, based on items 2 and 3 of the Yale-Brown Obsessive Compulsive Scale (Goodman et al., 1989), mainly in classrooms or lecture halls. They were given a brief oral explanation about the background and purpose of the scale, and a written explanation about unwanted, intrusive images about future catastrophe, which included examples, like images about someone being pushed under a train, becoming seriously ill, or being in a fatal car or plane crash (taken from Rachman & De Silva, 1978). Then they were asked: (1) whether they suffer from similar unpleasant, intrusive thoughts or images, using a yes/no format. If they marked yes, they were asked to rate: (2) how often these intrusions occur, and (3) how much they upset them, using a 4-point scale, 1 = (almost) never, 2 = sometimes, 3 = often, 4 = (almost) always. Questions 2 and 3 both had to be scored 2 or higher to be eligible to participate in the experiment. Of those eligible ($N=151$; 24%), a subsample was invited by email or telephone to participate, and 42 female students enrolled in the study for course credit or a financial reward. Five of them were excluded: three could only report one vivid image (i.e., vividness rating > 40 on 0–100 scale, determined a priori), one said she felt dizzy and lightheaded in the control-stationary dot-condition, and one moved her head rather than her eyes during the experimental condition (and said she was unable to concentrate on the moving dot). This resulted in a final sample of 37 participants (mean age = 21.7 years; $SD=2.8$).

In the experiment, participants were first given oral and written information about the study. After written informed consent was obtained, participants were administered a background scale, the SCL-90, and the EPQ (see measures), followed by the experiment, and a brief relaxation exercise. Finally, they were debriefed and given their reward.

1.2. Measures

The *background scale* included questions about demographics and whether participants had been treated by a psychologist in the past. The *Symptom Checklist* (SCL-90; Arrindell & Ettema, 2003) was used to measure common mental problems. Participants were asked to rate how much each symptom had bothered them during the past week on a 1 (not at all) to 5 (very often) scale. The SCL-90 has established reliability and validity (Arrindell & Ettema, 2003). The sum score was used for general distress (SCL-90; range 90–450). The short version of the *Eysenck Personality Questionnaire* (EPQ; Eysenck & Eysenck, 1975; Sanderman, Arrindell, Ranchor, Eysenck, & Eysenck, 1995) was used to measure neuroticism. The psychometric properties of this scale are good (Sanderman et al., 1995). Only the neuroticism scale will be reported (EPQ-N; range 0–22).

1.3. Experiment

Participants were tested individually using the protocol for images of unpleasant memories by Van den Hout et al. (2001), which was modified by Engelhard et al. (2010a) to distressing mental images of future-oriented catastrophe. We made another modification: Engelhard et al. (2010a) used 4 phases of 24-s each with 10-s breaks in between. As participants in the current study actually suffered from intrusions, we decided to use 8 phases of 24-s each, with 10-s breaks in between.

Participants were instructed to select an intrusive image of an unpleasant event which they feared might happen to them in the future and which had not already happened to them in the past. They were told not to use images about impulsive acts they might do, and to select images that would not be too emotional. Then participants were asked to describe each of the two images in 3–5 words on a piece of paper. The experimenter stepped out of the room to allow participants to come up with the disturbing images in private. Upon returning, the experimenter asked questions to clarify the image and to be able to write down a more elaborate description (“Can you form a clear image of this situation and briefly describe it to me? What do you see? What do you do? What’s happening? What does it look like? What else do you see?”). The experimenter made sure that the participant did not find these images too upsetting. Then, participants were asked to indicate which image was the most unpleasant to them. Half of the images were randomly assigned to the ‘recall with eye movements’ condition and half to the ‘recall only’ condition. The most unpleasant images were equally represented in both conditions, and the order of the conditions was counterbalanced across participants.

The recall with eye movements condition consisted of one session of 8×24 -s of eye movements, with 10-s breaks in between in which participants were told to focus on something else. These intervals were used to be consistent with prior studies that used this paradigm (e.g., Van den Hout et al., 2001; Gunter & Bodner, 2008; Engelhard et al., 2010a). Participants were seated about 45 cm from a computer screen. They were told to keep the image in mind while tracing a 1-cm light gray circle with their eyes as it moved horizontally from one side of the screen 21 cm across to the other side at a rate of one movement per s (cf. Gunter & Bodner, 2008). The recall only condition was the same, except that a stationary circle was used. Before and after each condition, participants were asked to retrieve the image, and to rate image vividness and emotional intensity on a visual analogue scale (VAS) on the computer screen, which ranged from 0 (not at all) to 100 (extremely). Prior to each session, participants also rated how difficult they found it to recall the image, using the same VAS.

The session ended with a 5 min relaxation exercise. The instructions were slowly read out loud by the experimenter. Participants were instructed to pay deliberate attention to their breathing (cf. mindfulness-based attentional breathing; Gijzen, 2010) and to picture themselves in the most beautiful place they could imagine. Then they were asked to envision a future goal that they wanted to accomplish. Finally, participants were asked whether they were familiar with several treatments, including CBT, mindfulness, and EMDR, and, if so, whether they could describe them.

1.4. Data reduction and analysis

Outliers were changed into $M \pm 2.5$ SD. To examine whether recall with eye movements, relative to recall only, would decrease image vividness and emotionality, 2×2 repeated measures analyses of variance (ANOVA) were performed with time (pre-test, post-test) and condition (eye movements, recall only) as within-

subjects factors¹. To check for pre-condition differences in difficulty recalling the image, 2-way within-subjects ANOVAs were performed, with condition (eye movements, recall only) as within-subjects factor. Alpha levels of .05 were used. When the direction of the differences was predicted, one-tailed p values are reported.

2. Results

The mean SCL-90 score was 155.19 ($SD=43.78$), which was higher than a sample from the general population ($M=118.28$, $SD=32.38$), but lower compared to a sample of psychiatric patients ($M=203.55$, $SD=61.60$; Arrindell & Ettema, 2003). The mean EPQ-N score was 11.27 ($SD=5.38$), which was comparable to a large sample of outpatients who mainly suffered from an anxiety disorder ($M=13.2$ $SD=5.4$; Sanderman et al., 1995). One-third of participants indicated they had been treated by a psychologist. This supports the notion that participants constitute a sub-clinical sample.

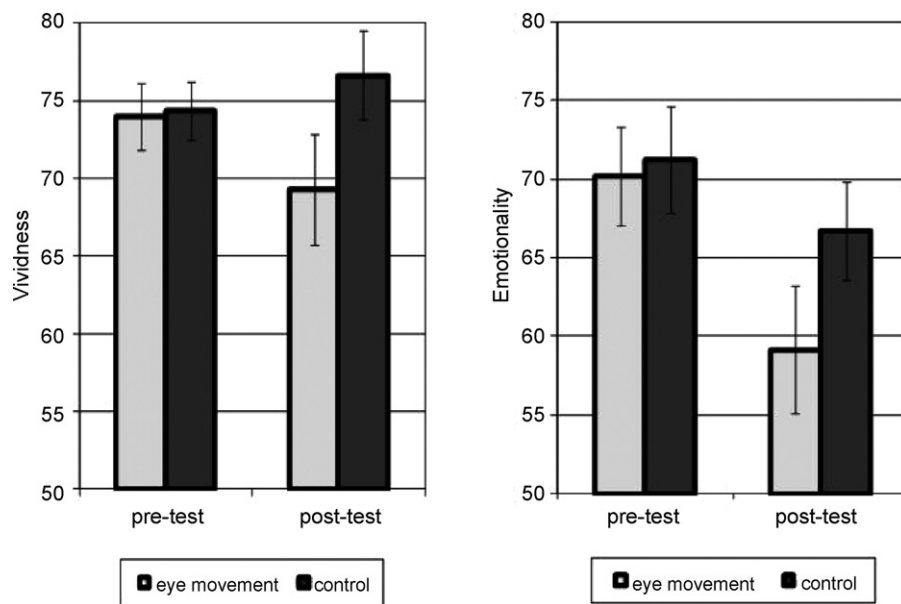
During the experiment, all participants indicated that they had suffered from disturbing, intrusive thoughts or images prior to the experiment. After discussing these further, participants produced two detailed descriptions of an image. About 20% of the images were related to the *death of a loved one* (e.g., I receive a phone call that my boyfriend, who deals with a lot of aggression at work, has been stabbed to death; I see my mother about to kill herself; My husband has suddenly died and I’m standing at his funeral in front of the coffin), 17% to *accidents* (e.g., I’m on a plane above the ocean, and suddenly the engine stops working and people panic), 15% to *disease of a loved one* (e.g., my mom tells us that she has cancer and we all cry); 10% to *disaster or assault* (e.g., I’m robbed while being alone in a train compartment at night), or other (e.g., a break-in, own death, not being able to speak during a presentation). The ratings for difficulty of retrieving the image in the eye movements condition ($M=36.74$, $SD=20.19$) and control condition ($M=37.13$, $SD=24.79$) did not differ significantly, $t(37)=1$; $d=.02$.

2.1. Vividness and emotionality of mental images

For vividness scores (Fig. 1), the ANOVA showed no significant main effect for time, $F(1,36)<1$, $\eta_p^2=.01$, and condition, $F(1,36)=2.95$, $p=.10$, $\eta_p^2=.08$, but the crucial condition $\times$ time interaction was significant, $F(1,36)=4.14$, $p<.05$, $\eta_p^2=.10$. A paired sample t -test showed that the pre-test vividness scores did not significantly differ between the conditions, $t(36)<1$, $d=.03$, but the post-test vividness scores were lower after eye movements compared to recall only, $t(36)=2.37$, $p<.05$, $d=.37$. For the recall only condition, no differences were observed between the pre and post-test vividness scores, $t(36)<1$, $d=.15$, and for eye movements, the pre to post-test drop did not reach significance either, $t(36)=1.23$, $p=.11$, $d=.26$.

For emotionality scores (Fig. 2), there was a significant main effect for time, $F(1, 36)=7.79$, $p<.01$, $\eta_p^2=.18$, but not for condition, $F(1,36)=1.74$, $p>.05$, $\eta_p^2=.05$. The crucial condition $\times$ Time interaction was not statistically significant, but showed a trend, $F(1, 36)=2.12$, $p=.077$, $\eta_p^2=.06$. To explore this trend, paired sample t -tests were conducted, which showed that the pre-test emotionality scores did not differ between the two conditions, $t(36)<1$, $d=.05$, but the post-test scores were significantly lower after recall with eye movements than after recall only, $t(36)=2.01$, $p<.05$, $d=.32$. For recall only, the pre-test and post-test scores did not significantly

¹ Vividness and emotionality ratings were subjected to a preliminary 2 (time) $\times$ 2 (condition) ANOVA with the order of conditions as between-subjects factor, which showed no significant effects for the order of conditions, largest $F(1, 35)=1.34$; $p=.26$; $\eta_p^2=.04$.



Figs. 1–2. Means for the vividness and emotionality scores before and after the eye movements and recall only conditions (error bar indicates ± 1 SEM).

differ, $t(36) = 1.28, p > .05, d = .20$, but for recall with eye movements, emotionality scores dropped significantly from the pre-test to the post-test, $t(36) = 3.07, p < .01, d = .52$.

3. Discussion

The main finding was that vividness of intrusive images about potential catastrophes was lower after recall with eye movements, compared to recall only, and there was a similar trend for emotional intensity. This fits with prior studies that focused on emotional images for past events (e.g., Andrade et al., 1997; Engelhard et al., 2010b; Gunter & Bodner, 2008; Van den Hout et al., 2001, 2011). The current study partially replicates a study that found that eye movements also affect future-oriented mental images about catastrophes (Engelhard et al., 2010a), and extends this to a sample of female students who indicated that they suffer from such images. However, as a whole, the effects were weaker in the current study: the post-test vividness scores were lower for the eye movements condition, relative to the recall only condition, but recall with eye movements did not significantly reduce vividness from pre- to post-test. Significant pre-post changes were found for emotionality scores, but the crucial interaction was only significant at trend level. This may be due to a problem of statistical power. Most studies have shown that eye movements affect both vividness and emotional intensity, but some studies found that only vividness, but not emotional intensity is affected, or vice versa (e.g., Engelhard et al., 2010b; Lee & Drummond, 2008; Maxfield et al., 2008). This may also be due to measurement imperfections related to a single VAS. More robust outcome measures are needed.

Effects of eye movements extend beyond the manipulation of taxing working memory. We focused on relatively short-term effects: the post-test took place after each condition, but within one experimental session. There is evidence that the effects of eye movements during similar 24-s phases are maintained over a one-week period for images of past events (e.g., Gunter & Bodner, 2008; exp. 2), which suggests there may be long-term gains. How might this be explained? Effects of eye movements cannot be explained by extinction caused by exposure, since they were absent in the recall only condition. The recall intervals were short (8×24 -s), and habituation after such short exposure periods may not be expected (see Marks, 1987; pp. 267–273). They do

support a working memory theory, which states that eye movements interfere with visual imagery and reduce image vividness, which may cascade into reduced emotional intensity (see Gunter & Bodner, 2008). There are at least two hypotheses regarding the underlying psychological mechanism. Gunter and Bodner (2008) proposed that “meta-cognitive” appraisals may be affected. During eye movements, people may experience that retrieval is less aversive than expected, which may change appraisals of the memory. Andrade and colleagues (e.g., Andrade et al., 1997; Kavanagh, Freese, Andrade, & May, 2001; Lilley et al., 2009) assume that working memory interference impairs the immediate recollection of the memory, and that a temporary weakening of the image and associated distress may allow the person to engage more fully in other components of treatment such as cognitive reprocessing. Future research is needed to elucidate the mechanism through which dual tasks may produce effects.

Caution is needed about interpreting the current findings in terms of long-term or clinical effects. Nevertheless, current and past findings as well as the working memory account seem to provide a rationale for using taxing dual-tasks during image recall to modify future-oriented vivid images. EMDR therapists are generally advised to focus on the processing of past events. This stems from the view that “incomplete processing and incomplete integration of memories of trauma and/or disturbing life experiences are a primary basis of psychopathology,” and the core of the treatment involves activating these memories “and pairing them with alternating bilateral or dual attention stimulation” (EMDR International Association, 2009, p. 1). However, there are no empirical or theoretical reasons to presume that distressing memories for past events need to be processed to reduce the distress associated with future-oriented mental images.

It should also be noted that EMDR therapists often use alternating binaural stimulation during memory recall, but it remains to be seen whether this is an effective distracting task. The working memory account posits that benefits of dual-tasks crucially depend on whether tasks make considerable demands on working memory, not on whether stimulation involves alternating bilateral stimulation or not. Benefits have been found for taxing tasks, like arithmetic, playing Tetris, or drawing a complex figure, but not for seemingly undemanding tasks, like simple finger tapping (Van den Hout et al., 2001), as the theory predicts. A new study shows that

binaural auditory stimulation barely taxes working memory and shows smaller effects on memories for negative events, compared to eye movements (Van den Hout et al., 2011), which challenges the view that it may be effective. To our knowledge, there is no evidence from clinical trials that binaural auditory stimulation is effective. Moreover, studies have found that more taxing of working memory is related to more reductions in vividness/emotionality ratings (e.g., Van den Hout et al., 2010), but extreme taxing may reduce benefits, possibly because it interferes with mental imagery (Engelhard et al., 2011). Thus, too little or too much taxing may be less effective. It seems important to adjust the degree of working memory taxing to an individual client. Depending on the client's working memory span, eye movements may be substituted by more taxing tasks.

Several limitations of the current study should be noted. First, this study focused on the immediate effects of eye movements. Further study is needed to establish the extent to which gains are maintained over a long period. Second, participants focused on one image during each condition, while new images may emerge. During the debriefing, several participants mentioned they found it hard to focus on only this image, perhaps also due to the length of the conditions (8 × 24-s periods). Future research may assess the effects of using more mental images or dynamic ones, rather than just one still. Third, participants were female students, and generalizability of findings to males requires further evaluation. Finally, the current study only focused on intrusive, visual future-oriented images, while people may also suffer, for instance, from recurrent negative thoughts (e.g., Borkovec & Inz, 1990) or an urge to act. If an urge to act involves visual images, one would expect that a taxing dual-task would decrease it, just like a visual imagery task reduces craving for cigarettes (May, Andrade, Panabokke, & Kavanagh, 2010).

In summary, in a sub-clinical sample, vividness of intrusive visual images about potential catastrophes were lower after recall with eye movements, compared to recall only, and there was a similar trend for emotionality. Given the importance of problems related to future-oriented mental images (e.g., Brewin et al., 2010), there is a need for research of long-term effects and clinical effects.

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