



The effectiveness of two novel approaches to prevent intrusions: A pilot study comparing Tetris_dualtask and imagery rescripting to control

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ABSTRACT

Background and objectives: Post-traumatic stress disorder (PTSD) is a global health problem. Although effective treatments for it exist, early interventions that prevent PTSD from developing are lacking. The aim of this pilot analogue trauma study was to compare the effects of two potential early intervention strategies, namely Tetris_dualtask and imagery rescripting (IR) to a no-intervention control group on intrusion frequency and the vividness and emotionality of aversive film memory.

Methods: Sixty healthy students were subjected to the trauma film paradigm and randomly allocated to either: Tetris_dualtask, IR or no-intervention. Main outcomes were the number of film-related intrusions at one week and vividness and emotionality ratings of the most aversive film memory. Secondary outcomes were PTSD-like symptoms, intrusion intensity, and explicit film memory.

Results: The Tetris_dualtask group reported significant fewer intrusions compared to the no-intervention group; whereas the IR group did not. No effect was found on vividness and emotionality ratings, PTSD-like symptoms, intrusion intensity, and explicit memory.

Limitations: The sample size was small, and analogue trauma in healthy individuals was examined, thus generalizability may be limited. Also, to increase comparability between interventions, the duration of Tetris_dualtask and IR was standardized. As a result, the IR intervention was shorter compared to other studies, which might have decreased its efficacy.

Conclusions: The results of this pilot study suggest that playing Tetris during retrieval of traumatic images, might hold potential as an early intervention strategy to reduce intrusions in the early aftermath of trauma and adversity. However, future large-scale replication research is needed.

1. Introduction

After exposure to traumatic experiences, posttraumatic stress disorder (PTSD) may develop in a significant minority of individuals (Breslau, 2009; Kessler et al., 2005). Although effective treatments for established PTSD exist, such as cognitive (processing) therapy, imaginal exposure therapy, and eye movement desensitization and reprocessing therapy (EMDR) (Bisson, Roberts, Andrew, Cooper, & Lewis, 2013; Cloitre et al., 2011), there is still an unmet need for early interventions that can prevent the onset of PTSD (Bisson et al., 2021; Iyadurai et al., 2019).

Intrusions, i.e., involuntary anxiety-provoking images and thoughts

related to the traumatic event are a key symptom of PTSD (American Psychiatric Association [APA], 2013) and are associated with the onset of PTSD (Freedman, Brandes, Peri, & Shalev, 1999). Influential models of PTSD, i.e., Ehlers and Clark's (2000) cognitive model and dual representation theory (Brewin, 2001; Brewin, Dalgleish, & Joseph, 1996; Brewin, Gregory, Lipton, & Burgess, 2010) focus on the development of intrusions, particularly information processing during and after a traumatic event. Normally, sensory-perceptual and conceptual memory representations are assumed to be tightly interconnected. However, in high-distress situations, one's processing style may shift towards stronger sensory-perceptual encoding and inhibited conceptual encoding.

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Accordingly, these overly strong encoded sensory-perceptual representations can be triggered involuntarily by cues associated with the trauma and manifest themselves as intrusions (Brewin et al., 2010; Ehlers & Clark, 2000). This suggests that interfering with sensory-perceptual encoding may weaken the otherwise strongly encoded sensory-perceptual representations, resulting in fewer intrusive memories. As such, early interventions that focus on interfering with sensory-perceptual encoding are potential candidates to successfully prevent the onset of PTSD.

Findings from cognitive neuroscience studies suggest that memories of an event are consolidated within the first 6 h after that event (Nader, 2003). During this time, the memory is labile and susceptible to manipulation before it is stored into long-term memory (McGaugh, 2000; Walker, Brakefield, Hobson, & Stickgold, 2003). It has been theorized that tasks taxing working memory shortly after initial learning may interfere retroactively with memory consolidation (Wixted, 2004) and reduce subsequent intrusions (e.g., Astill, Horstmann, Holmes, & Bisson, 2021; Deeprose, Zhang, DeJong, Dalgleish, & Holmes, 2012; Holmes, James, Coode-Bate, & Deeprose, 2009).

Recent laboratory-based studies using the well-established trauma film paradigm (for a review see Holmes & Bourne, 2008; James et al., 2016) have indeed found promising results for various visuospatial cognitive tasks in reducing intrusive memories (see Asselbergs et al., 2023, for a meta-analysis). For example, performing a complex pattern tapping task, shortly after watching an aversive film, reduced the frequency of subsequent intrusions compared to a no-task control (Deeprose et al., 2012). Another visuospatial task that is often used to study the efficacy of retroactively interference with memory consolidation after analogue trauma is the videogame Tetris. Tetris is a videogame in which the player has to organize falling blocks of different shapes in rows at the bottom of the computer screen. Several experiments in healthy volunteers, who watched a trauma film, showed that participants who did a Tetris-based intervention (trauma memory reminder cue plus Tetris gameplay) within the consolidation time window (i.e., 6 h), reported fewer film-related intrusions during the following week than participants who did not receive this intervention (e.g., Badawi, Berle, Rogers, & Steel, 2020; Holmes et al., 2009; Holmes, James, Kilford, & Deeprose, 2010; Lau-Zhu, Henson, & Holmes, 2019; Lau-Zhu, Henson, & Holmes, 2021). Recent studies, conducted in a clinical setting, have also found that playing Tetris within 6 h following a motor vehicle accident (Iyadurai et al., 2018) or an emergency caesarean section (Horsch et al., 2017) reduced subsequent intrusions.

Another line of research shows that vividness and emotionality ratings of distressing memories can be reduced using a dual-task intervention (see Engelhard, McNally, & van Schie, 2019). According to the working memory (WM) theory, see Andrade, Kavanagh, & Baddeley, 1997, keeping a memory in mind and simultaneously performing a demanding task (e.g., making eye movements, drawing complex figures) both compete for limited working memory resources. As a result, the memory becomes less vivid and less emotional and can be differently appraised and stored as such in the long-term memory (Andrade et al., 1997; Baddeley & Andrade, 2000; van den Hout & Engelhard, 2012; Gunter & Bodner, 2008). A recent meta-analysis showed that eye movements and alternative dual-tasks reduced vividness and emotionality of negative autobiographical memories compared to control conditions (Houben, Otgaar, Roelofs, Merckelbach, & Muris, 2020). Another meta-analysis assessing 53 laboratory studies showed that the dual-task interventions made both negative and positive memories less vivid and less emotional; but the reductions were more pronounced for autobiographical memories compared to newly acquired memory of a film or pictures (Mertens, Lund, & Engelhard, 2021).

An alternative strategy to interfere with psychological problems related to aversive imagery is imagery rescripting (IR). IR can be integrated into cognitive behavioural therapy interventions and can be used as a stand-alone intervention to modulate aversive memories or images (e.g., Holmes, Arntz, & Smucker, 2007; Landkroon, Meyerbröker,

Salemink, & Engelhard, 2022; Morina, Lancee, & Arntz, 2017; Siegesleitner, Stroh, Wittekind, Ehling, & Kunze, 2019; Wild & Clark, 2011). During IR, participants are instructed to visualize (parts of) the aversive memory as vividly as possible and imagine different intervening actions and outcomes (Raabe, Ehling, Marquenie, Arntz, & Kindt, 2022). Clinical studies have shown that IR is an effective treatment for PTSD (Raabe et al., 2022). It also reduces nightmares (Long et al., 2011), feelings of anger, shame and guilt (Arntz, Tiesema, & Kindt, 2007), and the vividness and frequency of intrusive memories (Hackmann, Ehlers, Speckens, & Clark, 2004). The underlying mechanisms of IR remain largely unknown, but presumably it involves changes in (metacognitive) appraisals of the memory or image (Kunze, Lancee, Morina, Kindt, & Arntz, 2019), but its effect may also be explained by retrieval competition between memory representations containing positive and negative information (Brewin, 2006). By imagining a 'more favourable' outcome, cues that previously led to the retrieval of negative memories may now be linked with positive elements. It is argued that this process alters the existing memory into a more helpful or less distressing version and as such is retrieved in favour of the original (Brewin, 2006). By manipulating imagery-based processing shortly after experiencing a traumatic event IR could be used as an effective early intervention tool to prevent intrusions from developing in the first place.

Indeed, several studies, utilizing the trauma film paradigm among healthy volunteers, have demonstrated beneficial effects on intrusion frequency when IR was performed shortly after watching an aversive film. For instance, in the study by Hageraars and Arntz (2012) participants watched an aversive film and after a 30-min break received a 9-min intervention consisting of either IR, imagery reexperiencing or positive imagery. Afterwards, participants were instructed to record all intrusive memories of the film for one week using an intrusion diary. Results showed that the IR group developed fewer intrusive memories compared to the imagery reexperiencing and positive imagery group. A similar study by Rijkeboer, Daemen, Flipse, Bouwman, and Hageraars (2020) showed that a 9-min intervention of either IR or writing rescripting, performed 20 min after watching an aversive film, resulted in fewer self-reported intrusions after one week compared to a no-intervention control group. Yet another study (Dibbets & Arntz, 2016) showed that participants allocated to 10.5 min of IR, whereby the aversive scene was included in the rescripted outcome, resulted in fewer self-reported film intrusions after one week compared to the control group. While early translation work for early intervention has been done for Tetris (e.g., Horsch et al., 2017; Iyadurai et al., 2018); it has not yet been done for imagery rescripting.

The aim of this pilot study was to test the effects of a dual-task intervention using Tetris (Tetris_{dualtask}) and IR on intrusion frequency, and vividness and emotionality ratings of the most aversive film memory, by comparing each to a no-intervention control group. The dualtask intervention using Tetris is a relatively novel approach, combining the protocols used in 'traditional' Tetris experiments (e.g. Holmes et al., 2009; Holmes et al., 2010; Lau-Zhu et al., 2019) and those used in dual-task experiments that combine a cognitive demanding task with deliberate and continuous recall of aversive memory (e.g. Engelhard et al., 2019; van Veen, Engelhard, & van den Hout, 2016). This approach reduces emotional ratings of aversive memories (Engelhard, van Uijen, & van den Hout, 2010). We predicted that both Tetris_{dualtask} and IR would lead to fewer intrusive memories and PTSD-like symptoms in the week following the intervention compared to a no-intervention control group, while leaving voluntary/explicit memory retrieval intact. Furthermore, we predicted that both Tetris_{dualtask} and IR would lead to reduced vividness and emotionality ratings regarding the most aversive memory, at post-intervention and at one week, compared to the no-intervention control group.

2. Methods

2.1. Participants

Sixty healthy students were recruited from the Vrije Universiteit Amsterdam (VU Amsterdam) campus through flyers and Sona Systems (a cloud-based participant pool management solution) to participate in exchange for course credits or financial compensation. For this pilot study no power calculation was performed; but based on the group sizes of similar experiments conducted with Tetris (Holmes et al., 2009, 2010) and IR (Hagenaars & Arntz, 2012), a sample size of 20 participants per group was determined based on pragmatic considerations. Individuals were excluded if they fulfilled the diagnostic criteria of depression, manic episodes, panic disorder, blood phobia or PTSD, as indicated by the structured Mini International Neuropsychiatric Interview (MINI; Sheehan et al., 1998; van Vliet & Beurs, 2007), which was administered during an in-person interview. In addition, medical students were not allowed to enter the study, as the film contained mostly medical trauma, to which they might be less responsive. None of the recruited students were excluded based on the MINI, leaving a total sample of 60 participants (34 women, 26 men). Age ranged from 18 to 65 ($M = 23.6$ years, $SD = 9.0$). All participants signed an informed consent form and approval for the experiment was obtained from the Ethics Committee of the Faculty of Behavioural and Movement Sciences of VU Amsterdam. The experiment was conducted in 2013.

2.2. Material

2.2.1. Trauma film

The film (10 min) contained four clips displaying the aftermath of real-life road traffic accidents. These images included: wrecked cars, injured people, and dead bodies. Following Hagenaars, van Minnen, Holmes, Brewin, and Hoogduin (2008), one scene was excluded from the original five scenes compiled by Steil (1996) to prevent fatigue from sitting still too long.

2.2.2. Thirty-minute filler tasks

Fourteen excerpts of classical music were played through headphones. Participants were asked to rate each excerpt on pleasantness (10 min), and then to answer non-PTSD related open-ended questions using a textbook and a dictionary during the remaining 20 min (Holmes et al., 2009, 2010). This 30-min filler task was used to resemble the actual waiting times in an emergency department (e.g., Hagenaars & Arntz, 2012; Holmes et al., 2009).

2.2.3. Film reminder task

The film reminder task consisted of a slide show with four images from the trauma film. For each of the four film scenes, one neutral but characteristic still was displayed automatically with a 7 s interval between images. This procedure is in line with earlier research (e.g., Deerprouse et al., 2012; Holmes et al., 2009; Holmes et al., 2010), and was used because memory reactivation may render memory malleable and vulnerable to disruption (Hupbach, Gomez, Hardt, & Nadel, 2007; Schiller et al., 2010).

2.3. Interventions

2.3.1. Tetris dualtask

Participants played the videogame Tetris for eight sessions of 24 s each with a 10 s break between each session. The dual-tasking procedure by van Veen Engelhard, and van den Hout (2016) was used. PC game Tetris Zone (Version 1.2.1; Blue Planet Software, 2007) was used and was set to "Marathon" mode (James et al., 2015). The objective of Tetris is to manipulate falling blocks by moving them sideways and rotating them by 90-degree units to form horizontal lines. Participants were instructed to keep thinking of their most aversive film memory whilst

playing and during the 10 s break.

2.3.2. IR

Participants were first asked by the experimenter to describe their most aversive film memory, i.e. the hotspot, as detailed as possible. Next, the participants were asked to intervene after the hotspot by imagining a different outcome for this event in any way they wished, as long as it resulted in a more positive outcome. This change could either be realistic (i.e., "When the crash happened the airbags activated, and the driver was only mildly injured.") or unrealistic (i.e., "A superhero entered the scene to help."). Participants were asked to describe the altered event as well as possible to help them create a clear representation of the new outcome. The total duration was about 4.5 min.

2.3.3. Control

Participants received instructions to sit quietly for 4.5 min. The participants were not allowed to talk to the experimenter and could think about anything, without restrictions.

2.4. Measures

2.4.1. Demographics

Age, gender, and cultural background were assessed using a self-report form.

2.4.2. Psychiatric symptoms

The Mini International Neuropsychiatric Interview (MINI, Dutch version 5.0.0; Sheehan et al., 1998; van Vliet & Beurs, 2007) was used to assess and exclude individuals showing signs of psychiatric symptoms. The MINI is a structured interview for the diagnosis of DSM-IV disorders. In this study the following sections were administered by the experimenters (FM and a colleague) via an in-person interview: [A] depressive episode, [D] (hypo) manic episode, [E] panic disorder, [I] (blood) phobia and [J] PTSD.

2.4.3. Pre and post film mood

Two visual analogue scales (VAS; Holmes et al., 2010) were used to measure how sad and anxious participants felt before and after watching the trauma film. Both VASs ranged from 0 (not at all) to 10 (extremely).

2.4.4. Vividness and emotionality

Separate VASs were used to assess vividness and emotionality of the most aversive memory of the trauma film (Engelhard, van den Hout, Janssen, & van der Beek, 2010). The scale ranged from 0 (not vivid at all, not at all unpleasant) to 10 (extremely vivid, extremely unpleasant).

2.4.5. Intrusion frequency

Participants were asked to keep track of their film-related intrusions using a pen and paper daily diary for seven days following the first meeting. In the diary, participants had to write down a brief description of the intrusion and record whether the intrusion was an image, a thought, or a combination of both (Holmes, Brewin, & Hennessy, 2004). They received clear instructions from the experimenter on how to use the event-based diary (which also had the instructions written inside). Participants were asked to always carry the diary with them and to record intrusive memories immediately after they occurred. The experimenter explained to the participants that intrusions were defined as memories related to the film that appeared spontaneously in their mind's eye, and that memories that were deliberately recalled did not count as intrusions and should therefore not be included in the diary. Participants were also orally explained the difference between intrusions in the form of an image (e.g., 'pictures in your mind's eye'), a thought (e.g., 'verbal thoughts in the form of words or phrases') or a combination of both an image and a thought. Intrusion frequency was calculated by the experimenters (FM and a colleague) by counting all intrusion entries that had an image component (e.g. James et al., 2015).

2.4.6. Diary adherence and accuracy

The following two VASs were used to assess diary adherence and the accuracy in completing the diary: “I often failed (or forgot) to write down my intrusions in the diary?”; and “How accurate did you fill in the diary?”. The VASs ranged from 0 (very often/very inaccurate) to 10 (not once/extremely accurate).

2.4.7. Intensity of intrusions

The Experience of Intrusion Scale (EIS) is a 5-item self-report that measures the frequency and intensity of intrusions (Salters-Pedneault, Vine, Mills, Park, & Litz, 2009). Each item is scored using a 5-point (0–4) response format with equal intervals, ranging from “not at all” (0) to “extremely” (4). The scores can be summed to produce a total EIS score (range 0–20) with higher scores indicating more frequent and more intense intrusions. The reliability of the EIS is good (Cronbach’s alpha = 0.83; Salters-Pedneault, et al., 2009). In present study, a Dutch translation of the EIS was used that was translated to Dutch and back-translated by the research team.

2.4.8. PTSD-like symptoms

To assess PTSD-like symptoms, the Dutch version of the Impact of Events Scale-Revised (IES-R) was used. The IES-R is a 22-item self-report measure that assesses subjective distress caused by PTSD symptoms during the past seven days with respect to a traumatic event. Since we used a trauma film to induce analogue trauma instead of actual trauma we apply the term PTSD-like symptoms. The IES-R consists of the subscales: intrusion (eight items), avoidance (eight items), and hyperarousal subscale (six items). The items are scored on a five-point Likert scale (0–4, with labels of ‘Not at all’ to ‘Extremely’). The scores can be summed to produce a total IES-R score (range 0–88), with a higher score indicating a greater level of PTSD-like symptoms. The Dutch version of the IES-R has good reliability (Cronbach’s alpha = .89; Olde, Kleber, van der Hart, & Pop, 2006).

2.4.9. Explicit memory

To assess explicit memory recollection, participants answered 15 true/false statements about the content of the trauma film (e.g., “The car that crashed was towing a caravan”). Each correct answer was scored with one point. Thus, the minimum score was 0 and the maximum score was 15.

2.5. Procedure

In the first session (day 0), participants were given information about the study and asked to sign the informed consent and complete the demographics questionnaire. They were also administered the MINI via a face-to-face interview. Individuals who showed signs of depression, (hypo) manic episode, panic disorder, blood phobia, or PTSD were to be excluded from the study. Next, participants watched the trauma film, followed by the 30-min filler tasks. Before and after the film participants also completed the mood VASs. After the filler tasks, participants were shown the film reminder task and were asked to identify their most aversive film memory and write down three key words corresponding to this memory on a piece of paper. Next, participants were instructed to look at the three keywords and retrieve the aversive film memory as vividly as possible. Participants then completed the VASs vividness and emotionality (pre-intervention). Next, participants were randomly allocated to either the Tetris_dualtask, IR or the control group by opening a sealed envelope containing the allocation. After the intervention, participants again retrieved their most aversive film memory as vividly as possible using the three keywords and completed the VASs vividness and emotionality (post-intervention). At the end of the first session, participants received an intrusion diary and were instructed to write down all film-related intrusions over the subsequent week. At one week, participants returned for the second session. During this session, they returned their completed intrusion diary. Participants also

completed the diary compliance questionnaire, and used the same procedure with the three keywords to complete the VASs vividness and emotionality (follow-up). Furthermore, the EIS, IES-R and explicit memory questionnaire were administered.

2.6. Statistical analyses

To test for baseline differences between groups we used a chi-square test for gender, a Fisher’s exact test for cultural background, and a one-way analysis of variance (ANOVA) for age. The impact of the film on participants’ mood (sadness and anxiousness) was measured by conducting two 2x3 mixed between-within subjects ANOVA’s with main factors of time (pre-film, post-film) and group (Tetris_dualtask, IR, control). Independent samples t-tests were used when the outcome data was normally distributed (intrusion frequency, diary accuracy, PTSD-like symptoms, intrusion intensity). For the outcome data that was not normally distributed Mann Whitney U tests were conducted (diary adherence, explicit memory). To test the effect of the interventions on vividness and emotionality ratings we conducted two 3x3 mixed between-within subjects ANOVA’s with main factors of time (pre-intervention, post-intervention, follow-up) and group (Tetris_dualtask, IR, control). In the event the sphericity assumption was violated we used the Greenhouse-Geisser degrees of freedom correction. Analyses were based on intention-to-treat, thus with all participants included and no outliers removed. All analyses were conducted using SPSS Statistics (release 23.0.0), with a rejection criterion of $p < .05$.

Table 1
Means and statistics on baseline and outcome measures (N = 60).

Measure	Tetris (n = 20)	Imagery rescripting (n = 20)	Control (n = 20)	Total (n = 60)
Measured on day 0				
Age	22.20 (2.78)	22.75 (7.35)	25.80 (13.58)	23.58 (9.04)
Gender (women %)	14 (70%)	9 (45%)	11 (55%)	34 (56.7%)
Cultural background (Dutch %)	19 (95%)	18 (90%)	19 (95%)	56 (93.3%)
Mood				
Sadness pre-film	1.07 (1.40)	0.95 (0.64)	1.36 (1.73)	1.12 (1.32)
Anxiousness pre-film	2.45 (2.10)	2.19 (2.07)	2.23 (2.02)	2.29 (2.03)
Sadness post-film	3.39 (1.91)	3.06 (2.08)	3.64 (2.75)	3.36 (2.25)
Anxiousness post-film	3.28 (2.11)	3.67 (2.29)	2.92 (2.21)	3.29 (2.21)
Measured at 1 week				
Intrusions	1.85 (1.63) *	2.60 (2.48)	4.50 (5.34)	2.98 (3.64)
Diary compliance				
Accuracy	8.92 (1.02) *	7.52 (1.85)	8.09 (1.28)	8.17 (1.52)
Adherence	2.27 (3.41)	2.12 (3.00)	0.72 (0.86)	1.70 (2.72)
IES-R	6.00 (5.46)	7.65 (5.85)	8.15 (7.99)	7.27 (6.48)
IES-R intrusion subscale	2.90 (2.59)	3.20 (2.19)	4.00 (3.83)	3.37 (2.94)
EIS	3.50 (2.46)	4.55 (2.04)	5.15 (3.90)	4.40 (2.94)
Explicit memory	11.15 (1.87)	11.60 (2.06)	11.45 (1.73)	11.40 (1.87)

Note: Standard deviation or percentages between brackets.
* = $p < .05$.

3. Results

3.1. Baseline characteristics

Table 1 shows participants' baseline characteristics. All three groups did not differ significantly with respect to gender, $\chi^2(2, N = 60) = 2.579$, $p = .275$; cultural background, $p = .766$, Fisher's Exact Test; and age, $F(2, 57) = 0.917$, $p = .405$.

3.2. Film manipulation check

Table 1 shows the pre- and post-film sadness and anxiousness ratings per group. A 2x3 mixed between-within subjects ANOVA with main factors of time (pre-film, post-film) and group showed a significant main effect of time for sadness, $F(1, 57) = 69.674$, $p < .001$, $\eta_p^2 = 0.55$, indicating that sadness ratings increased after film viewing in each group. There was no significant main effect of group, $F(2, 57) = 0.511$, $p = .603$, $\eta_p^2 = 0.018$ and group x time, $F(2, 57) = 0.056$, $p = .946$, $\eta_p^2 = 0.002$. Regarding anxiousness, a significant main effect of time was found, $F(1, 57) = 17.115$, $p < .001$, $\eta_p^2 = 0.23$, indicating that anxiousness ratings increased over time in each group. There was no significant main effect of group, $F(2, 57) = 0.190$, $p = .827$, $\eta_p^2 = 0.007$ and group x time, $F(2, 57) = 1.010$, $p = .371$, $\eta_p^2 = 0.034$.

3.2.1. Task manipulation check

The Tetris_dualtask group ($Mdn = 9.05$) showed no significant difference on diary adherence compared to the control group ($Mdn = 8.10$), $U = 174.5$, $p = .485$, 95% CI = [0–0.2], $d = 0.22$; and neither did the IR group ($Mdn = 7.65$), $U = 136.5$, $p = .084$, 95% CI = [0.2–0.7], $d = 0.56$. Regarding diary accuracy, the Tetris_dualtask group reported higher scores ($M = 8.92$, $SD = 1.02$) than the control group ($M = 8.09$, $SD = 1.28$). This difference, 0.83, 95% CI = [0.09–1.57], was significant, $t(38) = 2.269$, $p = .029$, $d = 0.46$. The IR group reported lower diary accuracy scores ($M = 7.52$, $SD = 1.85$) than the control group. This difference, 0.57, 95% CI = [–0.45 – 1.59], was non-significant, $t(38) = 1.121$, $p = .269$, $d = 0.36$.

3.2.2. Intrusion frequency

The Tetris_dualtask group reported fewer intrusions ($M = 1.85$, $SD = 1.63$) than the control group ($M = 4.50$, $SD = 5.34$). This difference, –2.65, 95% CI [0.12–5.18], was significant, $t(22.52) = 2.124$, $p = .045$, $d = 0.67$. The IR group reported fewer intrusions ($M = 2.60$, $SD = 2.48$) than the control group. This difference, –1.90, 95% CI [–0.77 – 4.57], was non-significant, $t(38) = 1.444$, $p = .157$, $d = 0.46$.

3.2.3. Vividness and emotionality

A 3x3 mixed between-within subjects ANOVA with main factors of time (pre-intervention, post-intervention, one week follow-up) and group showed a significant main effect of time on VAS vividness ratings, $F(1.63, 92.63) = 10.646$, $p < .001$, $\eta_p^2 = 0.16$, indicating that vividness decreased over time in each group (Fig. 1). There was no significant main effect of group, $F(2, 57) = 0.195$, $p = .823$, $\eta_p^2 = 0.007$ and group x time, $F(3.25, 92.63) = 0.169$, $p = .929$, $\eta_p^2 = 0.006$. Regarding VAS emotionality ratings, a significant main effect of time was found, $F(1.42, 80.91) = 20.506$, $p < .001$, $\eta_p^2 = 0.27$, indicating that emotionality decreased over time in each group (Fig. 2). There was no significant main effect of group, $F(2, 89) = 1.623$, $p = .206$, $\eta_p^2 = 0.054$ and group x time effect, $F(2.84, 80.91) = 0.325$, $p = .796$, $\eta_p^2 = 0.011$.

3.2.4. PTSD-like symptoms and explicit memory

Table 1 shows the mean and standard deviations per group on PTSD-like symptoms (IES-R), the IES-R intrusion subscale, intrusion intensity (EIS) and explicit memory scores. Both the Tetris_dualtask and IR group showed no significant differences on these measures compared to the control group (Table 2).

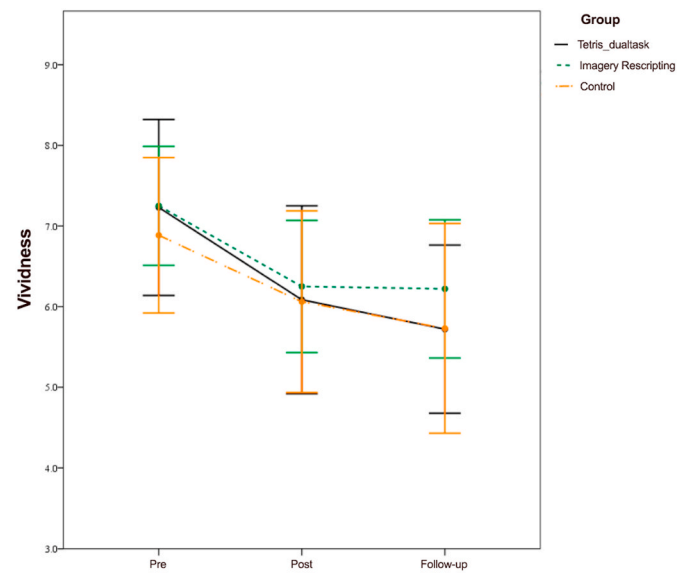


Fig. 1. Mean vividness ratings at pre-intervention, post-intervention and at follow-up. Note: error bars represent 95% confidence intervals.

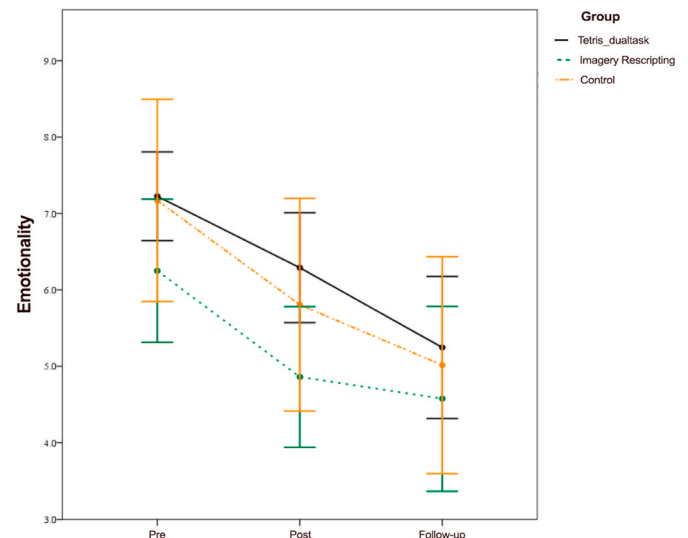


Fig. 2. Mean emotionality ratings at pre-intervention, post-intervention and at follow-up. Note: error bars represent 95% confidence intervals.

4. Discussion

The objective of the present study was to compare the effects of Tetris_dualtask and IR to a no-intervention control group on intrusion frequency and memory vividness and emotionality in healthy participants after viewing a trauma film. After the trauma film, participants reported a more negative mood. Over the course of the following week, they reported, on average, about four film-related intrusions. No differences between groups were found regarding diary accuracy and adherence, except that the Tetris_dualtask group reported a significantly higher diary accuracy compared to the control group. This may have resulted in the Tetris_dualtask group reporting relative more intrusions than the control group, since they were more accurate in keeping track of their intrusions. In line with our hypothesis, the Tetris_dualtask group reported fewer film-related intrusions compared to no intervention. Although the present study did not examine the underlying mechanisms explaining the beneficial effects of Tetris, it is likely that the high visuospatial demand of playing Tetris selectively interfered with

Table 2
Test statistics on PTSD-like symptoms and explicit memory.

Measures	Tetris _{dualtask} versus control			IR versus control		
	Test statistics	95% CI	Effect size	Test statistics	95% CI	Effect size
IES-R	$t(38) = 0.994, p = .327$	−6.53–2.23 ^a	0.31	$t(38) = 0.226, p = .823$	−4.98–3.98 ^a	0.07
IES-R intrusion subscale	$t(38) = 1.064, p = .294$	−3.19–0.99 ^a	0.34	$t(38) = 0.812, p = .422$	−2.80–1.20 ^a	0.26
EIS	$t(32.069) = 1.601, p = .119$	−3.75–0.45 ^a	0.51	$t(28.673) = 0.610, p = .574$	−2.61–1.41 ^a	0.19
Explicit memory	$U = 179.0, p = .564$	−1–0 ^b	0.18	$U = 179.5, p = .573$	0–1 ^b	0.18

Note: Effect sizes were calculated using Cohen’s *d*.

^a 95% Confidence Interval of the means difference.

^b 95% Confidence Interval of the median difference.

sensory–perceptual aspects of memory through competition (Baddeley & Andrade, 2000), hence retroactively interfering with memory consolidation.

Contrary to our expectations, the IR group did not report fewer film-related intrusions compared to the no intervention control group. This finding does not correspond with previous experiments that showed that IR, performed shortly after watching a trauma film, reduced intrusions (e.g., Dibbets & Arntz, 2016; Hagenaars & Arntz, 2012; Rijkeboer et al., 2020). One possible explanation for these differences in findings might be the brief duration of the IR procedure in our study. Intervention duration in earlier studies was 9 min (Hagenaars & Arntz, 2012; Rijkeboer et al., 2020) or 10.5 min (Dibbets & Arntz, 2016), which is approximately twice as long as the 4.5 min in our study. In imagery rescripting, reliving the traumatic memory allows for inhibited emotional responses (i.e., anger, shame, guilt) to be expressed (Arntz, Tiesema, & Kindt., 2007). Also, imagining a more desired outcome may cause feelings of power and control to become associated with the original memory (Arntz et al., 2007; Hagenaars & Arntz, 2012). It is possible that 4.5 min of IR was insufficient to establish such positive associations.

Our second hypothesis was that Tetris_{dualtask} and IR would reduce the vividness and emotionality of participants’ most aversive film memory compared to no-intervention controls. Contrary to our hypothesis, neither Tetris_{dualtask} nor IR reduced vividness and emotionality ratings. Previous studies have repeatedly shown reductions in these ratings after participants recall an aversive autobiographical memory while they perform a taxing dual-task, including Tetris (e.g., Mertens et al., 2021) or after the IR intervention (Lee & Kwon, 2013; Shibuya et al., 2018; Wild, Hackmann, & Clark, 2008). However, in the present study we aimed to reduce the vividness and emotionality of newly acquired memories (i.e., trauma film) instead of negative autobiographical memories. Several other recent studies, involving newly acquired trauma film memories, have also found no effect for visuo-spatial and non-visuo-spatial tasks taxing WM on vividness and emotionality ratings (Asselbergs et al., 2018; van Schie & Leer, 2019; van Schie, van Veen, & Hagenaars, 2019). It is possible that taxing WM and IR may not be as effective when applied to newly acquired memories from a trauma film than when applied to existing autobiographic memories, for instance, because of rapid memory decay.

Indeed, a recent meta-analysis showed that reductions in vividness and emotionality were more pronounced for autobiographical memories compared to newly acquired memory of a film or pictures (Mertens et al., 2021). Another explanation is that because autobiographical memories are more emotional, more WM taxation is needed in order to affect the memory (Mertens et al., 2021; van den Hout, Eidhof, Verboom, Littell, & Engelhard, 2014). Moreover, factors related to the potential underlying mechanism of IR, such as mastery or perceived control over memories, were not assessed. Such measures could be sensitive in this laboratory context (see e.g., Siegesleitner, Strohm, Wittekind, Ehring, & Kunze, 2020).

In addition, we found no significant differences between groups on the IES-R, IES-R intrusion subscale or the EIS, indicating that both Tetris_{dualtask} and IR did not result in fewer self-reported PTSD-like

symptoms or lower intrusion intensity after one week compared to no-intervention control. Contrary to our hypothesis and earlier studies (e.g., Holmes et al., 2009; James et al., 2015 [exp. 1]; van Schie et al., 2019 [exp. 2]), this result is in line with more recent studies that also found no significant effect for Tetris and IR on the IES-R, or IES-R intrusion subscale after one week (e.g., Badawi et al., 2020; Brennen et al., 2021; James et al., 2015 [exp. 2]; Siegesleitner et al., 2019; van Schie et al., 2019 [exp. 1 & 3]). It is likely that the symptoms induced by the film decreased substantially by natural course after one week, making it less likely to detect differences between groups.

Finally, groups did not differ on explicit memory recall scores, suggesting that neither Tetris nor IR affected the actual content of the memories of the film. This is in line with previous studies, suggesting that playing Tetris during memory consolidation may modify intrusion frequency while leaving recognition memory intact (e.g., Deeprose et al., 2012; Holmes et al., 2009; James et al., 2015). As for IR, it has been argued that IR changes the meaning and the associated fear response, but not the original memory trace itself (Arntz, 2012; Field, 2006; Long & Quevillon, 2009). Moreover, all three groups in present study scored high on the explicit memory test (74–77% correct answers), indicating that Tetris and IR do not negatively affect factual details of the memory compared to the no-intervention group. Deliberate recall of factual details is important in case trauma survivors need to act as a witness or provide a legal testimony.

The present study has some limitations. First, the groups sizes were small. Although small sample sizes are common in pilot studies and similar group sizes have been used in comparable experiments done with Tetris (e.g., Holmes et al., 2009; Lau-Zhu et al., 2019; Lau-Zhu et al., 2021) and IR (e.g., Dibbets & Arntz, 2016; Siegesleitner et al., 2020) the results of this study should be interpreted with caution and more research with larger group sizes is warranted. Second, we used the trauma film paradigm to induce analogue trauma in an experimental setting. Although the trauma film paradigm is a well-established and often-used approach to induce intrusions in a controlled environment in healthy participants (Holmes & Bourne, 2008; James et al., 2016), the induced traumatic responses may be different to that of real-life trauma exposure. Therefore, our results cannot be generalized to trauma-exposed populations. Third, in order to increase comparability between Tetris and IR, the time frame of both interventions was standardized. As a result, the length of the IR group was shorter than comparable studies which might have decreased the efficacy of IR. Fourth, the time between the trauma film and the intervention was rather short. Although the 30-min gap conforms with similar experimental studies on Tetris (e.g., Holmes et al., 2009; 2010 [experiment 2]) and IR (e.g., Dibbets & Arntz, 2016; Hagenaars & Arntz, 2012), it does not equate to the real world where trauma survivors may not have access to an intervention for several hours. Fifth, we measured intrusions and explicit memory based on prior studies (Brennen et al., 2021; Holmes et al., 2009, 2010; James et al., 2015). By its very nature, these are limited to what participants are willing or able to report. Future laboratory research should incorporate more sensitive tests for various memory forms and systems, including non-declarative memory (e.g., priming), to further elucidate which aspects of memory can and should

be targeted with clinical interventions (Visser et al., 2018). For instance, laboratory studies using perceptual discrimination tests have shown potential unwanted effects of the dual-tasking intervention with respect to the legal context (e.g., Leer & Engelhard, 2020; Leer et al., 2017).

To conclude, the present study supports our hypothesis that administering Tetris dualtask, shortly after analogue trauma, reduces the number of intrusions during the subsequent week. Contrary to our hypothesis, IR did not reduce intrusions relative to no intervention control. Vividness and emotionality ratings of participant's most aversive film memory in both the Tetris dualtask and IR group did not differ compared to the control group; neither did we find an effect on PTSD-like symptoms, intrusion intensity and explicit memory at one-week. Although further studies are warranted, the results of this pilot study suggests that playing Tetris dualtask, shortly after experiencing analogue trauma, might be an effective early strategy to reduce intrusions. We encourage future replication studies, with larger group sizes, to validate these early findings.

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CRediT authorship contribution statement

Joost Asselbergs: Writing – original draft, Formal analysis. **Heleen Riper:** Supervision, Writing – review & editing. **Iris M. Engelhard:** Writing – review & editing. **Fancy Mannes:** Investigation. **Marit Sijbrandij:** Conceptualization, Writing – review & editing, Supervision.

Declaration of competing interest

All the authors declare that they have no conflict of interest.

Data availability

Data will be made available on request.

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