

Does playing Tetris counter intrusions from analogue trauma? A replication study.

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Abstract

Studies suggest that playing the computer game, Tetris may be used as an effective intervention to reduce the frequency of flashbacks from PTSD. The present study was a replication of the Holmes et al. (2009) study. It aimed to investigate whether playing the computer game, Tetris counteracted intrusions from a traumafilm. It was hypothesized that those who played Tetris would experience fewer intrusions than those who did not play Tetris. The present study was an online study and consisted of a sample of undergraduate students. The sample size was 62, with 44 females and 18 males. The Mann-Whitney U test and log-transformations were used to test the hypothesis. The present study did not replicate the findings of Holmes et al (2009). Results did not suggest that those who played Tetris experienced fewer intrusions than those who did not play Tetris. Future studies should investigate the effectiveness of Tetris in reducing intrusions by using more sensitive study design. The relationship between visuospatial working memory (VSWM) capacity and frequency of intrusions was explored using Pearson's correlation. Results were inconclusive, but suggested that there might be a negative relationship between VSWM capacity and frequency of intrusions. Further research is required to determine the nature of this relationship.

Keywords: intrusions, flashbacks, traumafilm, Tetris, traumafilm paradigm, VSWM

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Introduction

Approximately 3.5 percent of the adults in the US suffer from Posttraumatic Stress Disorder (PTSD) every year and approximately 1 in 11 people in the US will experience it in their lifetime (APA, 2022). PTSD is a psychiatric disorder that may develop in individuals that have witnessed or experienced a traumatic event, such as serious injury, death, physical or sexual violence, etc. Symptoms include experiencing recurrent flashbacks, avoiding reminders of the traumatic event, negative changes in thought and mood or changes in physiological arousal (APA, 2013). Flashbacks are one of the core symptoms of PTSD. A flashback is a sensory-perceptual (visuospatial) image that is distressing, intrusive, recurrent and involves an involuntary re-experiencing of a traumatic event (APA, Ehlers et al., 2004; Holmes et al., 2005). In the present paper, flashbacks and intrusions are used interchangeably.

Treatment options for PTSD that are supported by research include Individual manualized trauma-focused psychotherapy, Cognitive Processing Therapy (CPT), Prolonged Exposure Therapy (PE), and Eye Movement and Desensitization and Reprocessing (EMDR; Schrader & Ross, 2021; Watkins et al., 2018). However, these can be costly and time consuming. Additionally, there is a lack of crisis interventions that reduce the build-up of symptoms in the aftermath of traumatic events (Holmes et al., 2009). To combat this Holmes et al. 2009 suggest a performing a visuospatial task as a “cognitive vaccine”, within six hours of the traumatic event to avoid trauma flashbacks. The idea is that after a traumatic event, the traumatic memory is stored in the working memory, and performing a visuospatial task during the window of memory consolidation, disrupts the traumatic memory. The main concepts involved in this idea are explained below.

Working memory (WM) is a system that holds a small amount of information for a short period of time (Cowan, 2014). It is said to have a limited capacity and can be divided

into verbal WM (VWM) and visuospatial working memory (VSWM, Lin & Matsumi, 2022; Lau-Zhu, et al., 2017). VWM is involved in the temporary storage and processing of linguistic information, while VSWM is involved in the temporary storage and processing of two- and three-dimensional representations of objects (Wang, et al., 2018).

Memory consolidation is the process where a memory trace stabilizes after initial acquisition (Alberini, 2013; Nadel et al., 2012). Research suggests that memory consolidation takes place within six hours of the traumatic event (McGaugh, 2000; Nader et al., 2000; Nader, 2003; Walker et al., 2003). During this consolidation window, the memory is open to interference, and thus can be disrupted (Nader, 2003; Walker et al., 2003). Performing visuospatial tasks during the consolidation window leads to competition of resources in the WM (Andrade et al., 1997; Baddeley & Andrade, 2000; Kavanagh et al., 2001). This is the basis of what Holmes et al., 2009 propose.

To study intrusions from traumatic events, Holmes et al., 2009 used a traumafilm. Giving participants (real) trauma is obviously unethical and cannot be done to experimentally study trauma. Thus, the traumafilm paradigm was developed as a way of studying the underlying mechanisms of intrusive memories from real-life trauma (Horowitz, 1969; Holmes et al., 2004). In this paradigm, participants watch a traumafilm for about 12 minutes. Statistical analyses show that it takes about 30 minutes to reach the emergency department in the United States (Wilper, et al., 2008). Thus, to simulate reality, a 30-minute filler task is performed. To reactivate memories of the traumafilm, participants are given brief reminder of the traumafilm. Then they perform the experimental or the control task. To measure the frequency of intrusions from the traumafilm, participants are asked to maintain a record of their intrusions for 1 week, after which they are debriefed. A review of the traumafilm paradigm shows that the traumafilm is effective in inducing PTSD-like symptoms, and thus

can be used to induce analogue trauma (Holmes & Bourne, 2008). Thus, variations of this paradigm have been used by many studies investigating intrusions from analogue trauma.

Theory & Support

The theory of Holmes and colleagues (2009) is as follows. (1) Flashbacks are visuospatial images, and (2) a visuospatial task during the consolidation period competes for VSWM resources with visuospatial images. (3) Performing visuospatial tasks during the consolidation period can disrupt memory (Andrade et al., 1997; Baddeley & Andrade, 2000; Kavanagh et al., 2001). (4) Thus, performing a visuospatial task, like Tetris within the six-hour consolidation window will reduce flashbacks.

Studies suggest that the beneficial effects of performing a cognitive task after analogue trauma seems to be limited to visuospatial tasks, such as pattern-tapping task (Holmes et al., 2004), or the computer game, Tetris. However, performing verbal tasks, such as a verbal distraction task (Holmes et al., 2004) or playing the computer game, Pub Quiz (Holmes et al., 2010) were not only ineffective in reducing flashbacks, but instead increased flashbacks. Holmes and colleagues suggest that visuospatial tasks, specifically, may be beneficial in reducing flashbacks due to its modality specific nature.

Holmes and colleagues posit two requirements for the effectiveness of Tetris in reducing intrusions – playing Tetris with six hours of the traumatic event (Holmes et al., 2009) and reactivation of the memories of analogue trauma (Holmes et al., 2009, 2010; Iyadurai et al., 2018; James et al., 2015, 2016; Lau-Zhu, 2017). Research has expanded on these findings. Studies suggest that playing Tetris may be effective even after the six-hour consolidation window has passed. More specifically, Tetris was effective after 24 hours (James et al., 2015), three days (Kessler et al., 2020) and four days (Hagenaars et al., 2017) of watching the traumafilm. Support for the effectiveness of Tetris has also been found in real-life trauma situations. In the study conducted by Horsch et al. (2017), women who had an

emergency caesarean section surgery played Tetris within six-hours of their surgery while still at the hospital. Those in the Tetris condition experienced fewer intrusions than those in the control condition. Similarly, Iyadurai and colleagues (2018) found that Tetris was effective in reducing intrusions in those who presented to the emergency room after witnessing or experiencing a motor accident.

From the studies have investigated the effectiveness of Tetris in reducing intrusions from (analogue) trauma, only two studies did not find support for the effectiveness of Tetris (Asselbergs et al., 2018; Bruhl et al., 2019). Asselbergs and colleagues (2018) developed their own trauma game. Their study included a dual-task Tetris condition, regular Tetris condition and control condition. After the reactivation task, in the regular Tetris condition, participants played Tetris for eight minutes. Similarly, in the dual-task condition, participants were asked to play Tetris while simultaneously recalling the traumafilm. They found no difference in the number of intrusions reported in the dual-task Tetris condition and the regular Tetris condition from those reported in the control condition. The procedure in the study conducted by Bruhl et al., 2019 was slightly different than in the Holmes study. In the study of Bruhl et al., 2009, participants watched the traumafilm for 21 minutes and played Tetris right after for 25 minutes. The filler task was omitted and so was the reminder task, as they assumed that the memories would still be “activated”. Results did not find support for effectiveness of Tetris in reducing intrusions. This may be because there was no delay after the traumafilm.

Need for a Replication Study

Multiple studies have investigated the effectiveness of Tetris. What might be the need of the present study? Research suggests that many published findings may be unreliable (Ioannidis, 2005). This is more so the case when focus is on research conducted by the same group of researchers (Nelson et al., 2018), when there may be bias (Nelson et al., 2018; Ioannidis, 2005) and when p-hacking occurs.

There is a misconception among researchers that when results are not statistically significant, they are not published (Nelson et al., 2018). However, this is not an accurate representation of the behavior of researchers. When many studies in an area are conducted by the original investigators, there may be more scope for bias (Ioannidis, 2005). When researchers have biased beliefs, they may use different techniques until their bias is confirmed (Nelson et al., 2018).

P-hacking is the misuse of data analysis techniques that make statistically significant results, that would not be significant otherwise, more likely. During data collection and analyses, researchers make many decisions, such as exclusion of cases, treatment of outliers, tests to be conducted, etc. When researchers have complete freedom in making these decisions, it is known as researcher degrees of freedom (Simmons, et al., 2011). When researcher degrees of freedom are high, there may be more scope for p-hacking, and thus, also for false-positive findings (Nelson et al., 2018 ; Simmons, et al., 2011). This is not preferable as we would like the literature to be an accurate representation of scientific research.

Nelson et al., 2018 suggest two ways to prevent p-hacking – full disclosure and pre-registration. Full disclosure is the practice of reporting all analyses and results, rather than selective reporting. This allows for transparency in results and allows reviewers detect p-hacking. Pre-registration is the practice of pre-determining the methods and analyses to investigate a hypothesis. It allows reviewers and readers to know if the analyses for key findings were pre-determined. Pre-registration provides one of the only ways to exclude the possibility of p-hacking in confirmatory analyses.

In the literature on visuospatial tasks and (analogue) trauma intrusions, 13 studies investigate the effectiveness of Tetris. Out of these 13 studies, eight have been published by the original group of researchers (Lau-Zhu et al., 2021; Kessler, et al., 2020; Iyadurai et al., 2018; Kessler et al., 2018; Horsch et al., 2017; Hagenaars et al., 2017; James, 2015; Holmes

et al., 2010). Given that when studies are published by the original group of researchers, there is a higher scope of bias (Ioannidis, 2005), this raises questions about the validity of findings of these studies. Additionally, out of the five studies that were performed independently of the original researchers (Badawi et al., 2020; Butler et al., 2020; Bruhl et al., 2019; Asselbergs et al., 2018; Page & Coxon, 2017), only three studies show an effect for Tetris (Badawi et al., 2020; Butler et al., 2020; Page & Coxon, 2017). Furthermore, out of the five studies that were published independently, only one was pre-registered (Badawi et al., 2020). This is relevant because as mentioned before, pre-registration is preferable to reduce the likelihood of p-hacking and thus the likelihood of false-positive findings (Nosek et al., 2018).

The effectiveness of Tetris is investigated to be used as the first line treatment for the PTSD. However, implementing Tetris as the first-line treatment for PTSD is not without consequences. Implementing such an intervention, like any new intervention, will require time, resources and training. Before expending time and resources on a large-scale implementation, it is wise to confirm the strength and effectiveness of this intervention. Given that studies in the literature were mostly published by the original researchers, and that none, except for one study, was pre-registered, there is need for a replication study that is conducted independently of the original researchers and one that is pre-registered. This is why the present study was conducted; it was conducted by a separate group of researchers, and is pre-registered (https://osf.io/64fuw/?view_only=6796c6c34bfb4000bce06a6951bec758).

The Present Study

The present study is a multi-site study that aims to replicate the findings of Holmes et al. (2009) and investigate whether playing Tetris counteracts intrusions from a traumafilm. For the hypotheses of the present study, “intrusions” refer to image-based intrusions, it consists of intrusions that were images, and intrusions that were a combination of images and thought(s). Following from the original study and the published literature, it was hypothesized

that those who played Tetris after watching the traumafilm would report fewer intrusions than those who did not play Tetris.

In the present paper, I also investigated an exploratory research questions. Is there a relationship between visuospatial working memory capacity and number of intrusions? EMDR research suggests that there is a relationship between the load on the WM capacity and number of intrusions reported (van den Hout & Engelhard, 2012; van Schie et al., 2016). However, the exact nature of this relationship – an upside-down U-curve or a positive linear relationship, is not clear. For the present study, the positive linear relationship model was adopted. It is suggested that visuospatial tasks compete for resources in VSWM (Horsch, et al., 2017), and some research suggests that the higher the load on WM capacity, the lower the number of intrusions. As WM capacity is limited, and there seems to be a relationship between the load on WM and intrusions, I wondered if there would be a relationship between WM capacity and intrusions.

Flashbacks are visuospatial images that compete for resources with visuospatial tasks such as Tetris. The difficulty level of Tetris was adjustable on the basis of gameplay, while this was not the case for the vigilance task. If Tetris works by occupying space in the VSWM and leaving inadequate resources for consolidation of the traumafilm memories, then in the Tetris condition, it was hypothesized that VSWM capacity would have a non-significant relationship with intrusions. Tetris would occupy all the space in VSWM because participants would play Tetris at the level of their VSWM capacity, leaving the level of WM load up to the participant. In the control condition, participants perform a vigilance task, that is less taxing than playing Tetris. The load on the VSWM would be stable as there would be no scope for the participant to adjust their performance. A higher VSWM capacity would allow for more resources for consolidation of traumafilm memories than a lower VSWM capacity in the control condition. Thus, it was hypothesized that there would be positive correlation between

VSWM capacity and intrusions. That is, those who have a higher VSWM capacity would experience more intrusions.

Methods

Participants

Sixty-two participants (44 female, 18 male) were recruited from a University of Groningen's student research practicum pool. The mean age for females and males was 20.11 ($SD = 1.7$) and 20.83 ($SD = 2.21$), respectively. The present study was approved by the Ethics Board of the Department of Psychology at the University of Groningen. As per the pre-registration, and the application to the Ethics Board, a cut-off score of 6 and 11 or above was used for the Trauma Screening Questionnaire (TSQ, Brewin et al., 2002) and the Quick Inventory of Depressive Symptomatology – Self Report (QIDS-SR, Rush et al., 2003), respectively. Out of the 78 participants were screened, 10 were ineligible. Participants whose diaries could not be coded were also excluded from the analysis. This resulted in a total sample size of 62.

Materials

Traumafilm

A 12-minute traumafilm that included images of blood, death, physical and sexual violence was used. The film in the study of Holmes, et al., 2009, is old film, and is of poor quality. Thus, a newer, updated film was created and was tested to be non-inferior against the old film. This new film was used for the present study. The scenes contained clips from real events and scenes from movies and TV shows. After each scene participants were presented with a blank screen for six seconds.

Tetris

The computer game Tetris was modified to suit the needs of the present study (Blue Planet Software, 2021). The game consists of 7 different shaped blocks that fall one at a time

from the top of the playing screen. The aim is to arrange the blocks such that there is no space in between the blocks before the screen is completely filled. When a horizontal line of blocks is filled, that row disappears and gives points. In the present experiment, participants were asked to pay attention to the three blocks that would fall after the one that was being played and think about the best position and rotation of the block in play.

Vigilance task

The vigilance task was adapted from Wilkinson and Houghton (1982) and was used as the control task for the present study. Participants were presented with 20 trials, of 30 seconds each, in which a red circle was presented in the middle of the screen at random intervals. Participants were instructed to press the spacebar as soon as they saw the red circle appear. This task took 10 minutes.

Filler Task

In the filler task, participants were asked to rate 15 excerpts of classical music for pleasantness on a scale of 1 for “not pleasant at all” to 10 for “extremely pleasant”. This task was performed for 10 minutes, in contrast to the 30 minutes in the traumafilm paradigm. This was because as per, Kessler et al. (2020), performing the filler task for 10 minutes did not interfere with the effectiveness of Tetris.

Questionnaires

The Quick Inventory of Depressive Symptomatology – Self Report (QIDS-SR) is a 16-item self-report questionnaire with four response options that measure depressive symptoms (Rush et al., 2003). Each item was scored from 0 to 4, and this yielded a total range of 0 to 54. A cut-off score of 11 or higher was used in the present study. Studies show a high internal consistency for QIDS-SR, Cronbach’s alpha were $\alpha = .86$ (Rush, et al., 2003; Brown et al., 2008). When a cut-off score of 13 was used, sensitivity and specificity was 0.76 and 0.81, respectively (Lamoureux, et al., 2010).

The Trauma Screening Questionnaire (TQS) is a 10-item questionnaire that was developed as a screening instrument for PTSD (Brewin et al., 2002). It is made of dichotomous questions, with “Yes” scored as 1 and “No” scored 0, thus resulting in a range of 0 to 10. In the present study a cut-off score of 6 or higher was used to screen out participants. When a cut-off score of 6 was used with victims of assault, sensitivity was 0.85 and specificity was 0.89 (Walters et al., 2007).

Participants rated how sad, hopeless, fearful, horrified, anxious and depressed they felt before and after watching the traumafilm on a visual analogue scale (VAS). The rating ranged from 0 for “not at all” to 100 for “extremely”.

To check if traumafilm was effective in inducing analogue trauma, after watching the traumafilm, participants were asked about how distressing they found the film, how much attention they paid to the film and to what extent they closed their eyes/looked away from the film. These questions were asked on a 100-point rating scale ranging from 0 for “not at all” to 100 for “extremely”/“total attention”/“the whole time”, depending on the question.

To gauge the accuracy of the frequency of intrusions from the traumafilm, participants were also asked a few questions about diary compliance on a 100-point rating scale. Participants were asked to rate the extent to which they were unable to record their intrusions in the diary, how accurate their diary was and the extent to which the daily reminders affected the frequency of intrusions. Again, the ratings ranged from 0 for “not at all ...” to 100 for “extremely...”.

As this study was part a larger study, other questionnaires such as Depression Anxiety Stress Scale (Lovibond & Lovibond, 1995), Retrospective Ratings after Tetris/Vigilance task, Impact of Movie Scale (adapted from Weiss & Marmar, 1997), Spontaneous Use of Imagery Scale (Reisberg, et al., 2003), The Internal–External Locus of Control Short Scale–4 (Kovaleva, 2012), Orientation to Life Questionnaire (Antonovsky A, 1987), International

Physical Activity Questionnaire – Short Form (Craig, et al., 2003), Intolerance of Uncertainty Scale (Freeston, et al., 1994) and the participant experience questionnaire were administered. These however, were unrelated to the hypotheses in the present paper.

Diary

As participants were asked to maintain a record of their intrusions for seven days after watching the traumafilm, a diary template was shared with the participants in session two. They were asked to either print the diary pages or maintain an electronic version. They received detailed instructions from the researcher on filling out the diary as accurately as possible.

Corsi task

The Corsi block-tapping task (Corsi, 1972) is a visuospatial task, used to assess visuospatial working memory (Brunetti et al., 2014). With each trial, participants were presented with an increasing number of blocks that lit up in a specific sequence. After each sequence was complete, participants were supposed to click on the blocks in the same sequence. The final score was the highest number of blocks that were clicked in the right sequence.

Procedure

The study was conducted online in a Google Meet due to the COVID-19 pandemic. To ensure standardization in delivery of instructions, a standard protocol was followed by all experimenters who were trained by experienced students. The study consisted of three sessions. In session one, participants were screened for eligibility. Those who scored 6 and 11 or above on the TSQ and QIDS, respectively, were screened out. For those who were eligible, session two followed immediately after session one. In session two, participants rated their mood on a VAS before watching the traumafilm. Then participants watched the traumafilm. Participants then rated their mood again on a VAS.

Participants then performed a 10-minute filler task in which they rated classical music for pleasantness. This was followed by a one-minute reminder clip that included a picture from every scene in the traumafilm. After random assignment in Qualtrics, participants either played Tetris for 10 minutes in the experimental condition, or performed a vigilance task for 10 minutes in the control condition. Then information about intrusions and instructions for how to use the diary were given. Participants returned for session three exactly seven days later. They were asked a few questions about the diary compliance and were provided a debriefing form that explained the full purpose of the study. Participants were also asked to fill in a few other questionnaires.

Data Analysis Plan

Two exclusion criteria will be created – a ‘strict’ and a ‘not-strict’ one. In the ‘strict’ exclusion criteria, all participants who sent their diary after day seven will be excluded. But, in the ‘non-strict’ exclusion criteria, these participants will be included. Using both, the ‘strict’ and ‘non-strict’ exclusion criteria, a mean for image-based intrusions will be calculated. In case of a large difference in means, results from both analysis will be reported. Outliers will be determined using the $1.5(IQR) + Q3$ rule. To check if the outliers influenced the statistical significance of findings, analyses will be conducted with and without outliers. If there is a change in the statistical significance of findings by excluding outliers, then both analyses will be reported. If not, then analyses with outliers will be reported, while those without outliers will be added as an appendix.

Based on pilot studies, we can expect a positively-skewed distribution. Thus, non-parametric tests and log-transformations will be used. To test the main hypothesis, the Mann-Whitney U test will be used. However, this test sorts all the intrusions in an ascending order and assigns a rank to each of number of intrusions. Thus, it uses a rank sum to test the hypothesis. For this reason, this test seems to test the difference in the median number of

intrusions in each condition, rather than the mean number of intrusions. Based on the pilot data, it can be expected that large number of people will report a small number of intrusions, both, in the Tetris and control condition. When the number of intrusions is sorted in an ascending order, the middle most value is known as the median. It does not take into account other values in the range. Thus, it is likely that the median in the Tetris and control condition will be the same, and that this technique may be biased towards the null. For a more complete picture, and to avoid using only one technique, Independent Samples T-test will also be used.

Due to the non-normal nature of the data, log-transformations will be used. Some people may experience zero intrusions. Log transformations may affect zero and non-zero values differently. To circumvent this, 1 will be added to all intrusions. A log-transformation on all image-based intrusions will be performed on SPSS, then an Independent samples T-test will be performed. To show the effect of a log₁₀ transformation on image-based intrusions, reverse-transformed means for the Tetris and control condition will be reported. Reverse transformations will be performed by 10^x . Additionally, an Independent Samples T-test was also performed on the non-transformed values to see the effect of log-transformations. A manipulation check will also be carried out.

For the exploratory analysis, a Pearson's correlation between the Corsi scores and intrusions will be calculated, with and without outliers on intrusions. In case there is a difference between the significance of the correlation when outliers are excluded, results from both analyses will be reported.

Statement of transparency

The data analysis deviated from the pre-registration in the exclusion criteria, treatment of outliers, and hypothesis testing. In the pre-registration, one of the exclusion criteria was sending the diary later than day seven. In the present study, this was used as a 'strict' exclusion criterion. All participants were tested exactly seven days after watching the

traumafilm, and filled in their diary only till seven days after watching the film. Thus, the day the diary was sent does not seem relevant to the number of intrusions. To include participants that sent the diary later than day seven, the ‘non-strict’ exclusion criterion used.

The formula that was used for determining outliers in the present study was different from the pre-registration. In the present study, for sake of simplicity, the $1.5(IQR) + Q3$ rule was used to determine outliers. The pre-registration states that outliers would be included in the analysis, unless in the case of special circumstances, such as computer failure, intoxication, illness, etc. However, after data collection, it was discovered that certain values were extreme outliers (as determined by SPSS). Thus, analyses were conducted both with and without outliers.

A Negative Binomial Generalized Linear Regression Model was stated as the statistical technique for testing the main hypothesis in the pre-registration. However, this technique was considered to be too advanced for the present paper. Thus, log transformations and a non-parametric test was used to test the main hypothesis.

Results

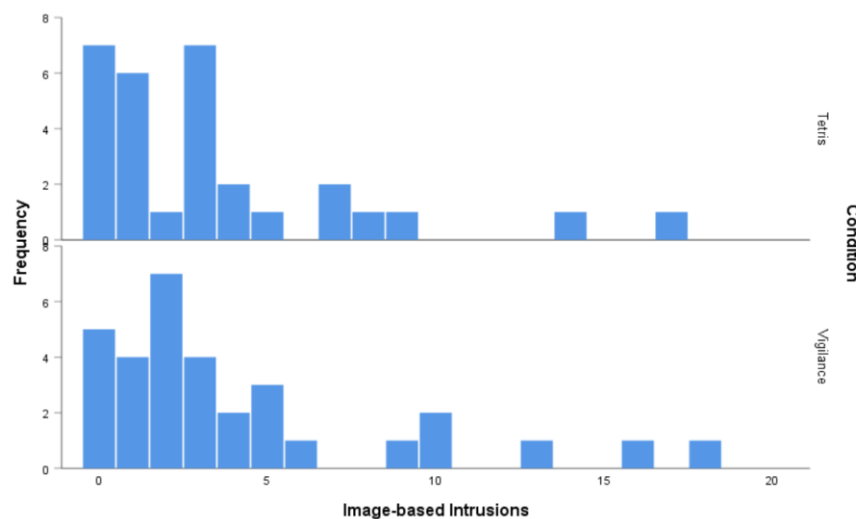
We tried to collect as many diaries as possible after exactly seven days from watching the traumafilm, but this was not always possible. Out of the 62 participants, 59 participants sent their diary on the same day of the week, and two participants sent their diary one day later, and one participant sent their diary two days later.

The mean number of intrusions as per the ‘strict’ exclusion criterion was 3.73 ($SD = 4.34$) and the mean number of intrusions as per the ‘non-strict’ exclusion criterion was 3.85 ($SD = 4.39$). The means seemed similar. Thus, the ‘non-strict’ exclusion criterion was used for further analyses.

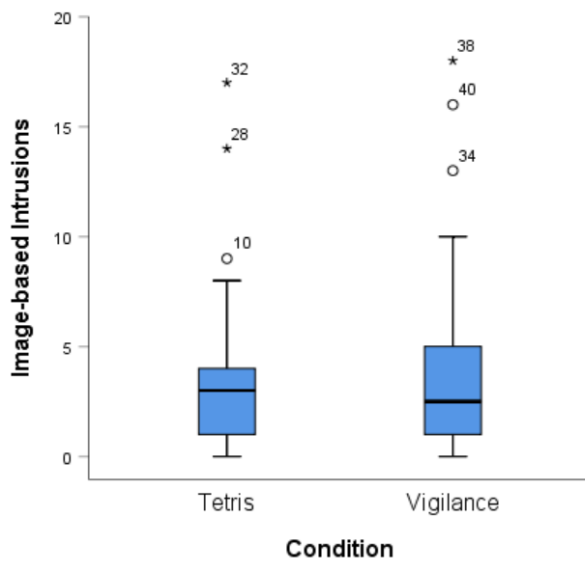
Assumptions

The normality was checked for diary intrusions. This was done by examining the histogram and boxplot for diary intrusions as per the conditions. The histogram (figure 1) showed a non-normal distribution, and the boxplot (figure 2) showed a strong positive skew and revealed outliers. The skewness of the intrusions in the Tetris and the control condition was 1.88 and 1.65, respectively. As per the 1.5 IQR rule for determining outliers, 11 and more intrusions was used as a cut-off score. Analyses were done both with and with outliers. Outliers did not affect the statistical significance of results. Thus, outliers were included in the analyses presented here, (for analyses without outliers see, Appendix A).

Figure 1

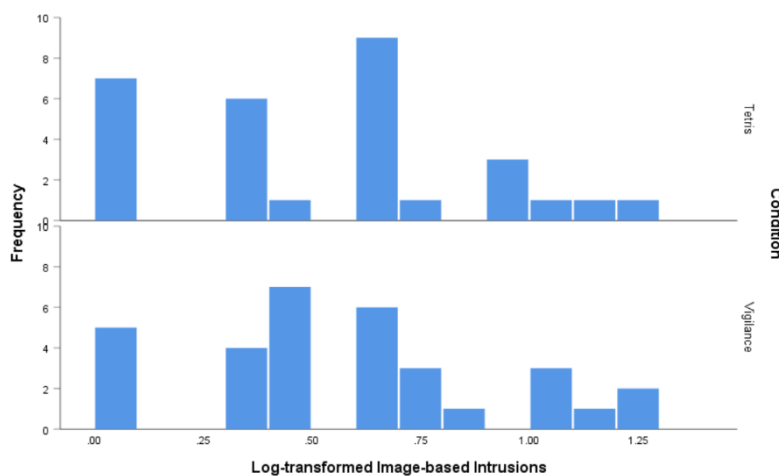


Note. A histogram of the total diary intrusions.

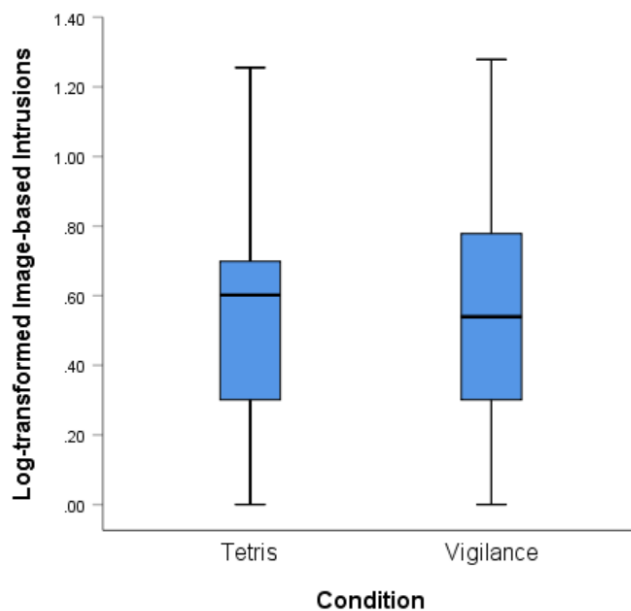
Figure 2

Note. A boxplot of the total diary intrusions.

After performing the log transformation, skewness of intrusions in the Tetris and the control condition reduced to 0.19 and 0.11, respectively (figure 3). The boxplot showed less skewed data than before the log-transformation (figure 4). Thus, the log transformation was successful in making the data less non-normally distributed.

Figure 3

Note. A histogram of the total diary intrusions after log transformations.

Figure 4

Note. A boxplot of the total diary intrusions after log transformations.

As part of checking assumptions, a manipulation check was performed. Means of VAS before and after the traumafilm, stressfulness and attention during the film and compliance with diary instructions were calculated. As outliers were included in the main analyses, they were also included for the manipulation check. After watching the traumafilm, all, sadness, hopelessness, fearfulness, horror, anxiousness and depressiveness, increased (see table 1). On a 100-point scale, the mean rating for how stressful participants found the film was 58.5 ($SD = 22.7$). The mean rating for the attention paid to film was 94.68 ($SD = 7.67$). The mean rating for the extent that participant closed their eyes during the film was 7.04 ($SD = 9.76$). For mean ratings as per condition on these three measures, see Table 2.

When asked about how often participants were unable to record their intrusions, the accuracy of their diary and the extent to which the daily email reminders affected the frequency of intrusions, the mean ratings were 11.18 ($SD = 17.02$), 85.08 ($SD = 10.58$) and 23.21 ($SD = 25.96$), respectively, (for means as per condition, see Table 2). To check if the

traumafilm successfully served as an experimental analogue of traumatic events, a correlation between stressfulness of the traumafilm and intrusions was calculated. A moderate correlation was found, $r(62) = 0.29, p = .023$.

Table 1

Mean Rating for Emotions on VAS Before and After Watching the Traumafilm

Item	Condition							
	Tetris				Control			
	Pre-film		Post-film		Pre-film		Post-film	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Sad	13.57	20.92	14.7	12.02	9.69	12.37	18.56	19.72
Hopeless	3.1	3.56	9.23	11.96	2.09	4.03	7.16	11.18
Fearful	8.4	9.42	22	18.87	7.22	8.9	17.09	17.16
Horried	0.87	1.25	34.67	30.9	3.4	6.36	32.47	22.98
Anxious	9.13	6.93	26.03	20.97	10.38	10.17	24.4	21.14
Depressed	2.27	3.6	6.37	7.15	2.47	5.93	9.94	13.22

Note. The ratings were on a 100-point scale. N (Tetris) = 30, N (Control) = 32.

Table 2

Mean Rating on Manipulation Check Questions

Item	Tetris		Control	
	Mean	SD	Mean	SD
Distress while watching the film	59.9	21.9	57.19	23.68
Attention paid to the film	93.97	8.65	95.34	6.69
Extent to which you closed your eyes/looked away during the film	8.2	11.94	5.97	7.18
Extent to which you were unable/forgot to record intrusions in your diary	9.57	15.83	12.69	18.19
Accuracy of diary	84.4	11.29	85.72	10
The extent to which the daily email affected the frequency of intrusions	20.73	24.78	25.53	27.20

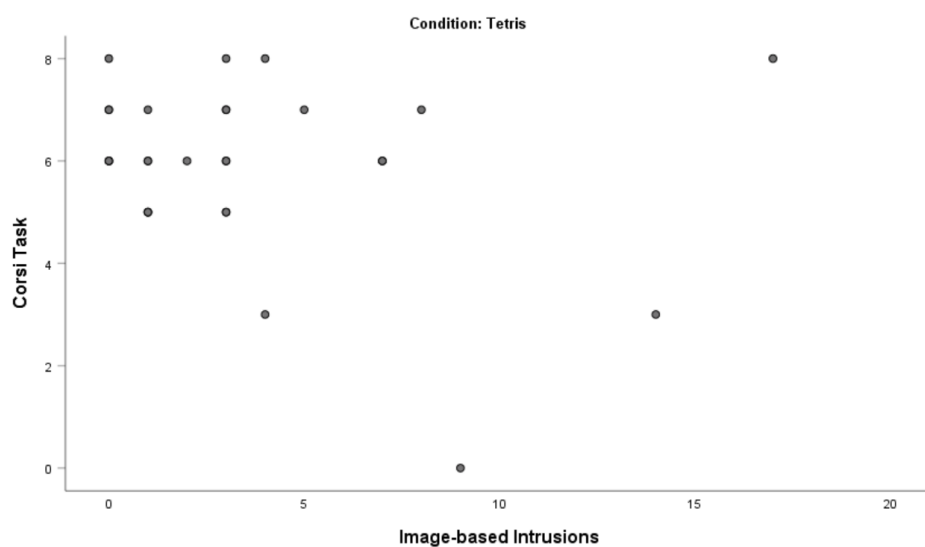
Note. The ratings were on a 100-point scale. N (Tetris) = 30, N (Control) = 32.

Hypothesis Testing

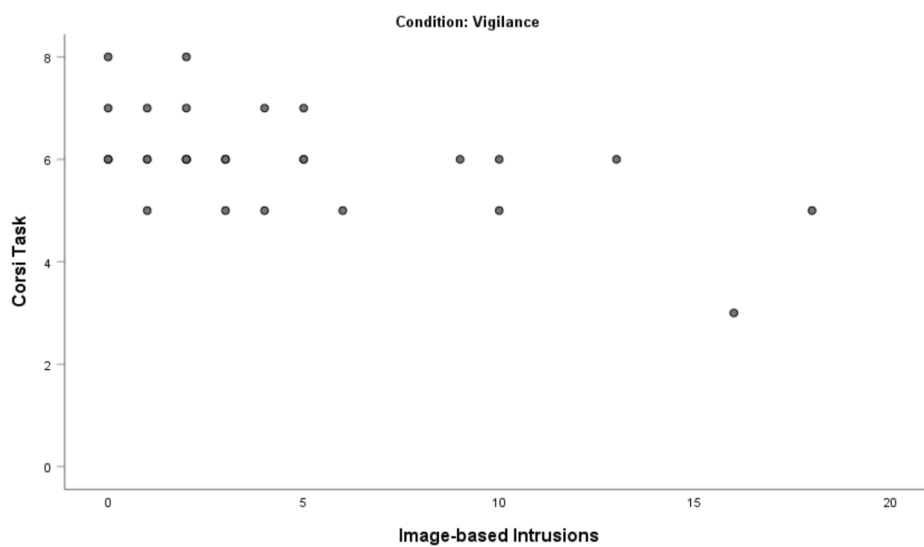
The mean number of intrusions in the Tetris condition was 3.47 ($SD = 4.14$) and mean number of intrusions in the control condition was 4.22 ($SD = 4.65$). The Mann-Whitney U-test showed that there was no statistically significant difference in the rank sum for the Tetris ($Mdn = 3$) and control condition ($Mdn = 2.5$), $U(N_{tetris} = 30, N_{control} = 32) = 429.00$, $z = -0.726$, $p = .468$. An Independent Samples T-test on the non-transformed data statistically non-significant results, $t(60) = -.67$, $p = .505$. The back transformed mean number of intrusions in the Tetris and the control condition was 3.13 ($SD = 2.36$) and 3.72 ($SD = 2.31$), respectively. The Independent Samples T-test on the log-transformed data showed non-significant results, $t(60) = -.805$, $p = .424$. In case of both tests, I fail to reject the null hypothesis that is there is no difference in the mean number of intrusions in the Tetris and control condition.

Exploratory hypothesis

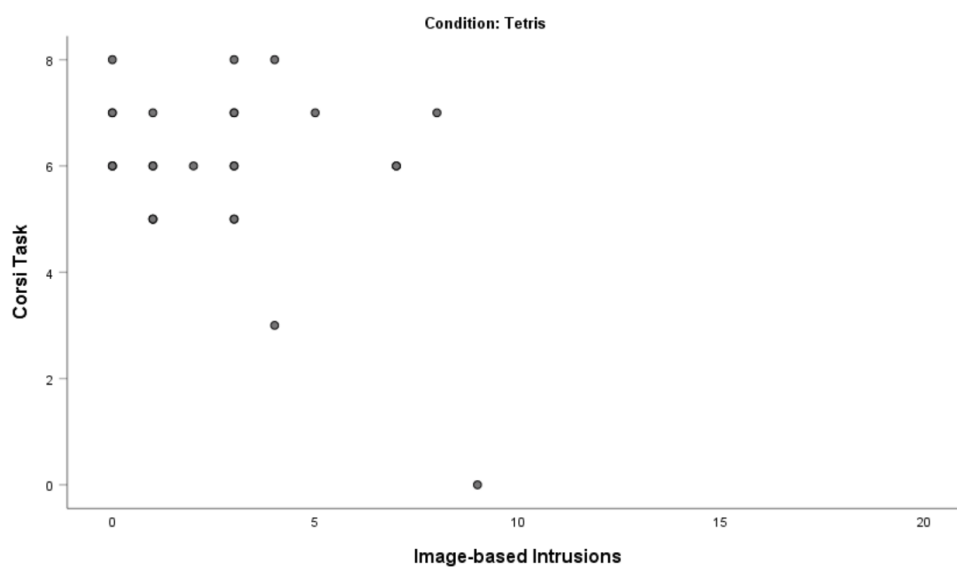
There was a difference in the statistical significance of the results when outliers on the diary intrusions were included and excluded. Thus, results from both analyses are reported here. When outliers were included, the mean score for the Corsi task in the Tetris and the control condition was 5.93 ($SD = 1.71$) and 6 ($SD = 0.97$), respectively. Unexpectedly, a negative correlation between the VSWM capacity and number of intrusions was found. Pearson's correlation was negative in the control condition, $r(31) = -.542$, $p = .01$ (figure 6) and statistically non-significant in the Tetris condition, $r(29) = -.210$, $p = .274$ (figure 5). When the outliers were excluded, the mean scores were 5.96 ($SD = 1.63$) in the Tetris condition and 6.14 ($SD = 0.80$) in the control condition. After the exclusion of outliers, there was no statistically significant correlation between the corsi scores and intrusions in both, the Tetris condition, $r(27) = -.348$, $p = .075$ (figure 7) and control condition $r(28) = -.325$, $p = .092$ (figure 8). This means that VSWM capacity does not have a statistically significant relationship with the number of diary intrusions.

Figure 5

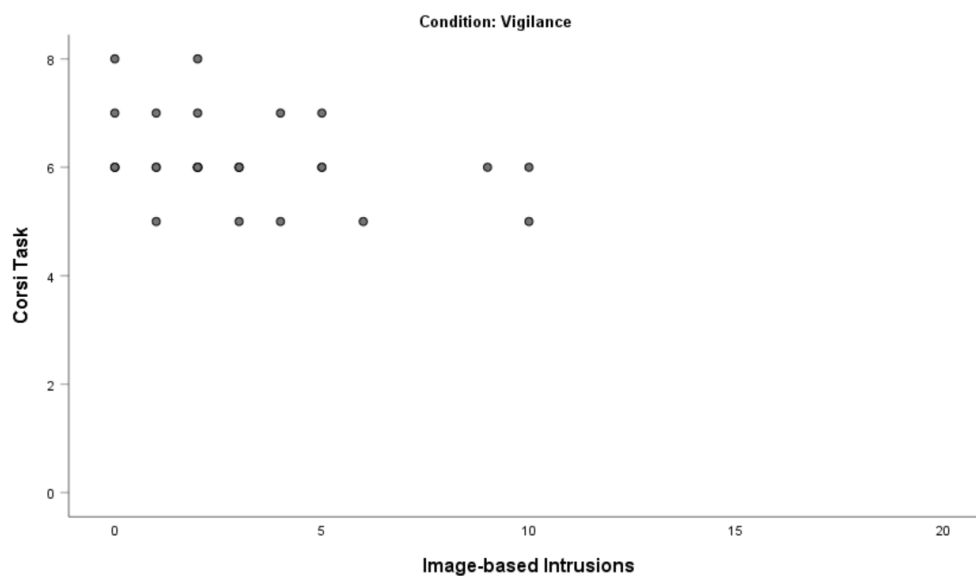
Note. Scatterplot of the Corsi scores and the total number of intrusions in the Tetrakis condition, when outliers were included.

Figure 6

Note. Scatterplot of the Corsi scores and the total number of intrusions in the control condition, when outliers were included.

Figure 7

Note. Scatterplot of the Corsi scores and the total number of intrusions in the control condition, when outliers were excluded.

Figure 8

Note. Scatterplot of the Corsi scores and the total number of intrusions in the control condition, when outliers were excluded.

Discussion

The aim of the present study was to conduct a replication of the findings of the Holmes et al., 2009 study. They propose that playing the computer game, Tetris, within six hours of analogue trauma, reduce the occurrence of flashbacks. The present study aimed to replicate this finding. It was hypothesized that those who played Tetris after watching the traumafilm experienced fewer flashbacks than those who did not play Tetris. Contrary to expectations, the results of the present study do not support this hypothesis. The present study did not find support for the hypothesis that participants who played Tetris reported fewer intrusions than those who did not play Tetris. Thus, the findings from the present study are inconclusive.

These conclusions are in line with two studies that did not show support for the effectiveness of Tetris (Asselbergs et al., 2018; Bruhl et al., 2019). However, these two studies are different from the present study, as participants either played Tetris without reactivation of the traumafilm memory (Asselbergs, et al., 2018; Bruhl et al., 2019) or were asked to simultaneously think about the traumafilm while playing Tetris (Asselbergs, et al., 2018). A memory reactivation task was performed in the present study and participants were not asked to recall the traumafilm while playing Tetris. This is similar to the original proposal of Holmes et al. (2009). As per Holmes and colleagues (2009, 2010, Iyadurai et al., 2018; James et al., 2015, 2016; Lau-Zhu, 2017), retrieval of the trauma memories is a prerequisite for the effectiveness of the Tetris. This may explain the findings of Asselbergs et al., 2018 and Bruhl et al., 2019.

The findings of the present study are not in line with published literature (James et al., 2015; Holmes et al., 2010; Kessler, et al., 2020; Horsch et al., 2017; Badawi et al., 2020; Hagenaars, et al., 2017). In most of these studies, participants played Tetris within six hours

of the (analogue) traumatic event and were reminded of the (analogue) trauma before playing Tetris. The protocol of the present study was designed by keeping these prerequisites in mind. Thus, the reason for not finding support for the effectiveness of Tetris is not immediately clear.

The present study was designed to detect a large effect size, as reported by Holmes et al., 2009. The mean number of intrusions in the Tetris condition (3.47) was smaller than the mean number of intrusions in the control condition (4.22). So it could be that the true effect size for Tetris reducing intrusions in experimental studies is smaller than anticipated, and that the present study was not sensitive enough to detect it. Another reason could be that because the study was conducted online, participants might have been distracted. As the present study was not a lab study, researchers were not able to control the environment that participants were in. It could be that participants did not play Tetris following the instructions, or might have been distracted during the film. Although the latter seems unlikely as the mean rating for attention paid to the film was quite high (94.68). A newer version of the traumafilm was used in the present study. This new film was different from the Holmes' film, and it could be that the effectiveness of Tetris lies in the unique features of the Holmes' film.

The present study did not find support of the proposal of Holmes et al. (2009). The present study was conducted independently of the original researchers and was pre-registered. Due to the null-findings in the present study, no comment can be made on the effectiveness of Tetris in reducing intrusions from a traumafilm. If the null were true, playing Tetris could not be used as a "cognitive vaccine" against the build-up of traumatic flashbacks. Tetris could not be used as an intervention for prevention of intrusions in PTSD. Current treatment options would have to continue to be used. Findings from previous research would be called into question. If the null were false, the theory of Holmes et al. (2009) would be supported and Tetris could be used as an intervention for flashbacks from PTSD. Further research should investigate the

effectiveness of Tetris in reducing intrusions using more sensitive study designs that are able to detect smaller effect sizes.

In the present paper, I explored a relationship between VSWM capacity and number of intrusions. I hypothesized that VSWM capacity would have a non-significant correlation with number of intrusions, in the Tetris condition. While in the control condition, there would be a statistically significant positive relationship between VSWM capacity and number of intrusions. The findings from the present study were unexpected. When the outliers were included, in the control condition, there was a large negative correlation between VSWM capacity and intrusions. The correlation was in the opposite direction than expected. In line with the hypothesis, I did not find support for the no-statistical-correlation hypothesis between working memory capacity and intrusions in the Tetris condition. But when outliers were excluded there was no correlation between VSWM capacity and intrusions in both, the Tetris and control condition.

The results are inconclusive as when the outliers were excluded, there was no correlation between VSWM capacity and intrusions, but when outliers were included there was a correlation between VSWM capacity and intrusions. This suggests that the statistical significance of correlation hinges on a few influential points. If there was a negative relationship between VSWM capacity and intrusions, this means, that those who had a higher VSWM capacity would report fewer intrusions. To my knowledge, there are no studies that investigate the relationship between VSWM capacity and intrusions from analogue trauma. The reason for a negative relationship is not immediately clear. It could be that those who had a higher VSWM capacity were able to complete the vigilance task while thinking about other things, thus taxing their VSWM, and reporting fewer intrusions. But those who had a lower VSWM capacity could only focus on the vigilance task, thus taxing their VSWM less than those who had a higher VSWM capacity. A limitation in the present study is that the Corsi

block-tapping task is a crud measure of VSWM capacity. Future research should use more sensitive measure of VSWM capacity explore the relationship between VSWM capacity and analogue trauma intrusions.

In conclusion, the findings of the present study did not replicate the findings of Holmes et al. (2009). The strength of the effectiveness of Tetris as an intervention to reduce intrusions from PTSD should be further investigated. Additionally, there might a negative relationship between VSWM capacity and frequency of intrusions, but this must be interpreted with caution as the relationship hinged on a few influential outliers.

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Appendix A

The following analyses were performed after excluding outliers. The mean number of intrusions in the Tetris condition was 2.61 ($SD = 2.6$) and mean number of intrusions in the control condition was 3.03 ($SD = 2.84$). The Mann-Whitney U-test showed that there was no statistically significant difference in the rank sum for the Tetris ($Mdn = 2.5$) and control ($Mdn = 2$) condition, $U(N_{tetris} = 28, N_{control} = 29) = 368.00, z = -0.614, p = .539$. An Independent Samples T-test performed on the non-transformed data showed statistically non-significant results, $t(55) = -.592, p = .556$. The back transformed mean number of intrusions in the Tetris and the control condition was 2.78 ($SD = 2.13$) and 3.19 ($SD = 2.05$), respectively. The independent samples t-test on the log-transformed data showed non-significant results, $t(55) = -.705, p = .484$.