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The effects of playing the computer game "Tetris" on intrusions for traumatic images.

SUMMARY

Successful treatments for full-blown PTSD have been established, but early interventions are scarce and questionable in efficacy. This study was an attempt to replicate the Holmes, James, Coode-Bate & Deeprose (2009) study, '*Can playing the computer game "Tetris" reduce the build-up of flashbacks for trauma? A proposal from cognitive science'*, which examined the utility of the computer game "Tetris" to ameliorate acute trauma symptoms and prevent PTSD intrusion development. Because intrusions are sensory-perceptual, visuospatial mental images, and visuospatial cognitive tasks selectively compete for limited working memory (WM) resources required to generate mental images, it can be expected that the visuospatial computer game (e.g. Tetris) will interfere with intrusions. Additionally, this study examined a dose-dependent effect of this interference. *Method & principal findings*: Two levels of difficulty for Tetris were determined using a dual-task reaction time (RT) task. Then, participants either played no Tetris, simple version of Tetris (SIM), or a complex version (COM) after watching a trauma film. Intrusions were monitored for one week and a clinical measure of PTSD symptomatology was taken after one week. Results indicated fewer intrusions for COM, compared to SIM and a no-task control during the task, though no effect was significant for intrusions or other symptoms at one week. This study re-established Tetris as a visuospatial task, but failed to replicate the Holmes et al. (2009) findings. Possible reasons are discussed.

Introduction

Background

Intrusive memories (intrusions) to a traumatic event are one of the three key-symptoms and a hallmark of posttraumatic stress disorder (PTSD). PTSD is a psychiatric disorder, resulting from viewing or experiencing a traumatic event, involving serious injury, death, or threat to self or others. (DSM-IV-TR, American Psychiatric Association, 2000; Brewin & Holmes, 2003). Intrusions are precursory to PTSD (Bryant & Harvey, 1995) and can be described as distressing re-experiencing of the trauma in the form of intrusive, image-based, sensory-perceptual memories (e.g., Holmes & Bourne, 2008; Holmes & Mathews, 2005; Ehlers, Hackmann, Michael, 2004). Though there seems to be a relationship between an avoidant coping style and the occurrence of intrusions and between an avoidant coping style and the development of PTSD (Bryant & Harvey, 1995), acute intrusive symptoms do not invariably predict PTSD (e.g. Shalev, 1992; Creamer, O'Donnell & Pattison, 2004). Intrusions remain distressing, nonetheless, and the question remains whether amelioration of these symptoms could carry on towards a beneficial development of PTSD.

Amongst the many psychological interventions for full-blown PTSD, the one with the strongest evidence-base is trauma-focused Cognitive Behaviour Therapy (CBT), which typically includes various forms of exposure, cognitive therapy and anxiety management. However, this is generally indicated after establishing a diagnosis for PTSD, which can be weeks or months after the trauma (National Institute for Health and Clinical Excellence, 2005; Foa, Keane, & Friedman, 2008). Early intervention after trauma using CBT typically commences at two weeks post trauma and is administered individually and only to carefully selected and highly symptomatic patients, thus still providing a delayed response to distress and excluding those that might not be highly symptomatic, but suffer nonetheless. Alternative early interventions seem to be few in number and immediate interventions seem to be fewer in number still. Talking therapy, such as critical incidence stress debriefing, typically starts within 72 hrs of the trauma and places an emphasis on education and providing an opportunity for survivors to discuss the event and “ventilate” (Bryant & Harvey, 2000). Debriefing has, however, caused some clinical concern (McNally, Bryant, Ehlers, 2003). Reviews indicate that it does not prevent PTSD and may even contribute to poorer recovery (Bisson, Jenkins, Alexander & Bannister, 1997; Mayou, Ehlers & Hobbs, 2000; see also Rose, Bisson & Wessley, 2001, for a review). Pharmacological interventions (e.g. propranolol; Pitman et al. 2002) show efficacy in the prevention of PTSD, yet raise concerns of their own regarding the potential for side-effects and certain ethical concerns that arise if voluntary memories are suppressed (Henry, Fishman & Youngner, 2007).

Thus, both those that do and do not develop PTSD, but nevertheless suffer from post traumatic intrusions are left to either rough it out on their own, or wait for diagnosis. The question naturally ensues if early intervention, in the immediate aftermath of trauma, may reduce symptoms and possibly prevent the development of PTSD. Recent findings indicate that manipulating working memory (WM) while the trauma is retrieved has beneficial effects and may potentially prevent posttraumatic symptoms after psychotrauma.

Conceptual and perceptual processing

Cognitive science has shown that WM has selective resources with limited capacity (Baddeley, 2003) and can be understood as the system involved with the consolidation and reconsolidation of memory (Baddeley, 2000). The model used here to delineate this system is Baddeley's multicomponent model (e.g. Baddeley, 2000), which describes four functional components. At the centre of the system is the central executive, a general processor that carries out higher-order cognitive functions, such as planning, problem solving and integrating information from other components. The central executive can allocate information to be held online for later use in two subsystem "buffers". The phonological loop stores verbal and auditory information, and the visuospatial sketchpad (VSSP) stores visuospatial information. The episodic buffer integrates information from long-term memory and the phonological and visuospatial subsystems.

Recent research towards modifying the nature of traumatic memories is based upon the assumption that WM processes information in (at least) two ways: conceptually and sensory-perceptually. Information processed conceptually is processed at a relatively high level of consciousness and forms the basis for the verbal and written account (a narrative) of events; this corresponds to ordinary autobiographical memories. Information that receives little to no conscious attention, however, is processed by the sensory-perceptual system. Intrusions are assumed to occur when there is a lack of high level processing to create a narrative for a large amount of sensory information. This creates sensory memories which can be elicited through situational cues (Brewin, Dalgleish, & Joseph, 1996; Foa & Rothbaum, 1998; see also Brewin & Holmes, 2003 for a review). It is still unclear in what way the WM components are tied to these processes. One could assume that the phonological loop plays a vital role in the construction of a narrative for memories, because this construction would require an internal dialogue to form the basis for a verbal account. And this would, in turn, require the phonological loop for processing. This requires attention and draws upon the limited resources of WM. In contrast, similar attentional resources are not needed for visual information, which is processed by the VSSP, and would thus form the basis for sensory cues and recollections. Research lends credence to these assumptions, showing that dual task interference of the VSSP leads to a reduction of vividness and emotionality of memories (e.g. Van den Hout, Muris, Salemink & Kindt, 2001; Kavanagh, Freese, Andrade & May, 2001). In addition, VSSP interference has also shown to lead to a reduction in intrusions and interference of the phonological loop to an increase (e.g., Brewin & Saunders, 2001; Holmes, Brewin &, Hennessy, 2004; Holmes, Bourne, 2008). However, the interference was applied during the viewing of traumatic images. It is obvious that these dual task interferences can not be applied in real trauma situations.

The above findings run parallel to findings and ongoing research in the field of Eye Movement Desensitisation and Reprocessing (EMDR). Widely used and a known effective treatment for PTSD (e.g., Bisson et al., 2007; Davidson & Parker, 2001), EMDR directly targets the vividness and emotionality of traumatic memories. During EMDR (Shapiro, 2001, 2002; see also Gunter & Bodner, 2008), the client holds a distressing memory in mind, along with the associated emotions and a negative cognition related to the memory. Horizontal eye-movements are then elicited and repeated in sets until the client reports minimal distress associated with the memory. Research has shown that specifically the eye movements made during EMDR, while recalling a distressing memory, decrease the self-reported vividness and emotionality associated with that memory (Andrade, Kavanagh, & Baddeley, 1997; Van den Hout et al., 2001; Kavanagh et al., 2001; Barrowcliff, Gray, MacCulloch, Freeman, & MacCulloch, 2004; Kemps & Tiggeman, 2007; Maxfield, Melnyk & Hayman, 2008; Gunter & Bodner, 2008). Kemps & Tiggeman (2007) also found that visual and auditory interference selectively affect visual and auditory memory aspects, respectively.[1]

[1]: However, it was shown that the eye-movements made interfere with a memory through demands on central executive resources (Gunter & Bodner, 2008), not because they selectively demand VSSP resources. This implies that any form of central executive taxation will have the same effect. This has proven true for vertical eye movements, drawing a complex figure and auditory shadowing (Gunter & Bodner, 2008), counting (Van den Hout et al., 2010), playing the computer game “Tetris” (Holmes, James, Coode-Bate, & Deeprose, 2009), and articulatory suppression (Kemps & Tiggeman, 2007).

EMDR research has focused mainly on consolidated memories and is most often indicated for treatment only after a diagnosis has been made. Few studies on efficacy in application as an immediate intervention have been done. Kutz, Resnik and Dekel (2008) found beneficial effects of an abridged version of EMDR provided for patients with acute stress syndrome suffering from intrusion distress and fewer risk factors for PTSD compared to those that did not receive this treatment. In contrast, Roberts, Kitchiner, Kenardy and Bisson (2009) conclude in their review of interventions to prevent PTSD that *'…at this time there is little evidence to support the use of psychological intervention for routine use following traumatic events and that some (…) interventions (…) may have an adverse effect on some individuals. The clear practice implication of this is that, at present, multiple session interventions aimed at all individuals exposed to traumatic events should not be used'*.

Cognitive vaccine

The study "*Can playing the computer game "Tetris" reduce the build-up of flashbacks for trauma? A proposal from cognitive science"* by Holmes, James, Coode-Bate and Deeprose (2009) proposed a preventative method for intrusion development following exposure to trauma. This 'cognitive vaccine' reduced the number of subsequent intrusions and ameliorated the distress experienced in these intrusions. This was achieved through the disruption of the encoding of traumatic images through visuospatial interference. This study was based on two key findings: 1) the brain has selective resources with limited capacity (Baddeley, 2003), and 2) there is a 6-hour window to disrupt memory consolidation (as suggested by neurobiology; Walker, Brakefield, Hobson, & Stickgold, 2003). In particular, they suggested visuospatial tasks would be useful according to the following rationale: *'(1) trauma flashbacks are sensory-perceptual images with visuospatial components. (2) visuospatial cognitive tasks compete for resources with visuospatial images. (3) the neurobiology of memory consolidation suggests a 6-hr time frame post-event within which memories are malleable'* (Holmes et al.,2009, p. 2).

Following a 12 min trauma-film (as per the trauma-film paradigm; Horowitz, 1969; Holmes & Bourne, 2008; Holmes, Brewin, & Hennessy, 2004), the participants of the Holmes et al. (2009) study were randomly assigned to either play the video game Tetris (the visuospatial condition, as Tetris has been demonstrated to be a visuospatial task; Green & Bavelier, 2003; Haier et al., 1992; Sims & Mayer, 2002; Stickgold, Malia, Maguire, Roddenbury & O'Connor, 2000) or sit still for 10 min (control condition), during which they recorded any initial intrusions to the trauma-film. During the following week, intrusions were recorded in a diary. After this period participants completed a recognition memory task to assess voluntary retrieval of the traumatic images and a clinical measure of PTSD symptomatic response was taken, using a for the trauma-film adapted version of the Impact of Events Scale (IES; Horowitz, Wilner, & Alvarez, 1979).

At one week, they found that the participants that had played Tetris had suffered fewer intrusions [M (SD) control: 6.7 (5.1); visuospatial: 2.9 (2.6)] and a less severe symptomatic response [M (SD) control: 20.7 (9.6); visuospatial: 13.9 (8.0)], the former confirming predictions and the latter a welcome find. There were no differences between the experimental and control conditions in the amount of voluntary memory recall, as indicated by the recognition memory test. This would suggest that only those aspects of the memories that lead to intrusions were disrupted by playing Tetris. Initial intrusions recorded shortly after the film were significantly higher in the control condition (10 min break) than in the experimental condition (playing Tetris). This is, however, to be expected as a larger demand is placed upon the assumed limited resources available for WM to process playing the video game and thinking of and recording the traumatic images. Long-term effects have yet to be researched, though the above results indicate utility in areas where immediate application and short-term amelioration of distress due to traumatic intrusions can be of great use, such as emergency response workers (e.g. ambulance, fire-fighters) and those exposed to warlike situations (soldiers and civilians).

A dose-dependent effect

This study is an attempt to replicate the Holmes et al. (2009) study and critically test the concluding theory and assumptions of that study. Thus, if it is the taxing of the VSSP during consolidation that is responsible for the found effects, it follows that the degree of VSSP taxing should correlate with the degree of improvement.

Assuming a simplified version of the game would require a smaller amount of WM resources than an unaltered version, one would assume the hypothesized effect of playing Tetris on the occurrence of subsequent intrusions would be similarly smaller. A preliminary experiment was conducted, wherein Tetris difficulty was assessed to determine two different levels of difficulty: a ‘complex’ version, which is the original version as used in the Holmes et al. (2009) study, and a simplified version. In order to test whether the two versions of the Tetris game really differ in the degree to which they tax WM, it was tested whether reaction time (RT) to a visual reaction task would change in a corresponding manner to the difficulty level of the game. The two versions of the game were applied as concurrent dual tasks and a no-dual task condition was included to determine whether the simpler version taxed WM at all. Slower response would mean more WM resources are needed to play the game and concurrently respond to the visual reaction task stimuli.

This study

This study will test the prediction that visuospatial interference, using differing levels of difficulty with the game Tetris, will reduce the number of intrusions related to a trauma film, compared to a no-task control. This will be done in two ways. Firstly, this study will replicate the Holmes et al. study, drawing a comparison between the effects of playing Tetris after viewing traumatic images and a no-task control. Secondly, this study will observe a possible dose-dependent effect, whereby a ‘simpler’ version of the video game Tetris will be used as the experimental task. The ‘complex’ version of the game will be the original, unaltered version as used in the Holmes et al. study.

In following sections, the preliminary experiment will be referred to as Experiment I (Expt I) and the replicated experiment including the extension of a dose-dependent effect will be referred to as Experiment II (Expt II).

Experiment I

Method Experiment I

Participants

Twelve healthy students of Utrecht University (aged 18-23 years; mean (M) age 21.0, SD 1.6; 3 male) participated.

Design

All participants performed an RT task under three conditions, the order of which was counter balanced. The conditions were: RT task without dual task (no dual task), RT task+simple Tetris (RT+simple) and RT task+complex Tetris (RT+complex). Dependent variable was RT in ms.

Materials

This experiment made use of two computers with monitors placed side by side; one for the visual RT task and one for the Tetris dual task. The monitor for the visual RT task was placed to the left of the monitor for the focal point / video game (Figure 1).

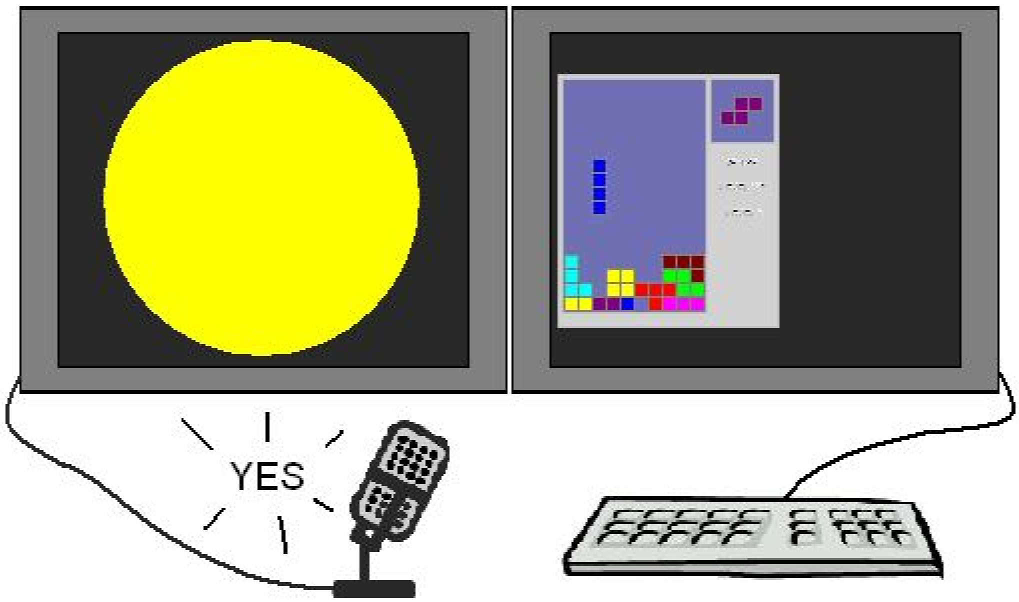

Figure 1. Illustration of experimental set-up.

Distance from the edge of the visual stimuli in the RT task to the centre of the focal point / video game = 13.5 cm. Distance from the centre of the visual stimuli to the centre of the focal point / video game = 27 cm. Distance range from approximated position of participant's eyes to centre point between screens = 75 cm. – 80 cm. Visual stimuli were blue (RGB 000.000.224) and yellow (RGB 232.232.000) circles with a diameter of 27.5 cm. on screen. Monitor size (cm.): width 38 cm. x height 30 cm. Resolution: 1280x1024 (monitor model S1911 Digital; video card NVIDIA GeForce GTX 260). The presentation of yellow or blue circles was random with the restriction that the same colour would appear no more than four times in a row. Stimulus display time was 500 ms, with an inter-stimulus interval that varied between 2 s. and 3 s.. Display lists were newly generated for each participant: 22 trials for the practice round and 66 trials for each experimental condition.

The video game used was Tetris Zone. This is a licensed Tetris game, downloaded from www.Tetris.com. Tetris Zone version ‘Marathon’ was selected for the experiment. The focal point and video game were presented on an Acer Aspire laptop computer. Monitor size (cm.): width 33 cm. x 20.5 cm. Video game window size on screen (cm.): width 12.5 cm. x 14.5 cm. Resolution: 1280x800 (video card ATI MOBILITY RADEON X700).

The visual RT task was voice-key controlled, using a microphone. The video game was controlled with the arrow keys on a standard qwerty keyboard, using the dominant hand. The voice-key was chosen as the answer possibility for the visual RT task, so the dominant hand would be free to play Tetris.

Procedure

Each participant started the experiment with a brief practice round to get used to focusing on the right screen, while reacting to stimuli on the left. Between conditions the researcher would enter the laboratory cabin to change condition settings on the focus / Tetris side. Transition between conditions was facilitated by on screen instructions on the left screen and additional instructions given by the researcher.

While focusing on the right screen, participants were asked to verbally answer “yes” whenever a yellow circle appeared in the left screen, or “no” whenever a blue circle appeared. They were also asked to answer as fast as possible. In this task the answer is unrelated, semantically, to the stimulus. This was done to make the task more challenging, based upon the assumption that a semantically unrelated response to a stimulus would demand a larger mental load.

The experimental conditions were comprised of the visual RT task coupled with the video game Tetris Zone. It was not possible to determine starting level or difficulty. The difficulty level has thus been manipulated:

No dual task: Visual RT task, no concurrent task, focus on right screen.

RT+simple: In this condition it is not possible to speed up (drop) the tetromino’s (blocks). Only placement and turning of the blocks is possible, thus slowing down game speed drastically, offering the participant much more time to decide what to do. Game speed increases automatically when a new level is reached; reaching a higher level, however, happens at a minimal rate, due to the restricted game speed.

RT+complex: In this condition dropping the blocks is possible; thus normal gameplay is unchanged. Game speed is higher than in the RT+simple condition and the possibility to reach a higher level during play is higher, thus raising game speed even more.

Participants were informed that it was not important to achieve a high score in the Tetris game, but that they still must try their best. Testing took place in soundproof laboratory cabins.

Data analysis

Raw data was reduced to M RT per condition per participant. One-way repeated measures ANOVA was then applied followed by paired samples t-tests.

Results Experiment I

A significant effect was found for the type of condition, $F_{(2,22)} = 28.49$, $p < .001$. Paired samples t-tests revealed significant differences between conditions (no dual task - RT+simple, $t_{(11)} = 9.01$, $p < .001$; no dual task - RT+complex, $t_{(11)} = 6.02$, $p < .001$; RT+simple - RT+complex, $t_{(11)} = 3.68$, $p < .005$). The distribution of values is illustrated in Figure 2.

Discussion Experiment I and introduction to Experiment II

In this experiment WM resources available are indicated by RT to visual stimuli: larger RTs mean less resources available and thus that the task is more taxing. The results of Expt I show that, relative to the no dual task condition, a significantly larger amount of WM resources are needed to complete a visual RT task while concurrently playing the video game Tetris Zone. The results also indicate distinctly different levels of difficulty in accordance with the manipulations applied to the gameplay characteristics of the video game: the RT +simple condition uses more WM resources than the B condition, but less than the RT+complex condition.

In Expt II the effect that playing Tetris has on intrusions and posttraumatic symptoms for traumatic images will be investigated. The levels of difficulty identified in Expt I will be applied to investigate this effect in a dose-dependent manner.

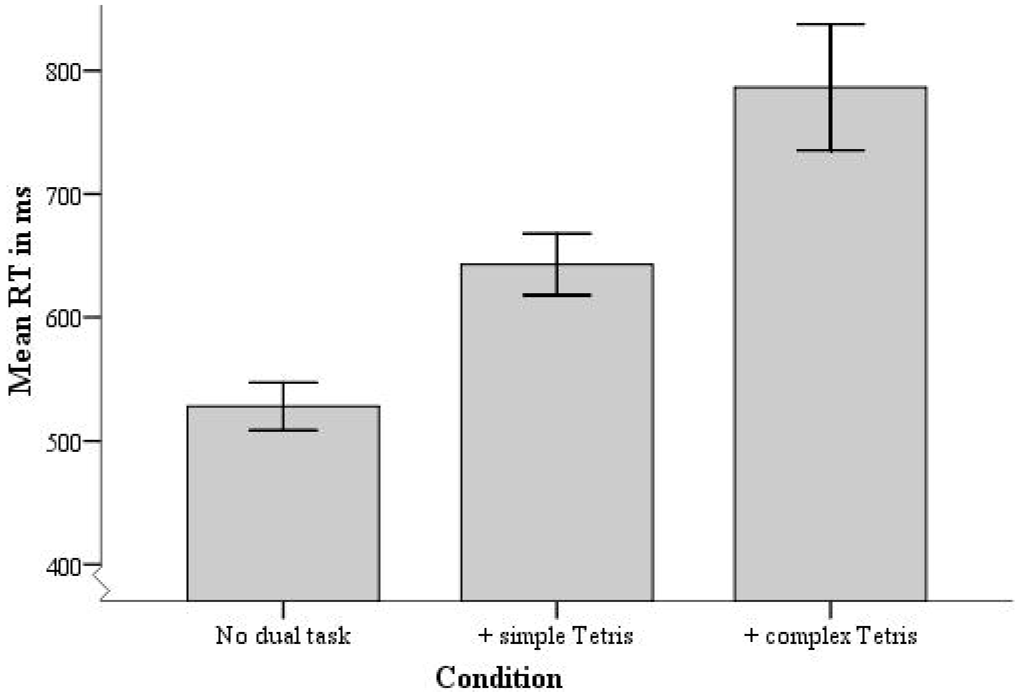

Figure 2. M (SE) RT in ms for the visual RT task of each condition. Condition, M (SD): no dual task, 528.19 (67.16); + simple Tetris, 642.78 (86.36); + complex Tetris, 786.51 (177.21).

Experiment II

Method experiment II

Participants

Sixty healthy students (aged 18-27 years; M age 21.2, SD 2.2; 19 male) participated for course credit and/or money.

Design

A 3-way between subjects design was used, with independent variable Condition: no-task Control (Ctrl) and experimental conditions SIMPLE (SIM) and COMPLEX (COM). The same manipulations as used in Expt I for the RT+simple and RT+complex conditions were applied to the video game Tetris Zone to create the difficulty levels for the SIM and COM conditions, respectively. Dependent variables were initial intrusions during the 10 min task, intrusions during the week following the trauma film (diary recorded) and scores on the Intrusion subscale of the SVL (see below).

Materials

Standardized questionnaires used were Beck's Depression Inventory (BDI-II, Beck, Steer & Brown, 1996; BDI-II-NL, Van der Does, 2002), the State-Trait Anxiety Inventory version DY-2 (STAI, Van der Ploeg, Defares & Spielberger, 1980) and the SchokVerwerkings-Lijst (SVL, Brom & Kleber, 1985; see also Van der Ploeg, Mooren, Kleber, Van der Velden & Brom, 2004), which is the Dutch version of the Impact of Event Scale (IES, Horowitz, Wilner, Alvarez, 1979). A Visual Analog Scale (VAS) was constructed to assess mood at different moments during the experiment. Mood was assessed by asking the participant to indicate on a 100 mm. line in what measure he/she felt at that very moment according to the following emotions: sad, happy, depressed, angry, afraid, hopeless and calm. A trauma film lasting 12 min was used and consisted of 11 clips of traumatic content including graphic scenes of fatal road traffic accidents, drowning and human surgery (the same trauma film as the one used in the Holmes et al. (2009) study was used here). A diary was constructed for the recording of possible intrusions during the seven days following the initial test period. The diary contained instructions, a seven-day 'calendar' section, wherein the occurrence of intrusions could be recorded, and room for details to be recorded for a maximum of 16 intrusions. Details recorded were date of occurrence, type of intrusion, subject of the intrusion, the trigger for the intrusion, if any, and the amount of discomfort experienced due to the intrusion on a scale of 0-10 (a copy of the diary can be found in appendix 1).

Procedure

The procedure used here is identical to the procedure used in the Holmes et al. (2009) study, except for the use of written materials (questionnaires, VAS scales, diary). For these, translated Dutch versions were used.

The initial testing period began with baseline assessments of depression (BDI), trait anxiety (STAI) and mood.[2] Participants then watched the 12 min trauma film. The trauma film was followed by a second mood assessment and a 30 min structured break, during which participants completed filler tasks (10 min each looking up answers to trivia questions, listening to and scoring music, then looking up answers again). A brief reminder task for the trauma film was then administered in which one neutral but recognizable image from each scene was presented. In accordance with simple randomisation to condition, participants then completed the Ctrl, SIM or COM condition task for 10 min Participants in the no-task Ctrl condition were asked to sit quietly. Participants in the SIM and COM conditions were asked to play a game of Tetris, with difficulty manipulations corresponding to the condition applied, only using their dominant hand. During these 10 min all participants recorded the number of trauma film intrusions they experienced using their non-dominant hand.

During the following seven days, participants used the daily diary to record the number of intrusions experienced, the amount of discomfort experienced due to the intrusions (per intrusion) and the subject of and possible triggers for the intrusions. This was done to make sure that the memory was indeed involuntary and related to the trauma film. Participants were instructed that it did not count as an intrusion if they deliberately brought the film to mind; only involuntary memories count as intrusions. If any insecurities about this were present at the time of the intrusion, they were asked to record the instance as an intrusion anyways, but to make note of it in the diary.

Participants returned to the laboratory at the conclusion of the seven-day diary period. During this follow-up session participants completed a VAS questionnaire designed to measure the effect by the trauma film on participants' daily life, as indicated by possible changes in behaviour due to behaviour seen in the film. They also completed the SVL to assess clinical PTSD symptomatic response relating to the film. A recognition memory test was given to determine voluntary memory for the film, consisting of 32 individually presented written statements regarding the film (e.g. 'Three cars were involved in the crash'). Participants could respond with either "true" or "false" and scored one point for each correct response. Diary entries were checked for validity with each participant by confirming that each intrusion was specifically related to the film. Attention was paid to using questions which were not leading (e.g. "What happened in the intrusion?", "Could

[2]: Mood was assessed before and after the trauma film to determine the effect the film would have on participants' mood; in line with the Holmes et al. (2009) study, a significant deterioration in mood was expected. These values were also used to determine whether this effect was equivalent between conditions. Other assessments of mood were made during Expt II (after the 30 min break, at the end of the initial testing period and at the start and the end of the follow-up period). However, results from these assessments provided no additional information and had no bearing on other results.

you be more specific?”). The follow-up session concluded with a detailed debriefing.

Data analysis

Outliers on the dependent variables initial intrusions and diary recorded intrusions were changed to M ± 2.5 SD. On the VAS mood scales, scores for ‘happy’ and ‘calm’ were recoded to align in valence with the rest of the emotions (higher score means more negative mood). M scores for the entire scales were calculated.

Data analysis was done using SPSS 16.0 for Windows. Between group differences in baseline measures of age, depression and trait anxiety and the measure of voluntary memory for the film were tested with One Way Analyses of Variance (ANOVA). Pre-trauma film to post-trauma film changes in mood were tested with a 2 x 3 mixed design ANOVA with Time (pre-film vs. post-film) as the within subjects factor and Condition (Ctrl vs SIM vs COM) as the between subjects factor.

Paired t-tests were applied towards the analysis of the number of initial intrusions during the 10 min condition task, the number of intrusions as recorded in the daily diary, SVL scores and the effect by the film on daily life (as indicated by behavioural change). Only the Intrusion subscale of the SVL was chosen to be included in analysis, as opposed to total scores (which include the Avoidance subscale). This decision was made to reflect the focus on intrusive symptoms in this study.

Paired t-tests were chosen to be able to separately compare the results found with only the Ctrl and COM conditions taken into consideration, as these results are directly comparable to the results found in the Holmes et al. study (2009). How the SIM condition relates to the other conditions could then be observed. Following the results of the Holmes et al. study (2009) and Expt I, there was reason to expect a specific directional outcome of results for the first three analyses (more intrusions and higher SVL scores for the Ctrl in comparison with the COM condition, with SIM showing intermediate scores). Thus, these analyses were tested one-tailed.

Results will be addressed in order of variable tested. Where relevant, they will also be subdivided into replication (Ctrl and COM) results and intermediate effects (SIM). The relevance of figures given to illustrate value distribution for the relevant variables will be addressed in the general discussion.

Results experiment II

Baseline measurements

There were no differences between the groups in terms of age, depressive symptoms or trait anxiety.

Mood measurements

Mood was equivalent between the groups prior to and after watching the trauma film (VAS mood scales: pre-film, $F_{(2,57)} = 0.71$, $p = .496$; post-film, $F_{(2,57)} = 1.68$, $p = .195$; see Table 1 for values).

Table 1. *VAS mood scales pre- and post-trauma film M (SD) per condition. Higher scores mean more negative mood.*

	Ctrl	**SIM**	**COM**
Pre-trauma film mood	17.5 (14.5)	15.8 (7.6)	13.7 (6.6)
Post-trauma film mood	30.8 (16.2)	29.8 (13.2)	37.7 (15.1)

Analysis for changes in mood revealed a significant effect of Time (pre- vs post-film) ($F_{(1,57)} = 97.05$, $p < .001$), indicating that mood was significantly more negative after watching the trauma film. There was no effect of Condition ($F_{(2,57)} = 0.35$, $p = .708$). The Time X Condition interaction was significant ($F_{(2,57)} = 4.05$, $p < .05$), indicating that the effect for Time was different between conditions. This effect had no bearing on further analyses.

Initial intrusions during 10 min task

Significantly fewer intrusions occurred during the 10 min experimental COM task compared to the Ctrl condition (Ctrl-COM $t_{(23.2)} = 2.72$, $p < .01$). There was a significant difference between the SIM and COM conditions (SIM-COM $t_{(26.5)} = 1.93$, $p < .05$). There was no significant difference between the Ctrl and SIM conditions (Ctrl-SIM $t_{(38)} = 1.04$, $p = .152$). A distribution of initial intrusion frequency is illustrated in Figure 3 (see Table 2 for values).

Diary recorded intrusions

No significant difference was found in the number of intrusions recorded in the daily diary (Ctrl-COM $t_{(38)} = 0.24$, $p = .408$). No intermediate effect was found (Ctrl-SIM $t_{(38)} = 0.83$, $p = .205$; SIM-COM $t_{(38)} = 0.25$, $p = .124$). A distribution of diary recorded intrusion frequency is illustrated in Figure 4 (see Table 2 for values). No significant differences were found between conditions in the M discomfort experienced due to the diary recorded intrusions ($F_{(2,55)}$ = 1.03, p = .365; see Table 2 for values).

SVL score

No significant difference was found on the measure of clinical symptomatic response (SVL score) at one week after viewing the trauma film (Ctrl-COM $t_{(38)}$ = 1.36, p = .091; Figure 5, see Table 2 for values). No intermediate effect was found (Ctrl-SIM $t_{(38)}$ = 2.82, p = .389; SIM-COM $t_{(38)}$ = 1.62, p = .056).

Table 2. *M (SD) for initial intrusions, diary recorded intrusions, discomfort experienced due to intrusions (on a scale of 0-10) and SVL scores per condition.*

	Ctrl	**SIM**	**COM**
Initial intrusions	9.8 (6.4)	7.9 (4.7)	5.7 (2.2)
Diary recorded intrusions	3.1 (2.7)	2.6 (1.7)	3.3 (2.5)
Discomfort experienced	2.0 (1.6)	2.2 (1.5)	2.7 (1.6)
SVL	7.0 (4.5)	6.6 (4.5)	9.0 (5.0)

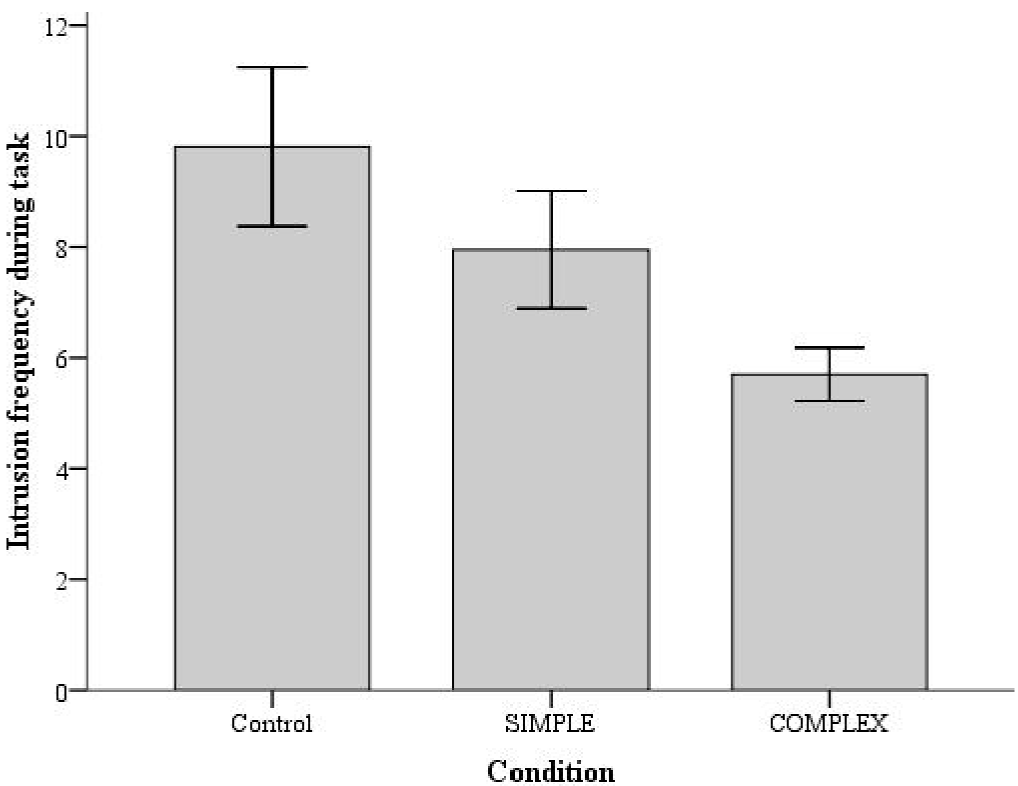

Figure 3. M (SE) number of intrusions experienced during the 10 min condition task per condition.

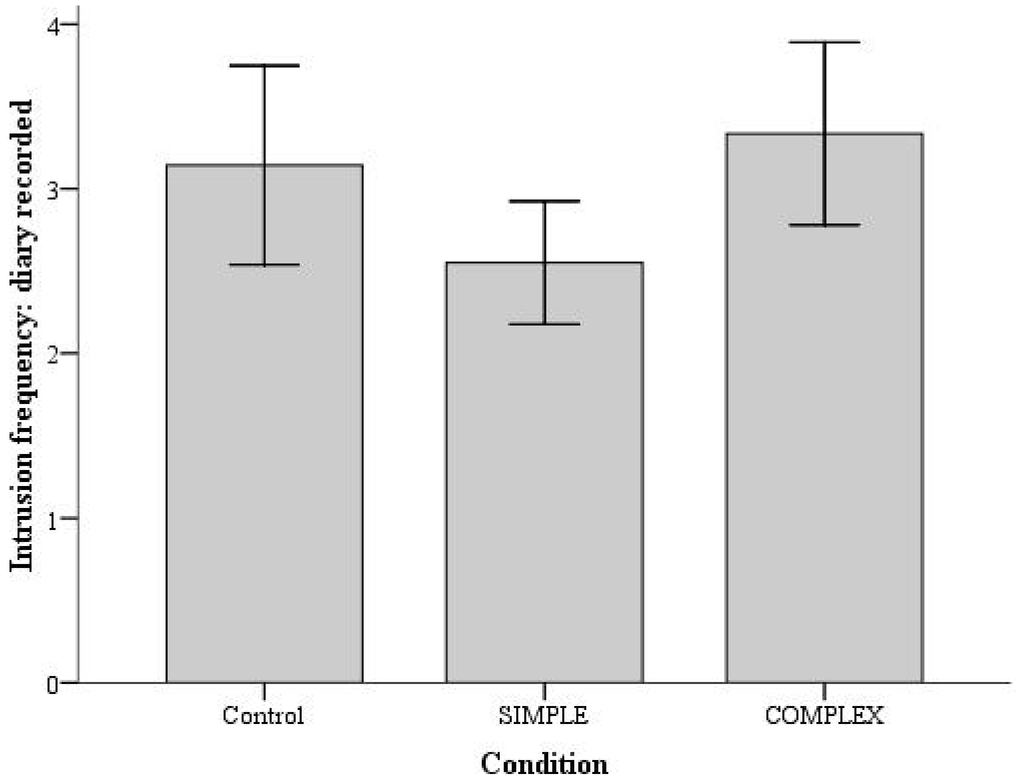

Figure 4. M (SE) number of intrusions experienced during the week following the trauma film as recorded in the daily diary per condition.

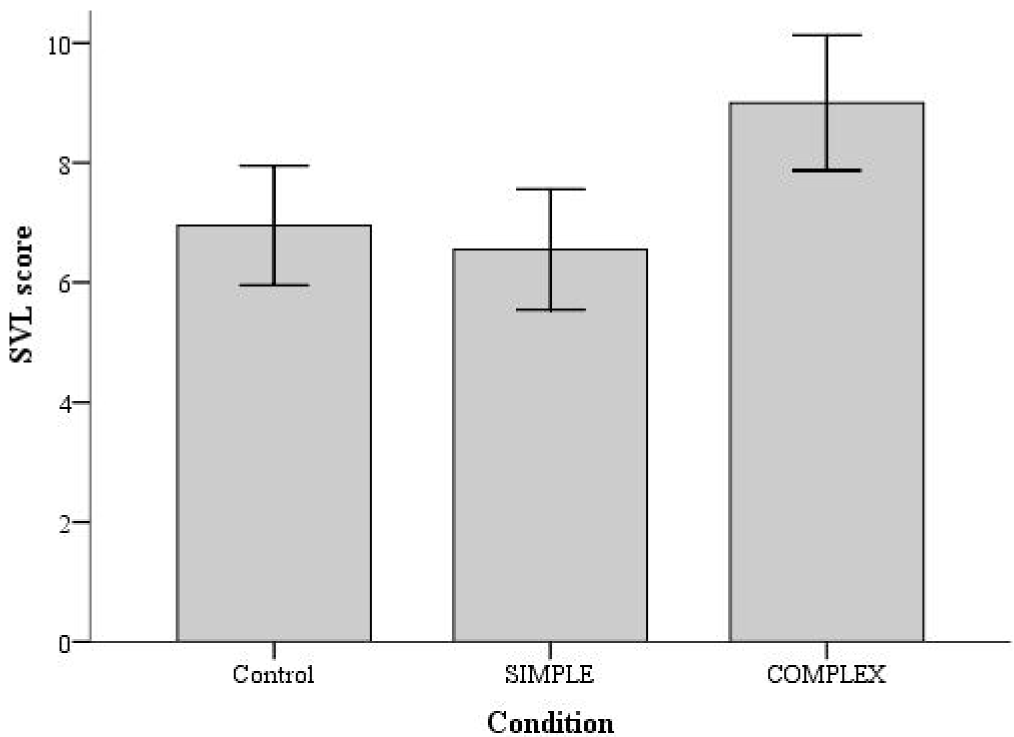

Figure 5. M (SE) score on the SVL Intrusion subscale per condition, indicating clinical symptomatic response.

There was no difference between conditions on the measure of voluntary memory retrieval for the film (Condition M (SD): Ctrl, 19.4 (3.1); SIM, 19.3 (2.7); COM 17.9 (2.21); $F_{(2,57)} = 1.76$, $p = .181$). A significant effect for the effect by the film on daily life was found (Condition M (SD): Ctrl, 11.0 (8.7); SIM, 9.6 (10.3); COM 20.0 (16.9); $F_{(2,57)} = 4.11$, $p < .05$). Paired t-tests revealed a significant difference between the COM condition and the other conditions (Ctrl-COM $t_{(28.5)} = 2.12$, $p < .05$; SIM-COM $t_{(38)} = 2.36$, $p < .05$), indicating more change in behaviour for those in the COM condition. There was no significant difference between the Ctrl and SIM conditions (Ctrl-SIM $t_{(38)} = 0.47$, $p = .319$). A distribution of values is illustrated in Figure 6.

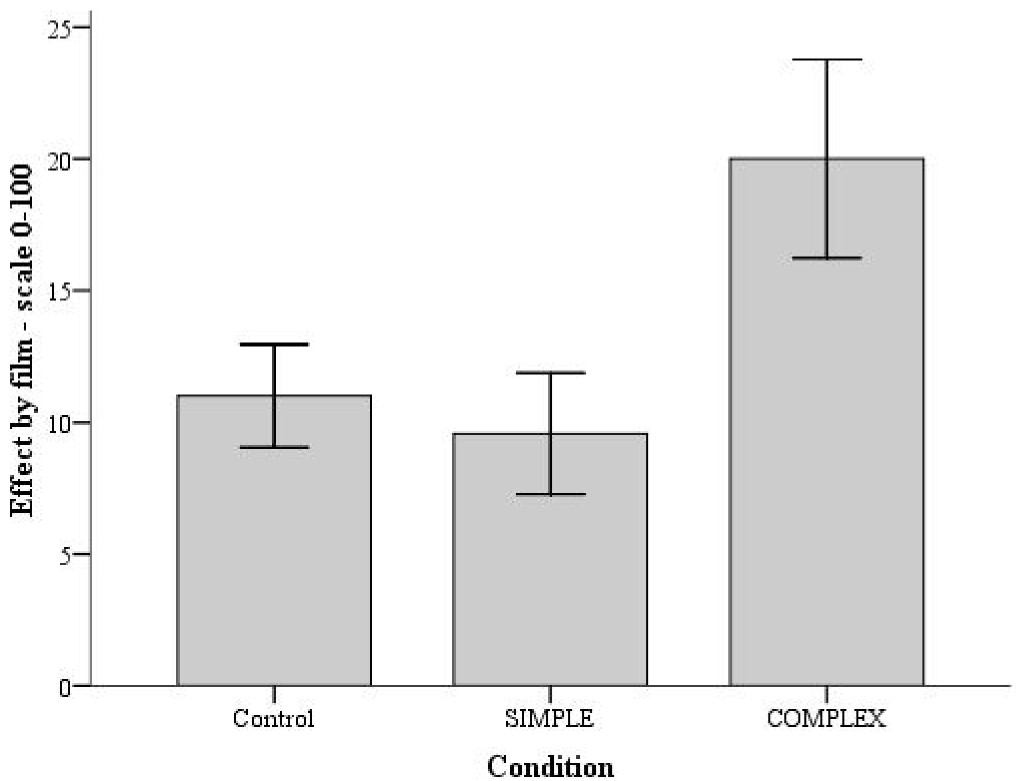

Figure 6. M (SE) of the effect by the film on daily life per condition as indicated by change in behaviour (scale 0-100). Higher scores indicate larger effect (more behavioural change).

General discussion

Experiment I

In Expt I the video game Tetris Zone was re-established as a WM task and two levels of difficulty for playing were established by manipulating game play characteristics: the original, unaltered version of the game [as used in the Holmes et al. (2009) study; noted here as the 'complex' version] and a simplified version (simple), wherein game speed was decreased. Difficulty was expressed by the amount of WM resources needed to complete a visual RT task and concurrently play the game. WM resources needed was indicated by RT size: larger RTs (slower response) indicated a larger demand on WM resources. It was expected that the complex version would demand more WM resources than the simple version, which would in turn demand more WM resources than no dual task. Analysis compared RT scores obtained for three conditions: RT task without dual task, RT task+simple Tetris and RT task+complex Tetris. Results show significant differences between all conditions in line with expectations: complex Tetris demands the largest amount of WM resources (as reflected by the slower responses on the RT task) and simple Tetris demands more WM resources than no dual task.

Experiment II

Expt II was an attempt to replicate the Holmes et al. (2009) study, wherein the effect of VSSP interference on the consolidation of traumatic images was observed. Following the viewing of a trauma film, VSSP interference was reasoned to disrupt the consolidation of traumatic images according to the following rationale: *'(1) trauma intrusions are sensory-perceptual images with visuospatial components. (2) visuospatial cognitive tasks compete for resources with visuospatial images. (3) the neurobiology of memory consolidation suggests a 6-hr time frame post-event within which memories are malleable'* (Holmes et al.,2009, p. 2). VSSP interference would be applied by using the video game Tetris as a visual WM task. Relative to a no-task control (Ctrl), playing Tetris after viewing traumatic images was shown to reduce posttraumatic symptoms, expressed by the number of initial intrusions to the images that occurred during the experimental task, the number of intrusions during the seven days following the viewing of the trauma film (as recorded in the daily diary) and the amount of clinical PTSD symptomatic response at one week.

A dose-dependent effect

The present study included an extension to observe possible intermediate effects between no interference and 'normal' interference [unaltered version of Tetris (COM)], using the in Expt I established task with an intermediate level of taxation (simple / SIM). Main effects of interference were indicated by the number of initial intrusions, as recorded during the experimental task (Ctrl, SIM and COM), the number of diary recorded intrusions and the amount of clinical symptomatic response. Expectations were drawn in line with the Holmes et al. (2009) results, predicting fewer initial intrusions, fewer diary recorded intrusions and less symptomatic response for the COM task in comparison with the other conditions and more intrusions and a larger symptomatic response for the no-task control. The intermediate task was expected to show intermediate values. In addition, the effect by the film on daily life was taken into account, with the expectation that the COM condition would show less change, relative to the other conditions. This expectation was drawn from the rationale that if playing Tetris would lessen the above-mentioned symptoms, it would similarly lessen any change in behaviour in real life situations similar to those seen in the trauma film.

Results

The findings of Expt II show three main results: firstly, relative to the Ctrl and SIM conditions, the COM condition showed significantly fewer initial intrusions to the trauma film (thus, during the 10 min condition task), indicating a significant effect of interference for the COM condition in line with the predicted effect. There was, however, no difference between the Ctrl and SIM conditions. Secondly, there was no difference between conditions in the number of intrusions experienced in the seven days following the film. And lastly, no difference was found between conditions on the measure of symptomatic response at one week. In addition, the results showed no difference in voluntary memory retrieval for the film. There was, however, a significantly larger effect by the film on daily life for the COM condition, relative to the other conditions, with no intermediate effect. This result is slightly puzzling, as one would assume that if the complex Tetris produces the largest interference with the consolidation of the traumatic images, the COM condition would have shown fewer symptoms. This issue will be addressed later in the discussion.

Limitations

During debriefing, participants were asked for their opinion of the experiment and the trauma film. This revealed possible limitations due to the nature of the trauma film and/or the test population. Though participants' mood changed significantly for the worse after watching the trauma film, this effect might not have been strong enough after all. Many noted that the traumatic images were <u>not</u> very impacting, commenting on lack of reality and shock value (e.g. “I’ve seen movies that freaked me out more.”). Values indicating the amount of discomfort experienced due to the intrusions reflected this, as they were generally very low. Also, although most were confident they completed the diary accurately, to many it was unclear as to what constituted an intrusion. During the instruction for use of the diary it was made as sure as possible, through confirmation, that the participant understood the instructions. However, during debriefing it became apparent that this might not have been true for everyone. Some would have the film as a whole intrude, with no emphasis on any specific scene, consider this ‘deliberate thinking’ and dismiss the intrusion. Other insecurities about deliberately bringing the film to mind were more often accompanied by a dismissal of the intrusion, instead of being noted with a remark of insecurity. Many considered the diary itself a trigger for the trauma film, thus compounding the problem of intrusion insecurities. Careful consideration and checking of noted intrusions, together with the participant, would eliminate false hits. But missed intrusions would remain missed.

Considering the results for the intermediate condition, a source of influence could simply have been the nature of aspects of Tetris game play. Though shown to require a larger amount of WM resources than no task and a smaller amount than the normal task, the SIM task might have failed to show a significantly different effect in comparison to the other conditions due to the possibly discontinuous nature of the taxation of WM during play: in the SIM condition, participants could not ‘speed up’ their Tetris blocks. Thus, while playing the game, participants could position their Tetris piece above the space at the bottom where they needed it to be. The piece would then eventually reach this space without further interference needed. The participant would then be mentally unburdened and essentially doing nothing (which would be equal to no task) during this time, until the next piece came into play.

Working Memory resources

Though no intermediate effect was found, the analysis of initial intrusions revealed results similar to those found by Holmes et al. (2009; fewer intrusions for the COM condition). As noted in the introduction, this was to be expected. The condition tasks were increasingly more taxing and thus increasingly limited the amount of WM resources left available for simultaneously completing the task, thinking of the trauma film and recording possible intrusions. Thus, the finding may serve to illustrate that playing Tetris demands WM resources. But itself that finding is silent about effects on the consolidation of trauma memories.

Two levels of difficulty for playing Tetris were established in Expt I, thus indicating two different levels of demand placed upon WM resources. However, individual differences between participants in the amount of WM resources available were not taken into account. Future research attempting to identify dose-dependent relationships between WM taxation and its effects upon memory should include WM capacity tests for covariate control. It is fair to assume that a WM task would have a smaller effect upon someone with a larger WM capacity, simply because that person would experience less interference from the task while keeping traumatic images or a memory in mind. Gunter and Bodner (2008; also found in Van den Hout et al., 2010) support this assumption, having found a negative correlation between the effects of WM tasks and an analogue of WM capacity. Thus, high capacity individuals were *less* affected than low capacity individuals.

Issues regarding WM capacity carry on in the following, as the results show a counter-intuitive relationship between WM taxation and experimental effect. Values for the diary recorded intrusions (Figure 4), SVL scores (Figure 5) and the effect by the film on daily life (Figure 6) are consistently higher in the COM condition than in the other conditions. It seems that in lieu of the expected, there is a trend towards an inverted relationship between taxation and effect. Gunter and Bodner (2008, p. 926) warn for this effect: *'Although tasks that are more taxing of the central executive may produce larger benefits, this relationship may not be linear. A task that is* overly *taxing might preclude holding a memory in mind, thereby precluding benefits'.* Thus, consolidation of new distressing materials or reconsolidation of recollected memories would be left delayed, but more or less unaffected, because this process would no longer be competing for WM resources during the time when the WM would be completely occupied by the task.

Different results

The absence of an experimental effect for the SIM condition could be explained by the amount of WM taxation applied: the simple version of Tetris might demand a significant amount of WM resources, relative to no task, but this 'dosage' could be too little to carry on in experimental effects. The dosage in the COM condition, however, was exactly the same as in the Holmes et al. (2009) study. So why are the results so different?

Reasons could lie with test population differences. For example, the male to female ratio was much larger in the current study in comparison to the Holmes et al. (2009) study (19 male and 41 female vs 22 male and 18 female respectively). Consistent with epidemiological research showing a higher prevalence for women of fear- and anxiety-based disorders (e.g. Bourdon et al., 1988), women are more likely to meet criteria for PTSD, even when frequency of exposure to trauma and type of trauma are accounted for (Tolin & Foa, 2006). It could then be reasoned that women show higher risk for PTSD and thus higher vulnerability to trauma. Indeed, Tolin & Foa (2006) illustrate in their meta-analysis on sex differences in trauma and PTSD that women are more likely than men to rate the same traumatic events as more severe in accordance with DSM-IV-TR criteria (more negative, dangerous, frightening). Women, more so than men, have also been shown to utilize counterproductive immediate posttrauma coping strategies, which have been found to predict the subsequent onset of PTSD (Vingerhoets & Van Heck, 1990; Clohessy & Ehlers, 1999; Valentiner, Foa, Riggs, & Gershuny, 1996). Logically, these tendencies could also predict more immediate posttrauma symptoms. Following this line of reasoning one would assume that the test population in the current study would display a stronger response to the trauma film than the test population in the Holmes et al. (2009) study. Thus, participants in this study would present with more symptoms (larger number of initial and diary recorded intrusions, higher SVL scores, etc.) across all conditions. This was, however, not the case. Values obtained in this study are comparable to those found in the Holmes et al. (2009) study (Table 3). Looking at these numbers, one could even say that the Holmes et al. (2009) participants show a stronger response to the trauma film, though this would need to be confirmed by analysis. So it seems that even though women show a tendency to display stronger posttraumatic reactions, the distribution of men and women in these studies has had no bearing on the outcome of results.

Table 3. *Mean number of initial intrusions, diary recorded intrusions and SVL (total)* scores for the current study and values obtained in the Holmes et al. (2009) study.*

	Current study			**Holmes et al. (2009)**	
Measure	**Ctrl**	**SIM**	**COM**	**No-task**	**Visuospatial**
Initial intrusions	9.8	7.9	5.7	12.8	4.6
Diary recorded intrusions	3.1	2.6	3.3	6.7	2.9
SVL / IES (total)	14.4	12.9	17.2	20.7	13.9

* Total SVL / IES scores are presented here for comparison between studies.

The possibility of a difference between test populations in average IQ should be taken into account, as this aspect of personality could influence the outcome of results in several different ways. Lower intelligence has been shown to be a predictor for PTSD and to share a relationship with the development of PTSD (lower IQ, more severe symptoms) after certain traumatic and life events (Brewin, Andrews & Valentine, 2000). Lower intelligence has also been shown to be related to peritraumatic dissociation (alterations in cognitive and perceptual functioning during trauma; Engelhard, Van den Hout, Kindt, Arntz & Schouten, 2001) and intrusion-based reasoning (Engelhard, Macklin, McNally, Van den Hout, Arntz, 2001). The latter is a form of the ex-consequentia reasoning fallacy (*'If I feel anxiety, there must be danger'*) and both are suggested to be predictive for PTSD (e.g. Ehlers, Mayou, & Bryant, 1998; Engelhard & Arntz, 2005).

So if it is assumed that IQ shares a negative relationship with the cognitive reaction to trauma (higher IQ, less severe reaction), the subsequent assumption could be made that participants with a higher IQ would show fewer symptoms due to viewing the trauma film. Students of the University of Oxford, where the Holmes et al. (2009) study was done, have been credited with IQ scores ranging far above average, higher even than the average for most universities (Charlton, 2008). As was shown above, however, the similarity between populations and possibly larger amounts of symptoms found in the Holmes et al. (2009) test population fails to support this line of reasoning.

Perhaps a more specific aspect of intelligence needs to be examined. A strong relationship between intelligence and WM capacity has been found (Engle, Tuholski, Laughlin, & Conway, 1999) and as WM capacity is an integral aspect of this study, it is logical to explore this further as a source of influence on results. Larger WM capacity is related to the ability to intentionally suppress intrusive thoughts (Brewin & Smart, 2005). Intentional suppression of intrusive thoughts during consolidation could then lead to fewer subsequent intrusions by disrupting the consolidation process. Successful suppression of intrusions while playing Tetris would also free up more WM resources to play the game, thus decreasing the demand it places upon those resources. For a particular participant, this would manifest as a higher level of skill at playing Tetris. It is also possible that some participants might have had more experience with Tetris or video games in general, thus being more skilled due to simple practice. Though the game is designed to quickly reach a level of difficulty equal to the player's level of skill, a minimum amount of time is still needed to reach each successive level. And in an experiment, given time is limited, so the skilled participant would not be taxed as much as the less skilled. So, considering the possibility that one test population had a larger average WM capacity and/or higher skill at playing Tetris, one could assume that population would experience fewer symptoms. However, as discussed above, the results speak against this possibility. Especially since one would expect higher WM capacity and associated skill to follow higher average intelligence, which would more readily be credited to participants in the Holmes et al. (2009) study. Possible influence by these variables could be controlled for to more clearly define taxation and effect within groups. As mentioned above, WM capacity should be measured for covariate control. Assessing experience with Tetris is difficult, but skill could be measured (how many points can you get in a set amount of time?).

Cultural differences might have played a role in the outcome of results. The trauma film contains various clips that were originally used in English programming (such as British news and traffic safety campaigns). It is possible that the participants in the Holmes et al. (2009) study, being based in Oxford, U.K., had a higher familiarity with the images used, as they were more likely to have been previously exposed to the images than the Dutch participants. It is fair to assume that higher levels of familiarity would lessen the traumatic impact of the images, by eliminating the shock aspect of novel materials. And this would in turn lead to fewer symptoms due to the trauma film. Though once again, the results are contrary to the expectations that follow this line of reasoning.

The fact that the exact same trauma film was used in both studies might present the problem of interpretation of the material due to language: narration in the film (where present) was in English. If comprehension of narration would increase the impact of the trauma film, one could assume that participants of the current study might have had a less intense trauma film experience. This could have had an effect on the outcome of found results: the absence of a difference in symptoms could be due to all participants having experienced an effectively less traumatic film. Those in the Ctrl condition could thus have had an insufficiently traumatic experience to contrast with those in the COM condition. Thus far, this seems to have the highest possibility of having occurred and it is difficult to check for its viability. One way would be to examine possible differences in voluntary memory. A stronger impact and better comprehension of the film would logically lead to better retention of material, in addition to a stronger trauma effect. Though analysis could illuminate oversights, measures on voluntary memory seem similar between studies [M score on voluntary memory test, current study: Ctrl, 19.4; SIM, 19.3; COM 17.9 vs Holmes et al. (2009): No-task 20.2; Visuospatial 20.1]. Thus, possible reasons for the difference of results between studies remain largely unclear.

Conclusion

In summary and conclusion, the present study re-established the video game Tetris as a visuospatial task and determined two levels of WM taxation in Expt I. Expt II failed to replicate the Holmes et al. (2009) finding that playing Tetris after viewing traumatic images reduces the number of intrusions and posttraumatic symptoms in the following week, nor could an intermediate effect be found. If anything, there seems to be a trend towards the opposite. As to why this study was unable to replicate the Holmes et al. (2009) results is unclear.

An emerging trend towards an inverted relationship between WM taxation and posttraumatic symptoms suggests that whenever WM taxation is used to affect these symptoms, individual WM capacity should be taken into account. This could prevent overshooting the desired effect due to excessive taxation. To this effect, future research should clearly determine different levels of taxation, from very low to very high, and include individual WM capacity tests.

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