Combining Game Play and Movement - Tetris and Physical Activity in Relation to Intrusions of Trauma

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Abstract

Experiencing intrusions counts as the main symptom of PTSD. These disruptive, involuntary flashbacks are often distressing and the individual has to relive their trauma. It has been proposed that the computer game Tetris might counteract the development of intrusions after experimental trauma. To investigate this, two parts of this thesis are presented. The first part is a literature review about Tetris and intrusive memory. The literature search was conducted within PsychINFO and Scopus. After screening, a total of 16 studies were included in the review of which the majority (13 studies) successfully found an effect of Tetris on intrusions. The aim was to provide context for the second part, replicating a previous study by Holmes et al. (2009). Visual imagery is supposedly affected by demanding visual-dual tasks that compete for working memory capacities. By disrupting memory consolidation, frequency and experience of intrusions might be influenced. One additional variable previously related to intrusions is physical activity (PA). An increased level of fitness seems associated with a decreased development of intrusions. Accordingly, we are extending the replication by assessing PA. Our sample of 62 students watched a 12-minutes film consisting of different stressful scenes. Afterwards, the experimental condition played Tetris while the control condition completed a perceptual vigilance task. Participants recorded any intrusions experienced in a diary for one week. At the follow-up session, diaries were collected and participants filled in the International Physical Activity Questionnaire – Short Form to assess PA conducted during the previous seven days. Our results did not find a statistically significant difference of intrusions between the Tetris and the control condition. Also, we did not find a significant correlation between physical activity and diary intrusions. This study adds valuable information to the existing literature. It helps to further evaluate the implications Tetris might have in the future as a possible immediate intervention approach.

Keywords: intrusions, intrusive memories, Tetris, physical activity, trauma film paradigm, post-traumatic stress disorder

Combining Game Play and Movement - Tetris and Physical Activity in Relation to Intrusions of Trauma

Our current global state is marked by increasing terrorism, war, refugee crises, and natural disasters. These examples of traumatic events pose an increased risk of the development of post-traumatic stress disorder (PTSD; Holmes et al., 2009; Oppizzi & Umberger, 2018). According to the DSM-5 (American Psychiatric Association [APA], 2013), PTSD is a disorder in which patients experienced or witnessed a traumatic event leading to the development of specific and persisting symptoms. These include significant changes in arousal and awareness, avoidance behavior, negative mood, distorted thoughts, and crucially the experience of intrusive memories (APA, 2013).

Intrusions are marked by a significant amount of distress and are expressed as involuntary memories, distressing dreams, or vivid flashbacks in which the patient is reliving the trauma (APA, 2013). These disruptive, automatic experiences can include verbal thoughts, sounds, and smell, but are most often expressed in form of images. This can cause emotional and physical arousal as well as impaired concentration (Marks et al., 2018). For example, an individual who witnessed a car accident may see in their mind how the car crashed with the sound of the honks and the screeching tires days or months later.

As intrusions can be seen as the core feature of PTSD, several studies investigated their development. It was found that memory consolidation plays a crucial role for possible prevention methods (e.g., Brewin & Smart, 2005; Badawi et al., 2020; Engelhard et al., 2010; James et al., 2015). Memory consolidation is the process by which memory becomes less susceptible to disruptions with the passage of time (McGaugh, 2000; Walker et al., 2003). As intrusions most commonly consist of visual imagery (Ehlers et al., 2004), there are two relevant systems according to Baddeley's model of working memory (WM). The phonological loop, which processes auditory input and the visuospatial sketchpad processing visual and spatial input

(Andrade et al., 1997; Baddeley, 1986, 1998). These systems have limited capacity, so a secondary visuospatial task will compete for processing capacities. This in turn implies that consolidating visual imagery is affected by visual-dual tasks (Andrade et al., 1997). Additionally, co-occurring tasks are not only supposed to make processing more difficult but memories become less emotional and vivid (Andrade & Baddeley, 1993, as cited in Andrade et al., 1997; Engelhard et al., 2010).

Therefore, a proposed technique to possibly prevent the development of intrusions involves the use of challenging visuospatial tasks like the computer game Tetris (e.g., Badawi et al., 2020; Holmes et al., 2010; James et al., 2015, 2016) The game consists of differently shaped blocks that fall from the top to the bottom of the screen. The goal is to create horizontal lines by rotation of the individual blocks. As a result, the lines disappear and produce points. Due to the rotation of geometrical shapes under time pressure, it fulfills the requirements of a high demanding visuospatial task (James et al., 2015).

One of the first studies investigating Tetris in relation to intrusion development was conducted by Holmes et al. (2009). They used the trauma film paradigm as a validated experimental replacement for real-life trauma. This paradigm allows researchers to investigate the development of image-based intrusive memories without placing individuals under real trauma (Kessler et al., 2020). Participants watched a short film consisting of different clips showing blood, traumatic incidents, and death. Afterwards, individuals played Tetris for 10 minutes (Holmes et al., 2009). While the just perceived trauma film is being processed, playing Tetris competes for working memory capacities, thereby interfering with consolidation (Engelhard et al., 2010; Holmes et al., 200). The results show that playing Tetris after watching a traumatic film had a significant effect on the number and emotionality of intrusions experienced over a time frame of one week (Holmes et al., 2009).

Unsurprisingly, there has been increased attention concerning Tetris and its relation to experimental trauma considering the game's popularity (e.g., Engelhard et al., 2010; Holmes et al., 2009). However, to our knowledge there is no overview of studies investigating Tetris in relation to intrusions of trauma yet. Therefore, little is known about the currently available evidence and concomitantly how robust the Tetris effect truly is. Addressing this gap in the literature will allow us to draw further conclusions about Tetris possibly being an intervention approach for people experiencing trauma.

Literature Review

This thesis consists of two parts. The first part encompasses a literature review about Tetris and intrusions. For this, we complied with the PRISMA guidelines for reporting systematic reviews (Preferred Reporting Items for Systematic Reviews and Meta-Analyses; Paige et al., 2020). The literature review had the following objectives: First, identifying the number of studies available at present. Secondly, evaluating the results on the intrusion variables and whether an effect was found. By this, we aim to provide an extensive context for the second research part of this project, in which we replicate the study by Holmes et al. (2009).

Methods

Literature Search

First, relevant articles were gathered using concrete search terms. We searched PsychINFO and Scopus for studies investigating the Tetris effect. According to the PICO framework (Schardt et al., 2007), we used the search terms *Tetris* OR *computer game** to specify our intervention AND *intrusion** OR *intrusive memor** OR *flashback** specifying our outcome measure. The term computer game was added to identify articles that used games similar to Tetris. No search terms for the target population were used as we specified our population by age. A limit can be selected for this within the search options. Also, no particular comparison was specified, so no search term was needed.

We decided for PsychINFO as the leading and most complete bibliography for psychological science (APA, 2008) and we added Scopus to have a complimentary, multidisciplinary database (Elsevier, 2021). In Scopus, we selected the subject area 'psychology'. The field of the databases to be searched through was the title, abstract, subject heading, and author's keywords. The search date was January 12, 2022. The results were limited to present open access and full-text articles only. Additional papers were added by screening the references of included papers.

Inclusion Criteria

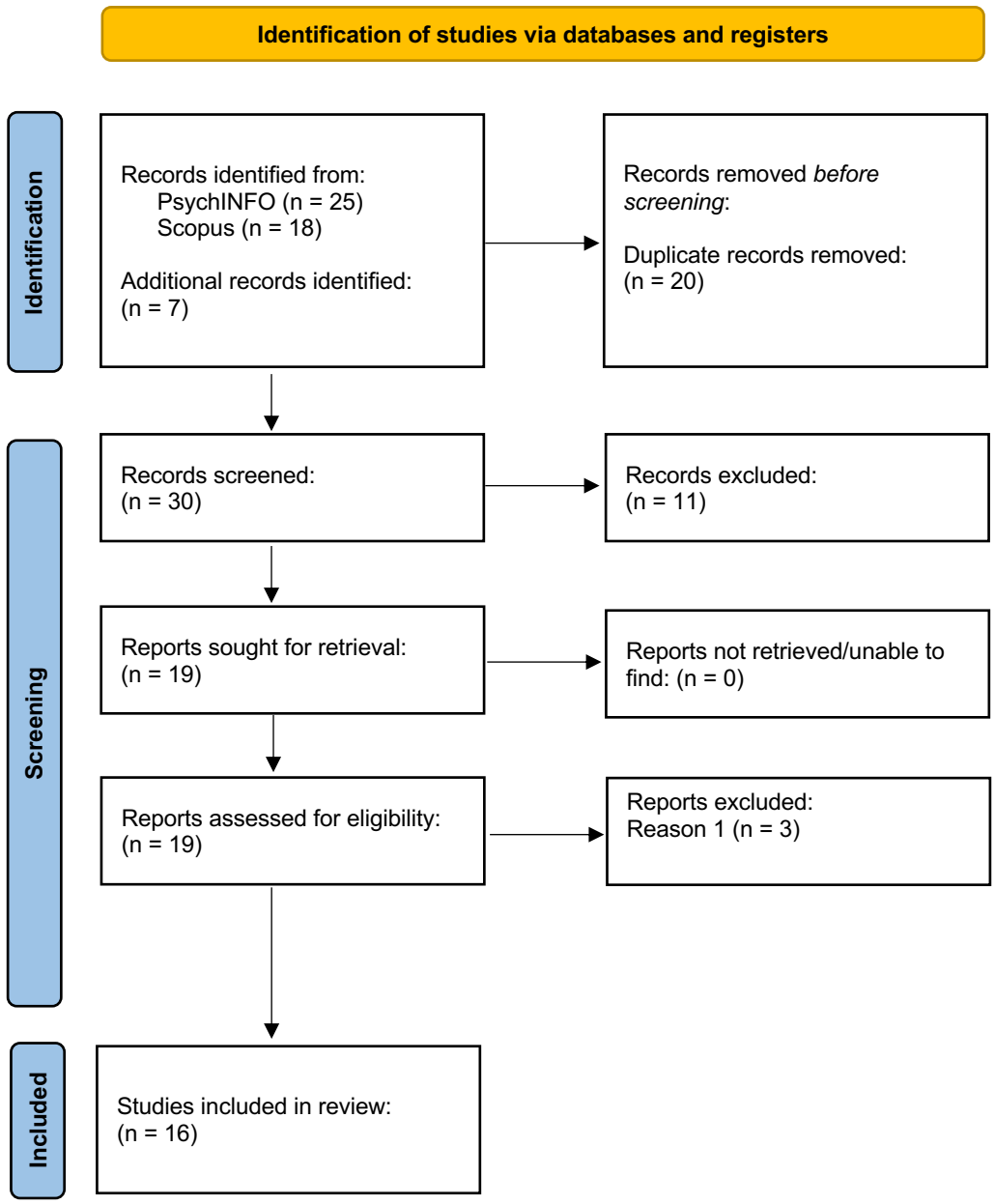
Our population was specified as adult samples of 18 years and older. We were interested in looking at non-clinical samples and individuals that experienced traumatic events. Tetris gameplay was defined as the main intervention. There was no specified comparison to Tetris that we were looking at. The outcome needed to be related to intrusion development and experience. Other inclusion criteria were English-written articles only. Publication needed to be since 2008 based on the fact that the study we are replicating in the second part was published in 2009. Thus, we wanted to include anything published since then. No filter to source or publication type was applied.

Search Results

The search for studies investigating Tetris and the relation to trauma with the mentioned keywords yielded 25 results in PsychInfo and 18 results in Scopus. After removing any duplicates, the title and abstract of the results were screened. Studies were removed if they did not suit the inclusion criteria. A flowchart with the selection process is presented in Figure 1. In line with our objectives, we identified how many studies actually investigated the Tetris intrusion relation. Further, we looked at the researchers, the sample size, and the control condition. Importantly, we evaluated the intrusion variables and the main findings.

Figure 1

PRISMA 2020 Flow Diagram



Note. From Page et al. (2020). Reason 1 = not in line with inclusion criteria. See Characteristics of excluded studies for further explanations.

Characteristics of Excluded Studies

Of the 19 reports assessed for eligibility, one was excluded as it was a commentary on the study by James et al. (2015), which is included (Ortiz de Gortari & Griffith, 2017). After the

assessment, two more studies were excluded: first, we excluded a neuroimaging study by Butler et al. (2020). The participants in their study received the Tetris as intervention. However, the main outcome was not intrusion-related but concerned the hippocampal volume. Secondly, the case study by Iyadurai et al. (2020) was excluded. Although the patient did experience PTSD symptoms her main diagnosis was bipolar disorder. Further, the game Tetris was delivered as a part of cognitive behavioral therapy. Since both reports were not clearly suiting the inclusion criteria, we decided to exclude them.

Results

To date (January 2022), there are 16 published studies investigating Tetris in relation to the frequency and development of intrusion experience. See Table 1 for an overview including the most important study characteristics and outcomes. The results show that the majority (13 studies) was successful in finding that Tetris influences intrusion experience. Only three studies did not find a significant effect of Tetris on intrusive memories (Asselbergs et al., 2018; Brühl et al., 2019; James et al., 2016).

Of the 16 included studies, 12 made use of the trauma film paradigm in non-clinical samples. Four studies included participants experiencing traumatic events in real life (emergency cesarean section, Horsch et al., 2017; motor vehicle accidents, Iyaduria et al., 2018; previous trauma of refugees, Holmes et al., 2017; Kanstrup et al., 2020). One of those was a feasibility study that assessed the acceptance of using Tetris in daily life in a sample predominantly from Syria (Holmes et al., 2017). A second study was a single case ABAB study design, including four refugees with previous trauma. Here, the development of intrusions during intervention and non-intervention phases was assessed (Kanstrup et al., 2020). Both studies found a reduction of intrusions in terms of frequency but no statistical analyses were reported.

In most of the studies, participants received the intervention within a time frame of six hours after watching the trauma film. However, Hagenaars et al. (2017), James et al. (2015), and

Kessler et al. (2020) found an effect of Tetris even when administered later (four, one, and three days, respectively). The study by James et al. (2016) was the only one having participants play the game prior to watching a trauma film, which did not result in a reduction of intrusions.

From the total number of studies identified, only four were independent of the original research group conducting the first study in 2009 (Asselbergs et al., 2018; Badawi et al., 2020; Brühl et al., 2019; Page & Coxon, 2017). For the majority of studies, the sample size lies within a range of 30 to 100. The smallest sample consists of four participants (Kanstrup et al., 2020) and the largest sample size is 120 (Asselbergs et al., 2018).

Conclusion

To conclude, there are currently 16 published studies investigating Tetris and related intrusion development with the majority finding significant results. Although this seems promising, most have used relatively small sample sizes and only a few studies do not belong to the original research group (Asselbergs et al., 2018; Badawi et al., 2020; Brühl et al., 2019; Page & Coxon, 2017). Findings can only limitedly be applied to clinical samples and long-term effects have not been investigated yet. So, although there is some literature on the topic of the game Tetris and PTSD symptoms available, further research is still needed.

Table 1

Study Characteristics and Outcomes

Reference	*N*	Conditions	Comparison	Intrusion variables	Reported test statistics	Main findings
J. Asselbergs, M. Sijbrandij, E. Hoogendoorn, P. Cuijpers, L. Olie, K. Oved, J. Merkies, T. Plooijer, S. Eltink & H. Riper (2018)	120	Trauma Gameplay resembling Tetris (*n* = 30) No task (*n* = 30) Recall only (*n* = 31) Dual task TGP (*n* = 29; lower difficulty with breaks)	Tetris – No task – Recall only – Dual task TGP	Total frequency across 1 week Image-based across 1 week VAS vividness ratings VAS emotionality ratings	$X^2(3) = 7.41$ ns $X^2(3) = 7.66$ ns F (3, 115) = 1.512 ns F (3,115) = 0.597 ns	No sign. difference of intrusion measures between conditions.
A. Badawi, D. Berle, K. Rogers & Z. Steel (2020)	100	Tetris (*n* = 32) No task (*n* = *34*) D-Corsi task (*n* = 34)	Tetris – No task Tetris – D-Corsi task	Frequency during task Total frequency across 1-week	X^2 (2) = 29.50*** *d* = 0.64**	Tetris condition reported sign. fewer diary intrusions than control & Corsi task.
A. Brühl, N. Heinrichs, E. E. Bernstein & R. J. McNally (2019)	71	Tetris (*n* = 24) Exercise (*n* = 24) No activity (*n* = 23)	Tetris – Exercise Tetris – No task	Frequency during task Total frequency across 1-week Associated distress Frequency during task Total frequency across 1-week Associated distress	$X^2(2) = 14.883$** *g* = 0.45 ns *g* = 0.44 ns $X^2(2) = 14.883$*** *g* = 0.14 ns *g* = 0.48 ns	Neither Tetris nor exercise had a sign. influence on diary intrusions or associated distress (only during task).
M. A. Hagenaars, E. A. Holmes, F. Klaassen & B. Elzinga (2017)	54	Tetris (*n* = 18) No task (*n* = 18) Word Game (*n* = 18)	Tetris – No task Tetris – Word Game	Change score (diary B – diary A) Frequency during task Change score	BF16 = 6.05 BFcu = 1.74 BF43 = 1.61	Reactivation of memory & intervention **after 4 days**. Tetris and Word Game led to fewer intrusions than no task.

E. A. Holmes, E. L. James, T. Coode-Bate & C. Deeprose (2009)	40	Tetris (n = 20) No task (n = 20)	Tetris – No task	Frequency during task Total frequency across 1-week Impact of events scale (IES)	$t_{(38)}$ = 2.50* $t_{(38)}$ = 2.87** $t_{(38)}$ = 2.47*	All three comparisons indicate fewer intrusions/lower impairment in the Tetris condition.
E. A. Holmes, E. L. James, E. J. Kilford, C. Deeprose (2010)	60	Tetris (n = 20) No task (n = 20) Pub Quiz (n = 20) *(Experiment 1)*	Tetris – No task Tetris – Pub Quiz	Frequency during task Total frequency across 1 week Total frequency across 1 week	F (2,57) = 3.69* d = .70* d = 1.21***	1.) Fewer intrusions for Tetris than PubQuiz and control. 2.) Fewer intrusions for Tetris than control; more intrusions for PubQuiz.
	78	Tetris (n = 26) No task (n = 26) Pub Quiz (n = 26) *(Experiment 2)*	Tetris – No task Tetris – Pub Quiz	Frequency during task Total frequency across 1 week Total frequency across 1-week	F (2,75) =5.25* d = .62* d = .70**	
E. A. Holmes, A. Ghaderi, E. Eriksson, K. O. Lauri, O. M. Kukacka, M. Mamish, E. L. James & R. M. Visser (2017)	17	Tetris on smartphone		Assesses feasibility (only count intrusions after intervention)	M = 12.65 (SD = 9.71)	Suggests that young refugees are willing to monitor symptoms & play Tetris.
A. Horsch, Y. Vial, C. Favrod, M. M. Harari, S. E. Blackwell, P. Watson, L. Iyadurai, M. B. Bonsall & E. A. Holmes (2017)	56	Tetris + usual care (n = 29) Usual care (n = 27)	Tetris + Usual care – Usual care	Total frequency across 1 week acute stress (re-experience subscale)	d = .647* d = .503 ns	Fewer intrusions in Tetris than control group after emergency cesarean section.

L. Iyadurai, S. E. Blackwell, R. Meiser-Stedman, P. C. Watson, M. B. Bonsall, J. R. Geddes, A. C. Nobre & E. A. Holmes (2018)	71	Tetris (n = 37) Attention-Placebo control (n = 34)	Tetris – Attention-Placebo control	Total frequency across 1-week IES (Intrusion subscale)	d = .67** d = .54*	Fewer intrusions in Tetris than placebo group after motor vehicle accident.
E. L. James, M. B. Bonsall, L. Hoppitt, E. M. Tunbridge, J. R. Geddes, A. L. Milton & E. A. Holmes (2015)	52	Tetris (n = 26) No task (n = 26) (*Experiment 1)*	Tetris – No task	Total frequency across 1 week Frequency during reminder (Day 7)	d = 1.14*** d = 1.05***	1.) Sign. fewer intrusions in the Tetris compared to control condition. 2.) similar findings as in exp. 1 with addition of the finding that Tetris + reminder to reactivate memory is necessary for finding an effect.
	72	Tetris (n = 18) No task (n = 18) Tetris without reactivation (n = 18) Reactivation only (n = 18) (*Experiment 2)*	Tetris – No task Tetris – Tetris without reactivation Tetris – Reactivation only	Total frequency across 1 week Frequency during reminder Total frequency across 1 week Frequency during reminder Total frequency across 1 week Frequency during reminder	d = 1.00** d = .97** d = .84* d = .085** d = 1.11** d = 1.31***	
E. L. James, A. Lau-Zhu, H. Tickle, A. Horsch & E. A. Holmes (2016)	56	Tetris (n = 28) No task (n = 28)	Tetris – No task	Total frequency across 1 week Frequency during reminder (Day 7)	d = .26 ns d = .13 ns	Could not find an effect (when Tetris is played prior to the trauma film).
M. Kanstrup, E. Kontio, A. Geranmayeh, K. O. Lauri, M. L. Moulds & E. A. Holmes (2020)	4	Tetris	Within-subjects design (ABAB)	A: nonintervention phase B: intervention week (memory reminder + Tetris)	Decrease of intrusions post-intervention given in Means	A single case ABAB withdrawal design; all participants reported decrease of intrusions.
H. Kessler, A.-C. Schmidt, E. L. James, S. E. Blackwell, M. von	86	Tetris (n = 28) Reminder only (n = 28)	Tetris – Reminder only Tetris – Reminder + Quiz game play	Post-intervention frequency (days 4-6)	d = 1.37***	Tetris delivered **3 days after trauma film** reduced intrusions compared to both control condition.

Rauchhaupt, K. Harren, A. Kehyayan, I. A. Clark, M. Sauvage, S. Herpertz, N. Axmacher, E. A. Holmes (2020)		Reminder + Quiz game play (n = 30)		Post-intervention frequency (days 4-6)	d = .65*	
A. Lau-Zhu, R. N. Henson & E. A. Holmes (2019)	46	Tetris (n = 23) No task (n = 23) *(Experiment 1)*	Tetris – No task	Total frequency across 1 week	d = .97**	Sign. fewer intrusion experiences in Tetris compared to control conditions across all 3 experiments.
	36	Tetris (n = 18) No task (n = 18) *(Experiment 2)*	Tetris – No task	Total frequency across 1 week Frequency during (vigilance) task; Day 8) Frequency during task; Day 1	d = 1.23*** d = .81* d = .96**	
	57	No-load condition (n = 19) Visuospatial load (n = 19) Verbal load (n = 19) (*Experiment 3)*	Tetris (engaged in a no-load, concurrent verbal or visuospatial load task)	Frequency during task; Day 1 No-load condition Visuospatial load Verbal load	d = 1.20*** d = .77** d = .86* d = .84**	
A. Lau-Zhu. R. N. Henson & E. A. Holmes (2021)	36	Tetris (n = 18) No task (n = 18)	Tetris – No Task	Frequency during (vigilance) task Total frequency across 1 week	d = .96** d = .73 ns	Sign. fewer intrusions in the Tetris group.
S. Page & M. Coxon (2017)	30	Tetris on desktop (n = 10) Tetris virtual reality (n = 10) No task (n = 10)	Tetris – No task Tetris – Tetris VR	Total frequency across 1 week IES Total frequency across 1 week IES	ns ns ** ns	Sign. difference found for the Tetris VR condition only (not Tetris on desktop) compared to control.

Note. ns > 0.05, *p ≤ 0.05, **p ≤ 0.01, ***p ≤ 0.001

Tetris Project

Based on the previous literature review, it seems that Tetris might be a promising and easy-to-implement intervention approach to counteract the development of intrusions. However, further research is clearly needed to confirm this idea. Interestingly, one of the studies included in the review (Brühl et al., 2019) investigated the effect of Tetris on intrusions with the addition of a comparison group doing aerobic exercise in form of cycling. No significant effect of either exercising or Tetris on intrusive memory was found (Brühl et al., 2019).

Physical Activity

In general, individuals who are regularly physically active are less likely to suffer the same mental illnesses as non-active individuals (Asmundson., 2013). Physical activity (PA) can be defined as "any bodily movement produced by skeletal muscles that requires energy expenditure. Physical activity refers to all movement including during leisure time, for transport to get to and from places, or as part of a person's work" (World Health Organization, 2020).

Oppizzi & Umberger (2018) looked at different types of PA and their relation to PTSD (e.g., yoga, vigorous strength training, aerobic exercises like cycling). It was found that physical activity affects PTSD symptoms like poor sleep patterns, cardiovascular health, depression, and anxiety (Oppizzi & Umberger, 2018; Rosenbaum et al., 2015). Apart from being linked to overall psychological well-being, exercising is also supposed to promote resilience against developing intrusions. Voorendonk et al. (2021) specifically looked at cardiorespiratory fitness (CRF) as an indicator of regular exercising. Results show that high CRF, so an increased level of fitness, indeed predicted a reduced development of intrusions after watching a trauma film (Voorendonk et al., 2021). So far, there is no consensus on the optimal type or duration of exercise. However, previous research consistently shows that

physical activity could be an effective complementary treatment for people with PTSD (Ley et al., 2017; Oppizzi & Umberger, 2018).

Several different mechanisms have been proposed for these findings (Voorendonk et al., 2021). First, some studies suggest that higher WM capacity is related to a more effective ability to suppress intrusions. In addition, increases in cardiorespiratory fitness or PA was found to be associated with improved cognitive control of working memory (Kamijo et al., 2012; Mackenzie et al., 2016). Hence, physical activity might help against the emerge of intrusive thoughts by improving WM capacities (Brewin & Beaton, 2002; Brewin & Smart, 2005).

Secondly, it has been proposed that physical activity might imply a distraction mechanism (Voorendonk et., 2021). Namely, exercising should help the individual to focus on the present moment and to fully emerge in the situation. Thereby shifting the focus away from arousal and intrusive thoughts or even preventing intrusions to come up (Ley et al., 2017, 2018). In a similar vein, a previous study investigating intrusions in an ADHD population found several benefits of physical activity (Abramovitch et al., 2013). For example, patients who frequently engaged in aerobic exercises reported less worrying and sadness about intrusive thoughts. Also, less difficulty with detaching from intrusions as well as fewer anxious intrusive thoughts were found in total (Abramovitch et al., 2013).

Although it seems that physical exercises may be associated with intrusive memories, previous findings are mixed and limited (Brühl et al., 2019; Rosenbaum et al., 2015; Ley et al., 2017). Therefore, physical activity needs to be further investigated in order to elucidate whether an actual relation exists. Both, the relation of Tetris and physical activity to intrusive memories remain interesting.

Current Study

To summarize, the visuospatial game Tetris seems to be a promising intervention approach but no final conclusion about the actual effect can be drawn yet. As there is still a need for immediate treatment for people experiencing trauma (Holmes et al., 2009) the replication will add important knowledge to the existing literature. By further exploring the Tetris effect, the aim is to help finding accessible and cost-effective approaches for risk groups like refugees or firefighters. Previously, PA has been used as a comparison condition to Tetris. However, the findings were not in line with previous significant results that suggested to include PA as an adjunctive treatment for PTSD patients (Brühl et al., 2019; Rosenbaum et al., 2015). As it seems that the current evidence is mixed physical exercise remains a promising and cost-efficient intervention method that needs to be further explored (Abramovitch et al., 2013). By including this additional variable PA, previous findings will be extended.

Based on the above-mentioned reasoning and in consideration of the preceding literature review, the following research question emerged: What is the relation of playing Tetris or physical activity on intrusion development after watching a distressing trauma film? Tetris is supposed to strain WM capacities and thereby impacts the development and experience of intrusion (Engelhard et al., 2010; Holmes et al., 2009). PA supposedly improves WM performance, which has found to allow for suppressing of arising intrusive thoughts. (Kamijo et al., 2021; Mackenzie et al., 2016). Additionally, the execution of physical activity should distract the individual from intrusions by increasing the focus on the present moment (Voorendonk et., 2021). If Tetris indeed has an effect on intrusions this could possibly prevent a relation between PA and intrusion development to emerge. So, a possible relation might be found in the control condition which would be absent in the experimental condition.

Therefore, it appears interesting to explore whether these correlations actually differ between the two groups.

To investigate this, we conducted an online study. Participants filled in various questionnaires and watched a 12-minute trauma film. Afterwards, the experimental condition played Tetris for 10 minutes. The number of daily intrusions was recorded in a diary for one week after which participants returned for a follow-up session. During this meeting physical activity of the previous seven days was assessed by self-reports. We hypothesize that participants playing Tetris after watching a distressing trauma film will experience fewer intrusions in comparison to the control condition (Holmes et al., 2009). Further, we hypothesize that an increased frequency of self-selected PA is related to a fewer number of intrusions (Oliveira et al., 2015). Lastly, we hypothesize a stronger negative correlation between PA and intrusions in the control condition compared to the correlation in the Tetris condition. If there is a significant difference between the two correlation coefficients, this might be a lead for further research.

Methods

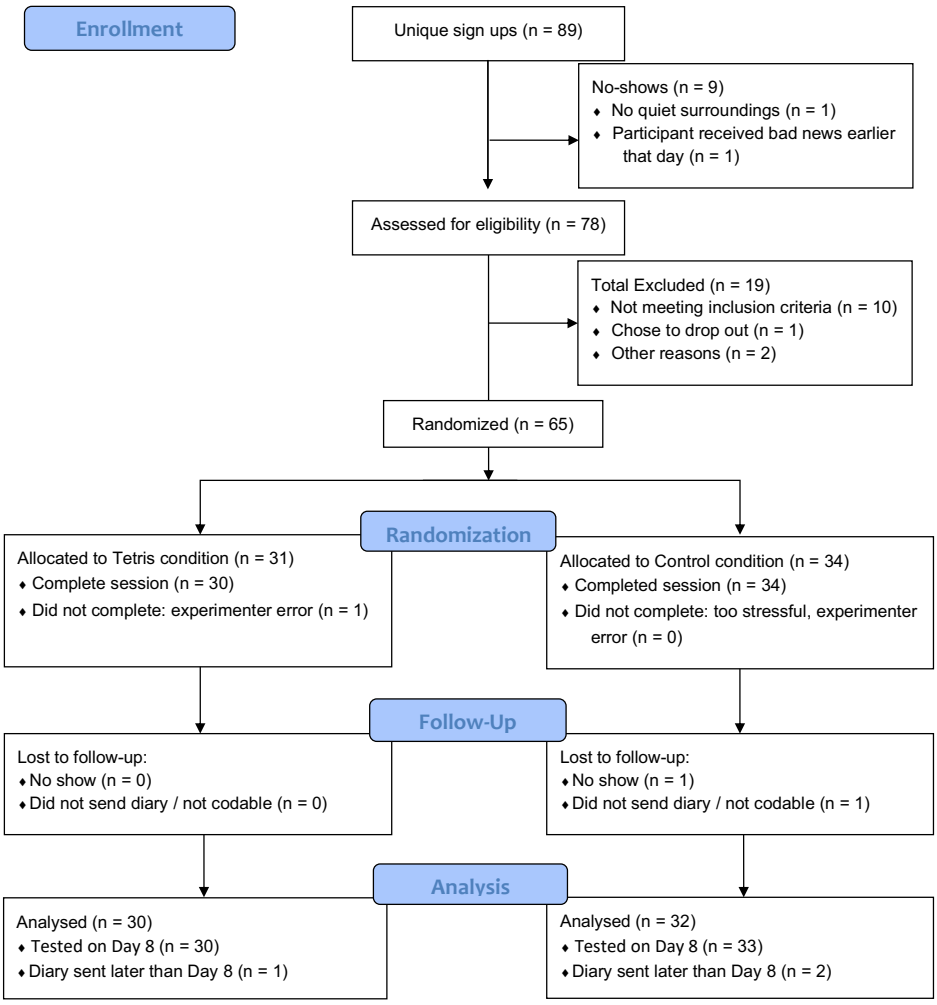
Participants

Before conducting the study, ethical approval was obtained. The final sample consisted of 62 undergraduate psychology students from the University of Groningen, participating in exchange for course credits. Recruitment took place through the university's digital participants pool SONA (http://rug.sona-systems.com/). The age range was 18 to 26 years (M_{age} = 20.32, SD = 1.85). Our analyzed sample consists of 44 females (71 %, m_{age} = 20.11, SD = 1.79) and 18 non-females (29 %, m_{age} = 20.83, SD = 1.85). Whereas the experimental condition (n = 30, M_{age} = 20.30, SD = 1.97) consists of 22 females (73.3 %) and 8 non-females (26.7 %), 22 females (68.8 %) and 10 non-females (31.2 %) were placed into the control condition (n = 32, M_{age} = 20.34, SD = 1.75). The majority of participants are either

Dutch (n = 40, 64.5 %) or German (n = 9, 14.5 %) but further 11 nationalities are included. See Figure 2 for the participant flow.

Figure 2

Participant Flowchart



Note. Adapted from CONSORT Flow Diagram.

A Priori Analysis

We aimed to detect a large effect size of Cohen's d = .91 as was found by Holmes et al. (2009). The conducted a priori power analysis (G*power v3.1.3; Faul et al., 2009) revealed

that a total of 72 participants was needed with power of 95% and an adjusted one-tailed alpha of 0.0167 for three dependent variables. The current study is part of a larger, international research project consisting of six university sites replicating the previous study by Holmes et al. (2009). Accordingly, it is aimed to reach a total combined sample of 432 participants. See the following link for the preregistration: https://osf.io/64fuw/?view_only. The data collected in Groningen reached the desired sample size. However, for the current thesis data was analyzed before the data collection finished due to time constraints.

Material

The experiment took place within three sessions. Session 1 consisted of screening questionnaires and was immediately followed by session 2 if eligibility criteria were met. Session 3 as follow-up took place exactly seven days after session 1 and 2. All of the questionnaires and the trauma film were presented via Qualtrics (November 2021 [computer software]. Provo, Utah, USA: Qualtrics).

Session 1 (Screening)

Screening Questionnaires. The Quick Inventory of Depressive Symptomatology (QIDS-SR; Rush et al., 2003) is a self-report measure for depressive symptoms. It consists of 16 items with answers given on a 4-point scale. Participants were excluded if their total score was 11 or higher from a total range of 0 to 27. The Trauma Screening Questionnaire (TSQ; Brewin et al., 2002) consists of 10 items measuring traumatic stress reactions. Answers were given as “Yes” and “No” responses and referred to experiencing any of the reactions at least twice the previous week. From a possible total of 10, participants were excluded if a score of six or higher was reached. Demographics were collected by asking for participants’ age, nationality, and gender identification.

Session 2

Mood Scales. Visual analogue scales (VAS) as pre- and post-mood measures were created within Qualtrics. Participants rated their emotional responses using six slider scales. The label "Right at the moment I am feeling" should indicate the extent to which individuals feel "sad", "hopeless", "fearful", "horrified", "anxious", or "depressed". Sliders could be moved from 0 (*not at all*) to 100 (*extremely*).

Trauma Film. The trauma film consists of 11 different scenes, containing both acted or real-life footage. In total, the clip takes 12:08 minutes and portrays blood, accidents, death, and interpersonal violence. As an example, one scene shows how a girl gets raped in a whirlpool. Instructions explained to not watch the clips film like a regular film but instead to pay close attention and imaging being there as a bystander (see Appendix A for complete instructions). The viewing time was recorded within Qualtrics, to check whether participants indeed watched the complete film.

Film ratings include: "How stressful did you find the film you just watched?", "How much attention did you pay to the film you just watched?", "To what extent did you close your eyes or look away during the film you just watched?" (James et al., 2015). Sliders can be moved from 0 (*not at all*) to 100 (*extremely, total attention, during the whole film,* respectively).

Filler & Reminder task. The filler task persists of 15 different excerpts of classical music that had to be rated for pleasantness (James et al., 2015). The numbers 1 (*not pleasant at all*) to 10 (*extremely pleasant*) were presented as answer options. The aim of the filler task was to create extra time after watching the trauma film to reflect real-life application (Holmes et al., 2009). The Reminder task presented fragments in form of still images from the trauma film (adapted from James et al., 2015). Each picture was shown for three seconds in the same

order as in the movie. The aim was to make it apparent, which scene the photo refers to without presenting the graphic details of it (see Appendix B for an example).

Tetris. The randomization to the experimental and control group occurred in Qualtrics. In the experimental condition, participants played the visuospatial game Tetris for 10 minutes (special research version, Tetris Company Inc., 2021). Instructions on how to play the game emphasized the goal to make as many lines as possible disappear. For this, it was explained to visually imagine how to best rotate and place the current block and also to focus on the next three blocks being previewed. To increase participants' engagement, they were told beforehand to report their high score in the end.

Control. In the control condition, an adapted version of the perceptual vigilance task was performed for 10 minutes (Wilkinson & Houghton, 1982). Participants pressed the spacebar as soon as possible when a red circle appeared in the center of the black screen. This happened in different intervals between 10 to 30 seconds. A total of 20 dots were presented during the whole task. To increase participants' engagement, they were told beforehand to report their high score in the end.

Initial Intrusions & Task Difficulty. In both conditions, the high score and retrospective ratings were entered: "How often did mental images of the film spontaneously pop into your mind while playing the game?" was answered with a slider scale from 0 (*Not at all*) to 100 (*The whole time*). Secondly, "How difficult or easy did you find the game you just played?" and the slider scale from 0 (*Not difficult at all/easy*) to 100 (*Extremely difficult/hard*) was presented.

Diary. The daily intrusion diary is a word file containing tables divided into morning, afternoon, and evening/night. The content and form of intrusion (verbal thought, image, combination) had to be noted (adapted version from James et al., 2015). The Involuntary Memory Diary Checklist (Badawi et al., 2020) consists of eight items (e.g., "I understand that

an intrusion is an involuntary memory that pops into my mind without me expecting it, and that the memory may be an image or a verbal thought"). Statements could be answered with "Yes" or "No".

Session 3 (1-Week Follow-Up)

Diary Compliance. Assessment of diary compliance included the questions (James et al., 2015): "To what extent is the following true: I have been unable (or forgotten) to record my unpleasant thoughts and images in the diary." and "Please indicate how accurate you think the diary you completed is." Answer options as rating scales ranged from 0 (*Not at all true for me/Not at all accurate*) to 100 (*Extremely true for me/Extremely accurate*, respectively).

The Impact of Movie Scale (IMS; James et al., 2015) was used to assess difficulties participants may have experienced after watching the trauma film. It consists of 22-items (e.g., "I thought about the film when I didn't mean to.") and a 5-point Likert scale from 0 (*Not at all*) to 5 (*Extremely*). A total score is calculated by summing the 22-items.

Physical Activity. The International Physical Activity Questionnaire (IPAQ – Short Form; Craig et al., 2003) was used to assess physical activity for the duration of the previous week. It consists of seven open-ended questions referring to walking, moderate- and vigorous-intensity activities (e.g., "During the last 7 days, on how many days did you do vigorous physical activities like heavy lifting, digging, aerobics, or fast bicycling?"). Answer options referred to time spent in minutes or hours to compute a total physical activity score. As a third answer option participants could select "Don't know/Not sure". The IPAQ-SF has a high test-retest reliability. ($\alpha < .80$; see Appendix C for complete IPAQ).

Procedure

Participants signed up for different time slots within the university's SONA system platform. The experiment took place online using Google Meets sessions on two separate days with one week in between (https://meet.google.com/). To convey all information as

equally as possible the experimenters followed a scripted protocol. Participants were explicitly informed about the distressing nature of the film material before written consent was collected. We emphasized that participation can be terminated at any point without negative consequences if the trauma film is unbearable. The research information and informed consent were provided as downloads before demographics and screening questionnaires were completed.

The first meeting consisted of two sessions, with the second subsequently following the screening if the student was eligible for participation. While the experimenter checked for eligibility, participants answered further questions. Next, all participants played a three minutes practice trial of Tetris to get familiar with the game. Afterwards, they indicated their current mood on the pre-film measure and read the instructions on how to watch the trauma film. Participants were asked to turn off the lights or close the curtains and to remove any possible distractions while watching the film. After the film sequence, the film ratings and the filler task followed by the reminder task were completed. Subsequently, participants were randomly assigned to the experimental (Tetris) or the control condition (perceptual vigilance task). The links and the login data were sent through the chat window and participants then played Tetris or the perceptual vigilance task. Afterwards, both conditions indicated their initial intrusion experience during the games and the film ratings.

At the end of session two, the experimenter explained what an intrusion is and how to use the diary to record any intrusions experienced for the following seven days. To assure that everything was understood, the diary checklist was provided. Every morning at 8:00 a.m. participants received an e-mail as a reminder to report daily intrusions. During session three, the complete diary was received, diary compliance was checked and the retrospective intrusion measures were assessed. Lastly, the IPAQ-SF to record physical activities of the

previous week and some other exploratory questionnaires were given. Participants were adequately debriefed and thanked for participating.

Data Analysis

Data Preparation

The first part of the analysis consisted of preparing the data. This involved checking each diary and noting the exact number of intrusions into a separate excel file. An inter-rater reliability assessment was conducted and discrepancies were resolved. A list of random ID codes was created online (https://www.random.org/integers/) and entered into a separate excel file. Copies of the diaries were created, in which the participant numbers were replaced by random ID codes to protect personal data. The information collected on Qualtrics was exported into SPSS files and had to be merged. We manually checked whether each participant had one complete record of data only. If this was not the case, we had to either remove incomplete rows, merged answers that belonged to the same participant, or adjusted otherwise accordingly. To make sure that no important information is lost by accident, we created copies of every file. After running descriptives for demographics, the participant and SONA numbers were removed and the random ID codes were entered instead.

T-Tests

We used an experimental between-subjects design with the conditions as factor variable (Tetris vs. active control) and the different intrusion measures as outcome variables. To test our hypotheses that participants in the Tetris condition would experience fewer intrusions and associated distress, we performed three separate independent *t*-tests. For this, we first tested the assumption of normality by creating histograms of each dependent variable. To check for influential outliers, we created boxplots. Outliers are defined as scores above or below the 1.5 interquartile range.

Next, we assessed possible between-group differences on the intrusion measures (continuous outcome variables): initial intrusion rating, diary intrusions (image-based), and retrospective impact of intrusions across the categorical predictor variable condition (Tetris vs. control). The initial intrusion ratings are the frequencies of intrusions experienced while playing Tetris or performing the control task. The diary intrusions will be a calculated total score of image and image-thought combinations entered in the diaries and the retrospective measure will be the sum score of all IMS items.

Physical Activity

According to the IPAQ scoring protocol, values of 15, 30, 45, 60, and 90 entered as hours should be corrected into the minutes column to ensure that responses were not entered incorrectly by mistake (https://sites.google.com/site/theipaq/scoring-protocol). Accordingly, participants that selected the answer option "Don't know/Not sure" for either vigorous, moderate, or walking activity needed to be excluded for the following analysis. We tested for influential outliers the same way as for the *t*-tests. For the assumptions of linearity and normality, we created a scatter plot using total physical activity and total diary intrusions (image- and thought-based). The diary intrusions will be a calculated total score of thoughts and image-based intrusions entered in the diaries.

To test our hypothesis that physical activity negatively correlates with intrusions from the diary (total diary intrusions, continuous outcome variable), we run a Pearson's correlation. Total PA (continuous predictor) will be expressed as calculated MET-minutes (metabolic equivalent task) per week. Based on Craig et al. (2003), the total physical activity MET-minutes per week is the sum of walking, moderate, and vigorous MET-minutes/week score.

Lastly, we compared the correlation between PA and diary intrusions (image-based) in the Tetris condition with the correlation between PA and diary intrusions (image-based) in the control condition. For this, we run two more Pearson's correlations and transformed the

correlation coefficients into *z* scores for comparison; this was be done online (Lenhard & Lenhard, 2014). All other analyses were performed using SPSS.

Statement of Transparency

This thesis is part of an international, preregistered research project replicating the study by Holmes et al. (2009). Prior to data collection, the complete study set up including the hypotheses, methods, and analysis plan were uploaded to the Open Science Framework (https://osf.io/64fuw/?view_only). In the following, important deviations from this preregistration are mentioned.

We anticipated to collect a total sample of at least 72 participants for each research site according to the a priori analysis. This number was reached. However, due to time constraints, data for the current thesis was analyzed before data collection terminated. This results in a sample of 62 for the current thesis. A daily reminder was sent to the participants via email, which states: "Dear participant, Thank you again for participating in our study! This is a friendly reminder to please report any intrusions you may experience into your diary today. Sincerely, Research team". This deviates from the preregistration, which originally stated: "Don't forget to complete your diary today."

Results

Viewing Time, Film Ratings, Diary Compliance

The mean scores of viewing time, film ratings, and diary compliance can be found in Table 2. In total, similar mean ratings for viewing time, film ratings, and accuracy of diary completion were found for the two conditions. None of the participants' viewing time was shorter than the duration of the total film clip (728 seconds). An exploratory *t*-test was run to control whether the difference of task difficulty is statistically significant. Participants in the Tetris condition rated the game as more difficult ($m = 28.43$, $SD = 17.57$) than participants rated the vigilance control task ($m = 16.53$, $SD = 15.27$), $t(60) = 2.84$, $p = .00$, $d = .73$.

Table 2

Mean Scores of Film Viewing Time, Film Ratings, and Diary Compliance for Each Condition

Measures	Tetris (n = 30)		Control (n = 32)	
	m	*SD*	*m*	*SD*
Viewing time of film	763.65	60.27	775.40	84.57
Distress resulting from film	59.90	21.91	57.19	23.68
Attention during film	93.97	8.65	95.34	6.69
Closed eyes/ looking away during film	8.20	11.94	5.97	7.18
Task difficulty	28.43	17.57	16.53	15.27
Being unable/ forgotten to record intrusions	9.57	15.84	12.69	18.19
Diary accuracy	84.40	11.29	85.72	10.00

Intrusion variables

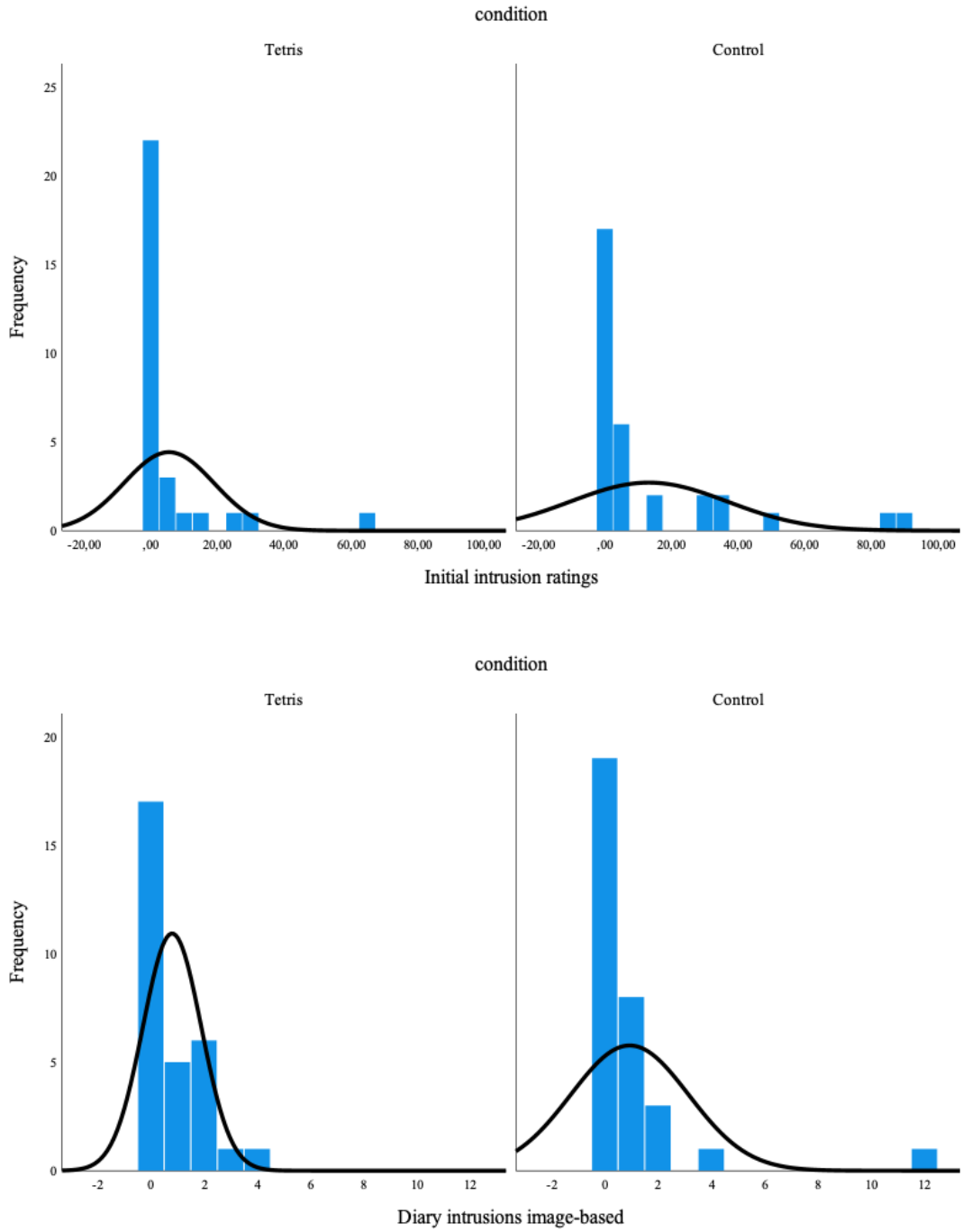
Preparation and assumption testing

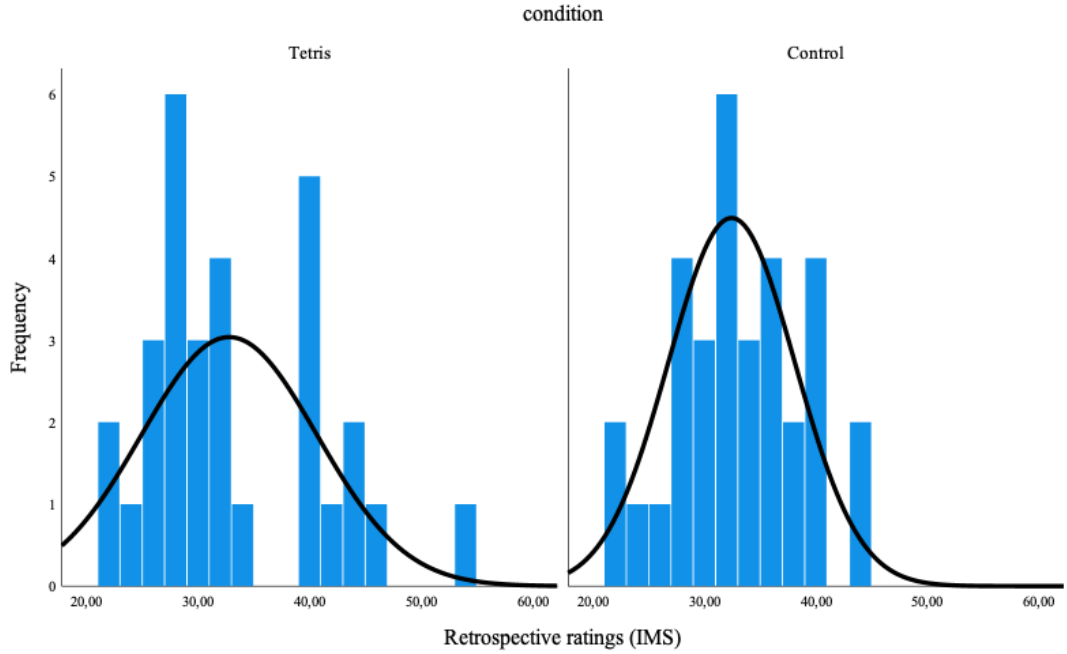
We identified 14 influential outliers. (10 for initial intrusion ratings and four for image-based diary intrusions). As visible in Figure 2, three participants returned for session three but sent their diaries days later. These cases were distinguished through an exclusion code variable. For the sake of readability, we refer to a strict exclusion code when these cases are excluded and to a non-strict exclusion code when these cases are included. We ran the following analyses with a strict and non-strict exclusion code as well as excluding and including outliers. No striking differences were found in the results. Therefore, the following analyses and findings are presented with a non-strict exclusion code and including outliers (N = 62). Next, we tested for the assumption of normal distribution of the dependent variables (see Appendix D for the results using a strict exclusion code and excluding outliers). The

histograms in Figure 3 indicate this assumption is violated. The values of retrospective ratings in the control condition came closest to normal (skewness = .05, kurtosis = -.53). The *t*-tests are still conducted to replicate the study of Holmes et al. (2009).

Figure 3

Histograms of the Three Dependent Intrusion Variables per Condition





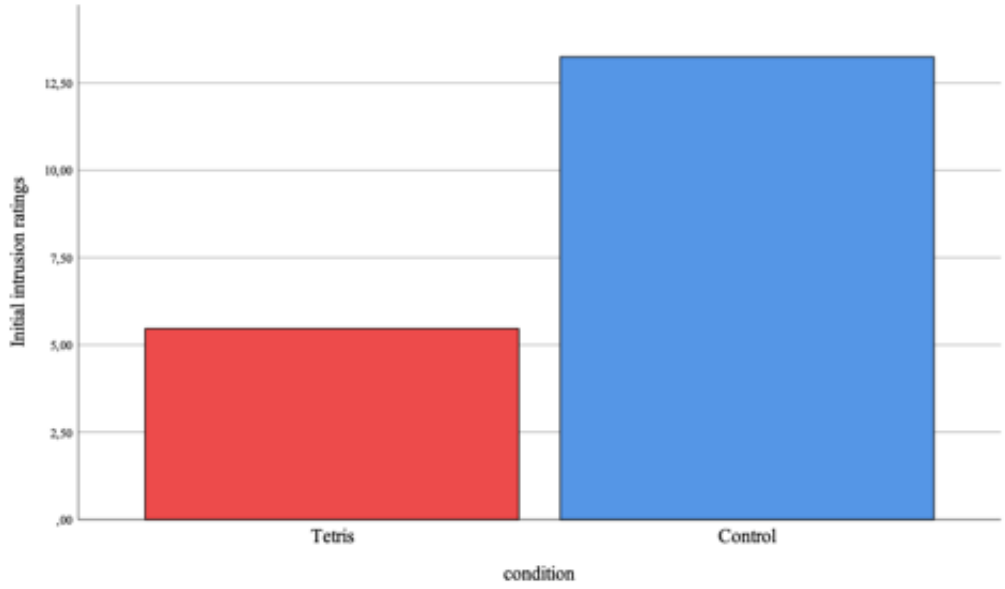
Note. Testing for normal distribution for each dependent variable per condition (N = 62, non-strict exclusion code and including outliers).

T-tests

The hypotheses that the three intrusion ratings are lower in the Tetris than in the control condition were tested. See Figures 4-6 for the mean differences of each analysis (see Appendix E for the results using the strict exclusion code and excluding outliers). The results of the *t*-tests indicate that there was no statistically significant difference of initial intrusions between the Tetris (m = 5.47, SD = 13.53) and the control condition (m = 13.25, SD = 23.56), $t(60) = -1.61$, $p = .06$, $d = -.40$. Secondly, there was no statistically significant difference of image-based diary intrusions between the Tetris (m = 3.47, SD = 4.14) and the control condition (m = 4.22, SD = 4.65), $t(60) = -.67$, $p = .25$, $d = -.17$. Lastly, the ratings of the retrospective impact of intrusions (IMS) in the Tetris condition (m = 32.80, SD = 7.88) were statistically not significantly different from the vigilance control task condition (m = 32.44, SD = 5.69), $t(60) = .21$, $p = .42$, $d = .05$.

Figure 4

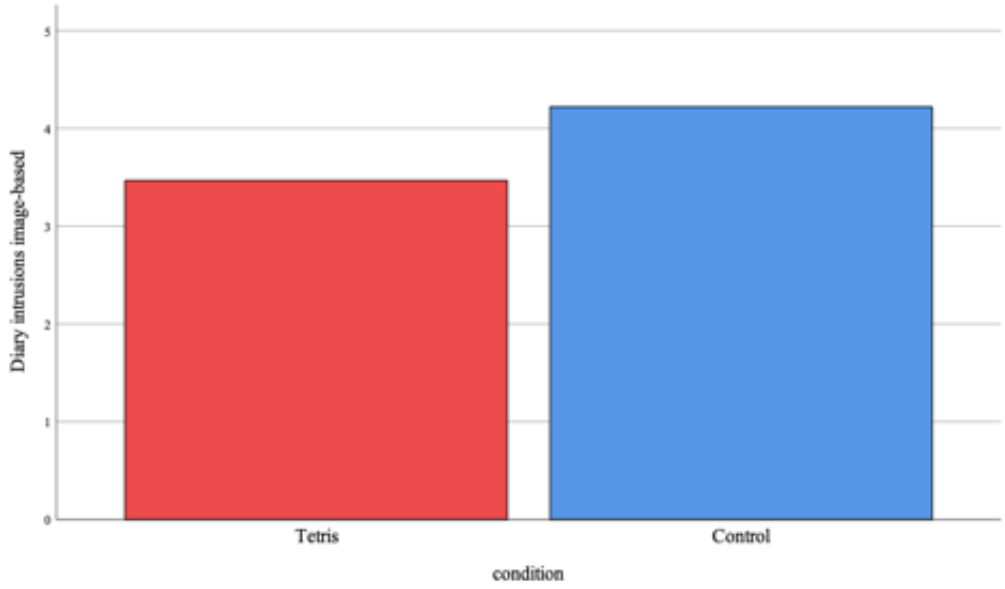
T-Test: Initial Intrusion Ratings



Note. Mean frequency of initial intrusion ratings during the tasks compared between the two conditions.

Figure 5

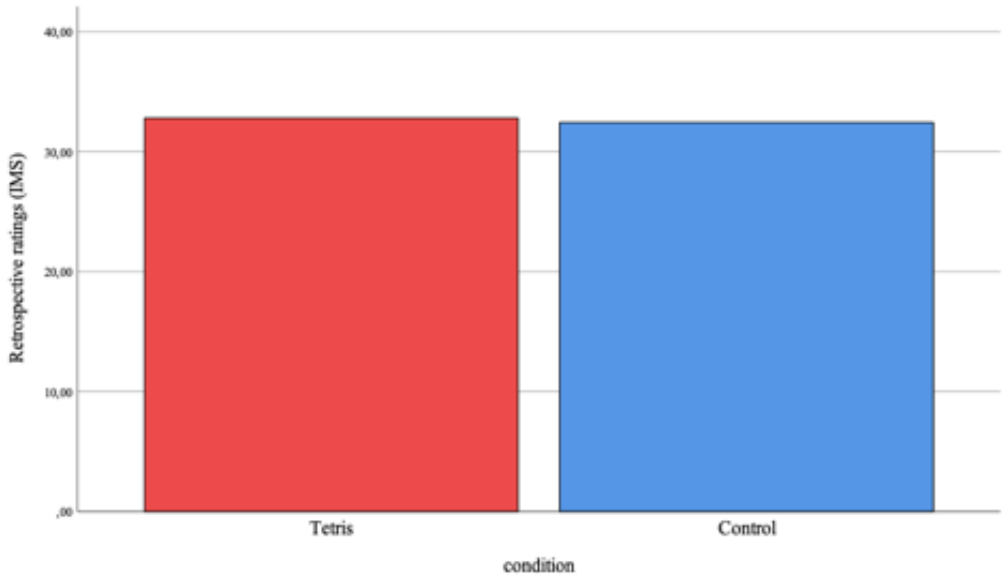
T-Test: Diary Intrusions Image-Based



Note. Mean frequency of image-based diary intrusions compared between the two conditions.

Figure 6

T-Test: Retrospective Ratings (IMS)



Note. Mean frequency of retrospective ratings (IMS) compared between the two conditions.

Mann-Whitney U test

As mentioned before, the assumption of normality has been violated. Therefore, an additional non-parametric Mann-Whitney U test was run. The results did not yield statistically significant differences across the three intrusion measures. Initial intrusions in the Tetris condition *(Mdn* = 0.00) were numerically lower than in the control condition (*Mdn* = 2.00, $U(n_{Tetris} = 30, n_{Control} = 32) = 585.00$, $z = 1.58$, $p = .11$). Imaged-based diary intrusions were numerically higher in the Tetris condition (*Mdn* = 3.00) than in the control condition (*Mdn* = 2.50, $U(n_{Tetris} = 32, n_{Control} = 30) = 531.00$, $z = .73$, $p = .47$). Lastly, retrospective impact ratings were also numerically lower in the Tetris condition (*Mdn* = 30.50) than in the control condition (*Mdn* = 32.00, $U(n_{Tetris} = 30, n_{Control} = 32) = 502.50$, $z = .318$, $p = .75$).

Physical activity

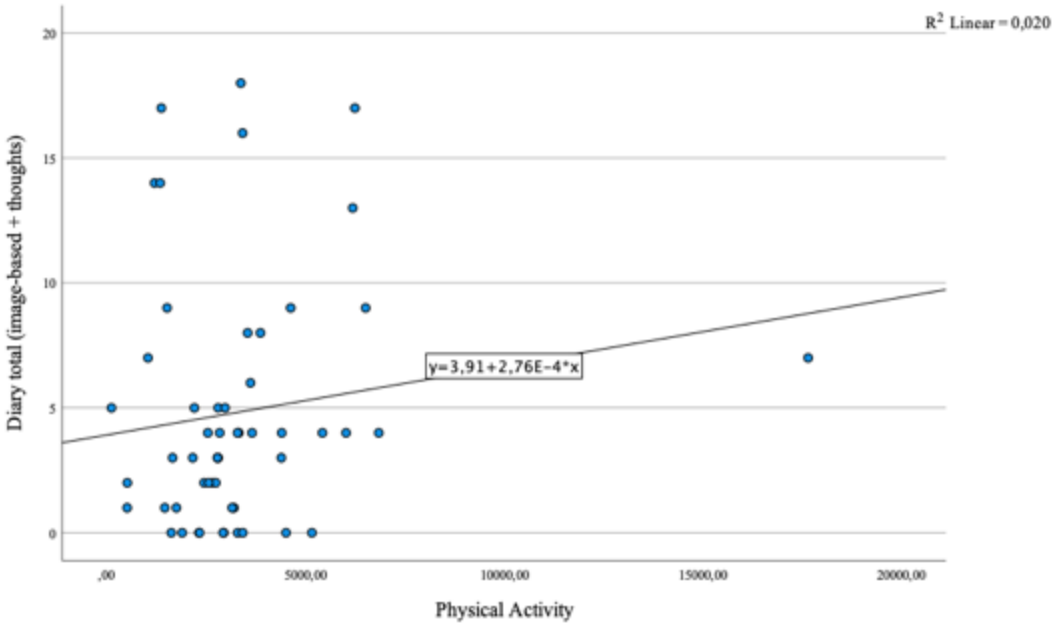
Preparation and assumption testing

First, the answers of the physical activity questionnaire were checked. A correction was done for nine participants, changing their values from hours to minutes (as indicated in the scoring protocol). One participant indicated during testing to have entered an incorrect answer by mistake. The correct answer was noted and changed manually as well. Further, eight participants selected the answer "Don't know/Not sure". These participants were excluded from the following tests.

Two influential outliers of PA and four of total diary intrusions (image- and thought-based) were identified, which accordingly shift the correlation. Both results are presented; using a non-strict exclusion code and including outliers ($N = 54$), as well as the strict exclusion code and excluding outliers ($N = 45$). The relationship between the two variables (total PA and total diary intrusions) was not normally distributed (see Figure 7 and Figure 8). Thus, the data of physical activity was transformed by taking its square root. These transformed variables are used for the Pearson's correlation.

Figure 7

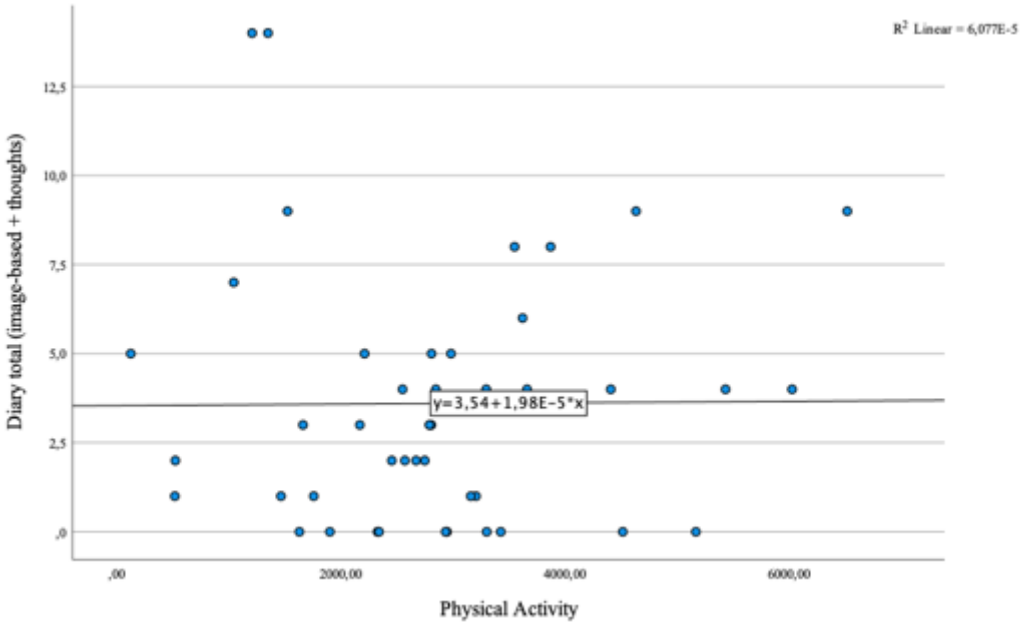
Relationship Between Total PA and Total Diary Intrusions (Image- and Thought-Based)



Note. Non-strict exclusion code and including outliers.

Figure 8

Relationship Between Total PA and Total Diary Intrusions (Image- and Thought-Based)



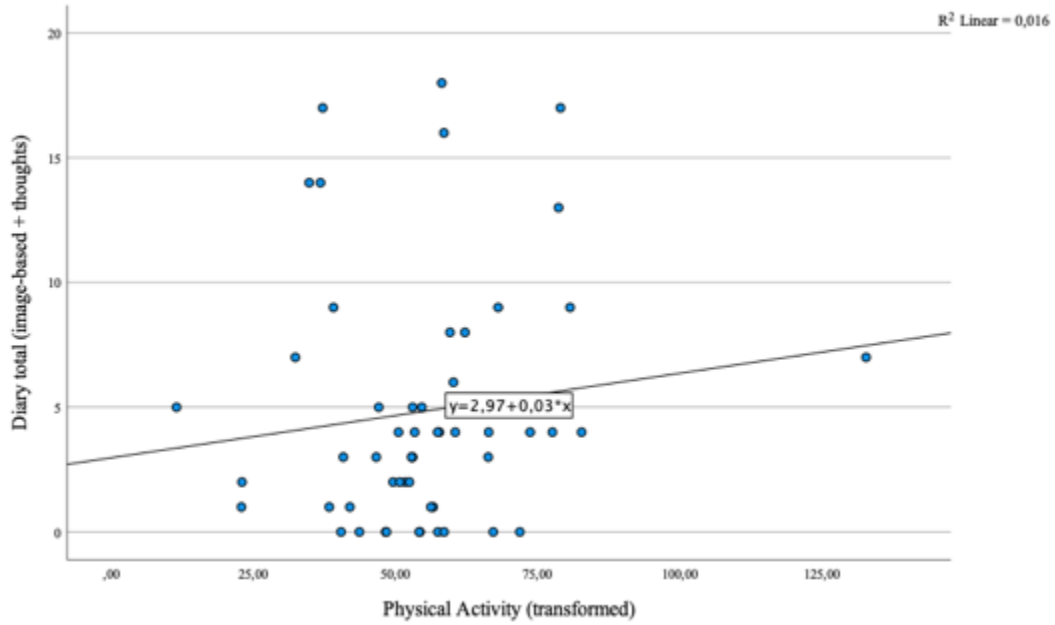
Note. Strict exclusion code and excluding outliers.

Pearson's Correlation

A Pearson product-moment correlation was conducted to test the hypothesis that an increased frequency of self-selected PA is related to a fewer number of intrusions over a one-week period (see Figure 9). There was a weak, positive correlation, which was statistically non-significant ($r(54) = .13$, $p = .18$). This correlation was repeated, using the strict exclusion code and excluding outliers of both variables (physical activity and total diary intrusions, see Figure 10). There was a weak, negative correlation, which was statistically non-significant ($r(45) = -.03$, $p = .41$).

Figure 9

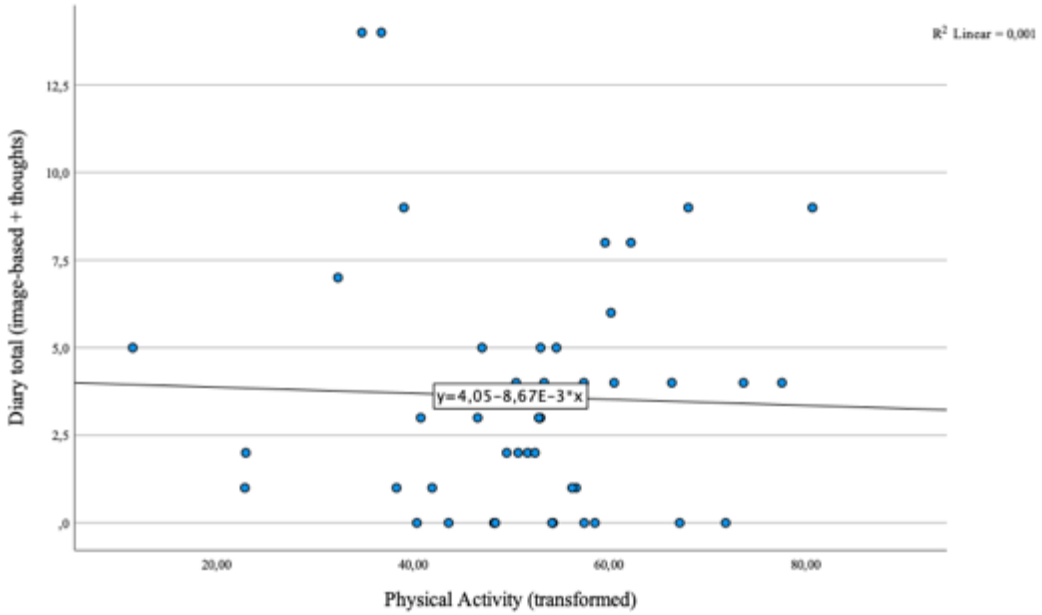
Scatterplot of Total PA and Total Diary Intrusions (Image- + Thought-Based)



Note. Physical Activity in MET-minutes (transformed by its square root). Non-strict exclusion code and including outliers.

Figure 10

Scatterplot of Total PA and Total Diary Intrusions (Image- + Thought-Based)



Note. Physical Activity in MET-minutes (transformed by its square root). Strict exclusion code and excluding outliers.

Comparison of Correlations

Two more Pearson's correlations were run to determine the association between PA (transformed) and diary intrusions (image-based) in the Tetris condition as well as between PA (transformed) and diary intrusions (image-based) in the control condition. This was done using the non-strict exclusion code and including outliers only. Both correlations were statistically nonsignificant. Whereas the first was a weak, negative correlation ($r(27) = -.15$, $p = .24$), the second correlation was weak and positive ($r(27) = .21$, $p = .15$), respectively. A z-test was performed to test for the difference between the two correlations, which was also statistically non-significant ($z = -1.24$, $p = .11$).

Discussion

To summarize, we tested whether the simple intervention approach of playing Tetris for 10 minutes after experimental trauma would influence the development and experience of intrusions in comparison to an active control condition. We hypothesized that participants who played Tetris after watching a distressing trauma film will experience fewer intrusions in comparison to the control condition. Contrary to expectations, both the parametric and non-parametric tests did not yield any significant differences for either of the three intrusion measures across the two conditions. Numerically, the mean scores for the initial intrusions experienced during the tasks and the total number of image-based diary intrusions were smaller in the Tetris than in the control condition. However, the effect sizes for these differences were small. Therefore, we could not reject the hypothesis that intrusion development and experience is the same for participants playing Tetris or a control task.

The results of our physical activity correlation are not in line with our hypothesis that an increased frequency of self-selected PA is related to a fewer number of intrusions. A positive and weak correlation was found, which slightly shifted into a negative and weak correlation after removing outliers. Both of these correlations were statistically non-significant. This implies that we could not reject the hypothesis that physical activity and intrusive thoughts are unrelated. Further, we compared the two relations between PA and diary intrusions in the Tetris condition and within the control condition. We found no significant correlation within the Tetris nor in the control condition. Similarly, the z-test comparison found no statistically significant difference between the two correlations. As we could not reject any of our null hypotheses, these findings are inconclusive as to whether a possible effect of Tetris on intrusions and similarly a relation between PA and intrusions exists.

Previous Empirical Findings

This project replicated the previous study by Holmes et al. (2009). However, our conclusions are not in line with their promising findings that playing Tetris significantly influences intrusive memories. None of our results yielded significant differences in contrast to the previous 13 studies found in the preceding literature review (e.g., Badawi et al., 2020; Hagenaars et al., 2017; Holmes et al., 2009, 2010). Our findings are more in line with three studies that did not find a significant effect of Tetris on intrusive memories (Asselbergs et al., 2018; Brühl et al., 2019; James et al., 2016). Importantly, two of these studies were independent of the original research group (Asselbergs et al., 2018; Brühl et al., 2019), in contrast to the studies that did find significant results (e.g., Hagenaars et al., 2017; Holmes et al., 2009, 2010; James et al., 2015). In relation to the publication bias, the question remains how much unpublished research exists without significant findings? The publication bias refers to the failure of studies being published based on the strength or direction of their results but based on statistically significant findings. (Nair, 2019). Accordingly, of the 16 published studies the majority (13 studies) presented successful findings. As concluded in the literature review, more independent research like this replication is needed.

However, it is difficult to determine the reason why we could not replicate the findings of Holmes et al. (2009). A possible reason might be that our trauma film did not evoke enough intrusions in total. Comparable to Asselbergs et al. (2018), our complete sample reported on average only a low number of diary intrusions. In contrast, Holmes et al. (2009) reported an average of seven intrusions over one week in the control condition. Taking this into consideration, several students mentioned the scenes were not scary or traumatic enough within the participant experience comments. One indication was knowing about the scenes from movies and series made them less traumatic. Nevertheless, there are studies that found

significant differences using tasks competing with WM capacities even if the frequency of intrusions was low (e.g., Krans et al., 2009; Stuart et al., 2006).

Also, our correlation analysis does not confirm earlier results that a relation between physical activity and intrusive thoughts possibly exists (e.g., Abramovitch et al., 2013; Voorendonk et al., 2021). In the review by Oppizzi & Umberger (2018) different types of PA have been found to positively affect PTSD symptoms. While the included studies assessed PA as controlled intervention type, we assessed retrospective self-report measure. The exact type and duration of PA needed for optimal results is still to determine (Oppizzi & Umberger, 2018). In line with our conclusions, the study by Brühl et al. (2019), could neither find an effect of Tetris nor exercising on intrusions or related distress (Brühl et al., 2019).

Theoretical and Practical Implications

This study has theoretical and practical implications. Our findings are inconsistent with the idea that intrusive memories can be influenced by disrupting memory consolidation by the use of a visual-dual task (Asselbergs et al., 2018, Baddeley, 1998, Engelhard et al., 2010). It was expected that a demanding visuospatial task would compete for WM capacities that simultaneously process the trauma film. Thereby causing a lower frequency and less vividness or distress of intrusive memories (Andrade et al., 1997; Engelhard et al., 2010). As expected, the task difficulty was rated higher for Tetris than for the vigilance control task. This difference was statistically significant, which suggest that Tetris was indeed more distracting from processing the movie than the control task. However, in contrast to Holmes et al. (2009) who included a structured break of 30 minutes, our participants had a filler task of 10 minutes only. It may be possible that this time frame plays a crucial role.

Also, the distraction mechanism expected by increased physical activity did not show the desired outcome (Ley et al., 2017, 2018). Secondly, the consideration that more physical activity could be related to higher WM capacities and thereby allowing to suppress intrusions

more effectively was not found (Brewin & Beaton, 2002; Brewin & Smart, 2005). To prove this, WM capacities should be assessed concurrently with PA as a possible mediator. Also, the distraction mechanism may be investigated in conjunction to intrusions, similar to the study by Ley et al. (2017), who looked at the flow state. It should be mentioned that we solely observed and did not influence PA. So, we could not support previous ideas that any self-selected physical activity may be beneficial for intrusive memories. However, this does not say anything about exercising as an intervention method. The question remains how different types of PA and varying durations might influence intrusions from an experimental study.

In general, it can be said that our results may not be in line with the theory but as we are reporting null findings, these are inconclusive and no further conclusions should be drawn from them. Still, they can be seen as valuable information in terms of practical implications. Considering the long-term benefits Tetris might have as a possible immediate intervention approach for people experiencing trauma, the robustness should be clearly determined by extensive research. Despite the advantages this replication had in contrast to the study from Holmes et al. (2009), such as its larger sample size or the preregistration, findings differ.

Interestingly, this reflects an often-found occurrence in research that newly proposed interventions result in successful findings while later replications find less often significant results. In relation to the publication bias, it was found that more time passes before nonsignificant results are published compared to significant results (Ioannidis, 1998). For this reason, our findings seem to add even more important knowledge to the existing evidence. These inconsistencies should be further illuminated before investing into possible large-scale intervention programs. Playing Tetris after an experimental analog for PTSD, considering the short time frame in which it was tested is of great practical relevance. The objective for Holmes et al. (2009) to wait 30 minutes was related to the average waiting time for emergency care within hospitals in the USA (Wilper et. al., 2008). Based on the results of the

literature review and conclusions of the replication, more research is needed to apply these findings to a real-life setting. Focusing on the bigger picture, this study contributes to finding a cost-efficient and easy-to-implement intervention approach for individuals at risk for PTSD.

Limitations and Strengths

This preregistered study attempted to minimize possible biases and was transparent about the progress. Still, some limitations exist. One of the reasons for conducting the study online was the ongoing corona pandemic. On one side, this had benefits in terms of feasibility and time management for the researchers as well as for the participants. On the other side, this implies several differences that could not be controlled for. For example, we cannot be completely sure whether participants checked their phone during the experiment. There may have been background interruptions and also the setting for each participant differed. The lighting in the room was inconsistent depending on participants' curtains and the time of testing. Also, the distance students had from their screen as well as the size of the laptops or computers could not be controlled.

Further, the sample might have been selective in consideration of age and level of education as participants were all first-year psychology students. Similarly, participants who are more used to watching distressing movies and series were probably more likely to sign up. The research information explicitly warned about the study material, which is important of course in terms of ethical considerations. Due to this however, participants who might be more prone to developing intrusions may have not signed up in the first place. Lastly, participants often mentioned that the daily reminder email brought up thoughts about the movie. So, this might had an undesired influence on the development of intrusive thoughts. The fact that the daily email brought the movie actively to mind might have reduced further memories participants would have had otherwise.

Importantly, this project offers also several strengths. First of all, this multi-site replication was preregistered on the open science framework (OSF), which shows the whole procedure, including analysis plan and hypotheses were designed before data collection started. Also, more reliable conclusions can be drawn from this project and it allows for easier and more thoroughly replications. Another great strength of this project is its independence from the original research group (e.g., Holmes et al., 2009). This adds important value to the current existing evidence on Tetris and intrusions. Additionally, the size of our current sample is larger in comparison to the study by Holmes et al. (2009), who had a sample size of 40. Once the collected data from all participating research sites are combined, the total sample is the largest we know of in the Tetris and intrusive memory literature (see previous literature review). Importantly, this multi-site project consists of six different research sites including three from the Netherlands, one from Germany, one from the UK, and one from Australia. Therefore, the combined sample will be more diverse and representative for the different countries and cultures. Lastly, many previous studies lacked an active control condition, which we have included by use of the perceptual vigilance control task (e.g., James et al., 2015; Holmes et al., 2009).

Future Research

Considering the study's strengths and limitations, future research might want to conduct similar experiments in a laboratory to control for confounding variables (e.g., the same settings for all participants, a larger screen for inducing the scenes more intensively). An improvement that has been done by Badawi et al. (2020) already; the recording of intrusions can be more accurate and the risks of forgetting reduced, if participants use their smartphone or a specific app to track their flashbacks (Badawi et al., 2020; Brühl et al., 2019). This should be adapted by future research as well. Taking into account that often students take part in such studies, this should be feasible and it would allow to record intrusions as they occur. Also, as

mentioned before, future research might want to reflect on the frequency and timing concerning the reminder email.

Our project has been conducted in a non-clinical sample. More independent research is needed to investigate a reliable estimate of the Tetris effect before further implications as an immediate treatment approach are considered. As mentioned before, we are reporting null findings which are therefore inconclusive. Our results should be interpreted with caution. Although, first studies did find significant results for participants experiencing real-life trauma (emergency cesarean section, Horsch et al., 2017; motor vehicle accidents, Iyadurai et al., 2018) findings of the current study should not be generalized to a clinical population.

Conclusion

The literature review gave an overview of the available evidence concerning the computer game Tetris in relation to intrusive memory. It can be summarized that the current state seems promising as there is increasing interest in this relationship. However, taking into consideration that the majority of projects were conducted among the same original research group (e.g., Holmes et al. 2009, 2010; James et al., 2015; 2016) and most studies used a rather small sample, more research is certainly needed. Therefore, the second research part of this thesis replicated the study from Holmes et al. (2009). We could not reject any of our null hypotheses. Hence, our findings are inconclusive as to whether a possible effect of Tetris on intrusions and similarly a relation between PA and intrusions exists. So, despite the fact that we did not find the same results as Holmes et al. (2009), this research is still of great importance due to its preregistration and independence from the original research group. Therefore, these findings do not only contribute important knowledge to the literature but they increase the accuracy of the current evidence. Focusing on the bigger picture, they are part of finding a cost-efficient and easy-to-implement intervention method for individuals experiencing trauma.

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Appendix A

Trauma Film Instructions

Now you will see a short film, containing various clips, just over 12 minutes long. Please sit still and pay close attention to the film.

Do not watch this film like you normally would. Try and imagine that you are there as a bystander at the scene watching the events unfold in front of your eyes. Try to really be immersed and involved in what is happening.

Please pay attention to the film and try not to look away or shut your eyes. Try to look at as many scenes as possible and try to keep watching for as long as you can.

If you feel that you really can't bear watching any longer, you may stop the film and proceed to the next page in this questionnaire.

Also, remember that you may stop participating in the study at any time without consequences.

'Page Break'

Please put on your headphones if you like to. The film should have sound.

The film will start automatically once you click the button below to proceed onto the next page. However, in some browsers the film does not start automatically. In that case, please press the button to start watching the film.

Appendix B

Example Image From Reminder Task

Appendix C

IPAQ-Short Form

INTERNATIONAL PHYSICAL ACTIVITY QUESTIONNAIRE

We are interested in finding out about the kinds of physical activities that people do as part of their everyday lives. The questions will ask you about the time you spent being physically active in the **last 7 days**. Please answer each question even if you do not consider yourself to be an active person. Please think about the activities you do at work, as part of your house and yard work, to get from place to place, and in your spare time for recreation, exercise or sport.

Think about all the **vigorous** activities that you did in the **last 7 days**. **Vigorous** physical activities refer to activities that take hard physical effort and make you breathe much harder than normal. Think *only* about those physical activities that you did for at least 10 minutes at a time.

1. During the **last 7 days**, on how many days did you do **vigorous** physical activities like heavy lifting, digging, aerobics, or fast bicycling?

   _____ **days per week**

   ☐ No vigorous physical activities → ***Skip to question 3***

2. How much time did you usually spend doing **vigorous** physical activities on one of those days?

   _____ **hours per day**

   _____ **minutes per day**

   ☐ Don't know/Not sure

Think about all the **moderate** activities that you did in the **last 7 days**. **Moderate** activities refer to activities that take moderate physical effort and make you breathe somewhat harder than normal. Think only about those physical activities that you did for at least 10 minutes at a time.

3. During the **last 7 days**, on how many days did you do **moderate** physical activities like carrying light loads, bicycling at a regular pace, or doubles tennis? Do not include walking.

   _____ **days per week**

   ☐ No moderate physical activities → ***Skip to question 5***

4. How much time did you usually spend doing **moderate** physical activities on one of those days?

_____ **hours per day**

_____ **minutes per day**

☐ Don't know/Not sure

Think about the time you spent **walking** in the **last 7 days**. This includes at work and at home, walking to travel from place to place, and any other walking that you have done solely for recreation, sport, exercise, or leisure.

5. During the **last 7 days**, on how many days did you **walk** for at least 10 minutes at a time?

_____ **days per week**

☐ No walking → ***Skip to question 7***

6. How much time did you usually spend **walking** on one of those days?

_____ **hours per day**

_____ **minutes per day**

☐ Don't know/Not sure

The last question is about the time you spent **sitting** on weekdays during the **last 7 days**. Include time spent at work, at home, while doing course work and during leisure time. This may include time spent sitting at a desk, visiting friends, reading, or sitting or lying down to watch television.

7. During the **last 7 days**, how much time did you spend **sitting** on a **week day**?

_____ **hours per day**

_____ **minutes per day**

☐ Don't know/Not sure

This is the end of the questionnaire, thank you for participating.

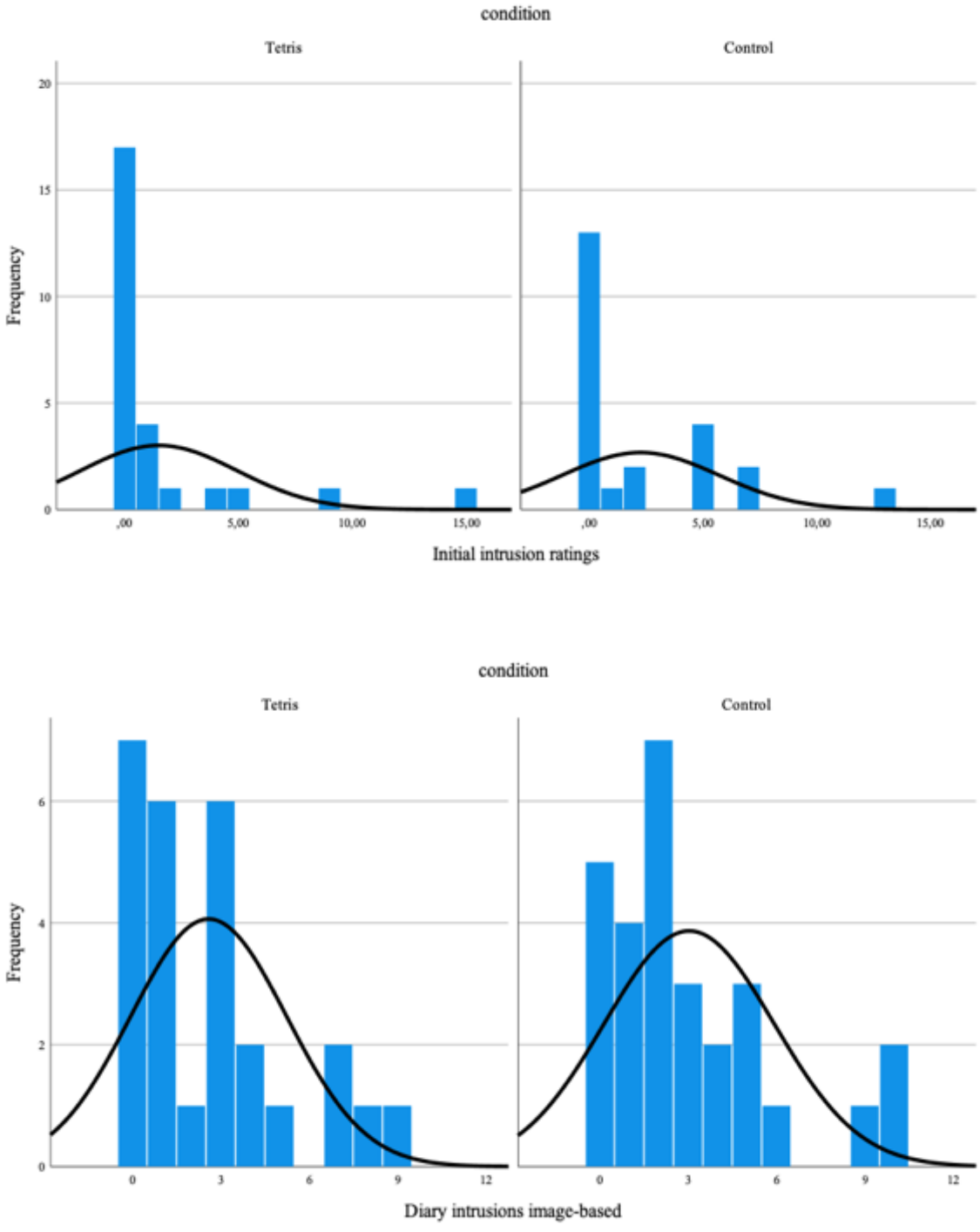
SHORT LAST 7 DAYS SELF-ADMINISTERED version of the IPAQ. Revised August 2002.

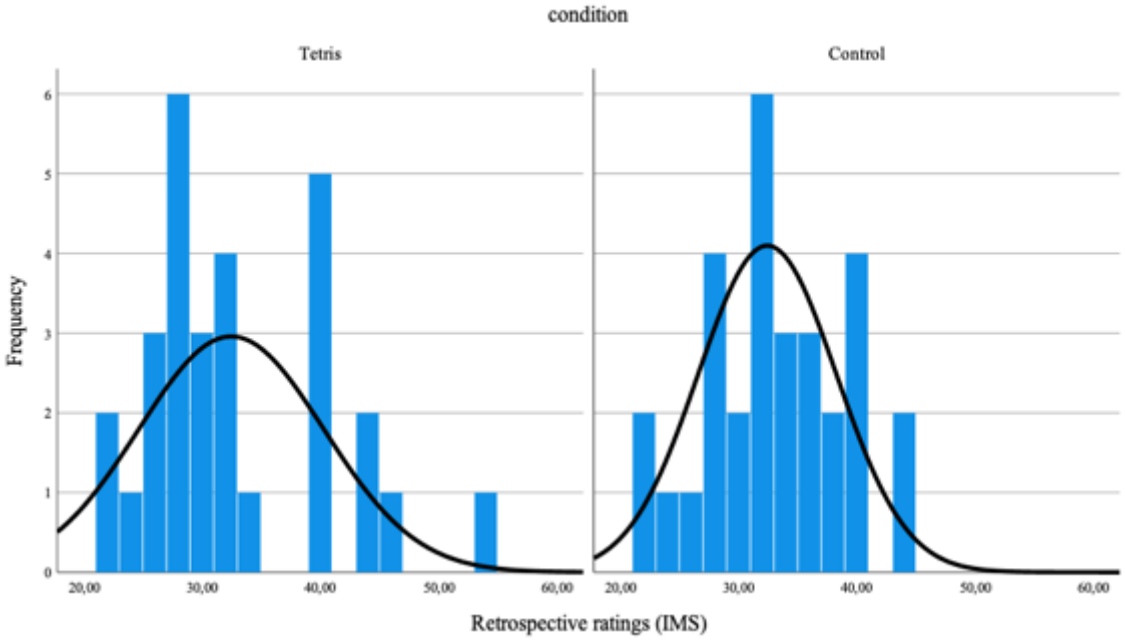
Appendix D

Testing for Normality (Excluding Outliers)

Figure D1

Histograms of the three dependent intrusion variables per condition using the strict exclusion code and excluding outliers.





Note. The strict exclusion code and removing outliers for each variable resulted in different sample sizes. Initial intrusion ratings: $N = 49$, diary intrusions image-based: $N = 55$, retrospective ratings (IMS): $N = 49$.

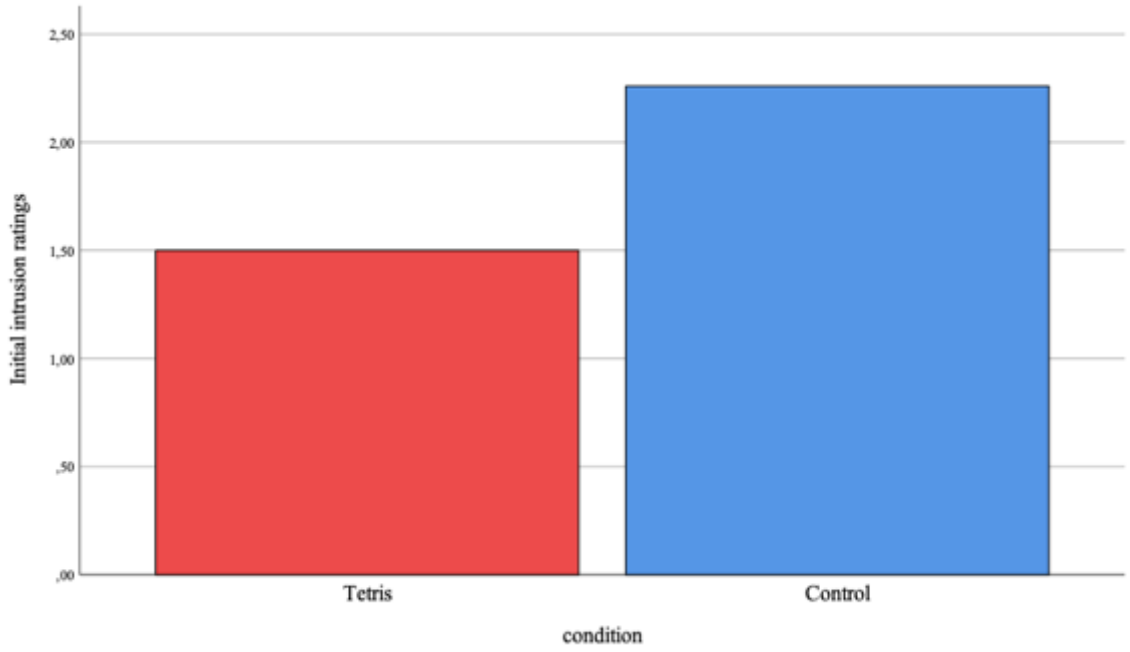
Appendix E

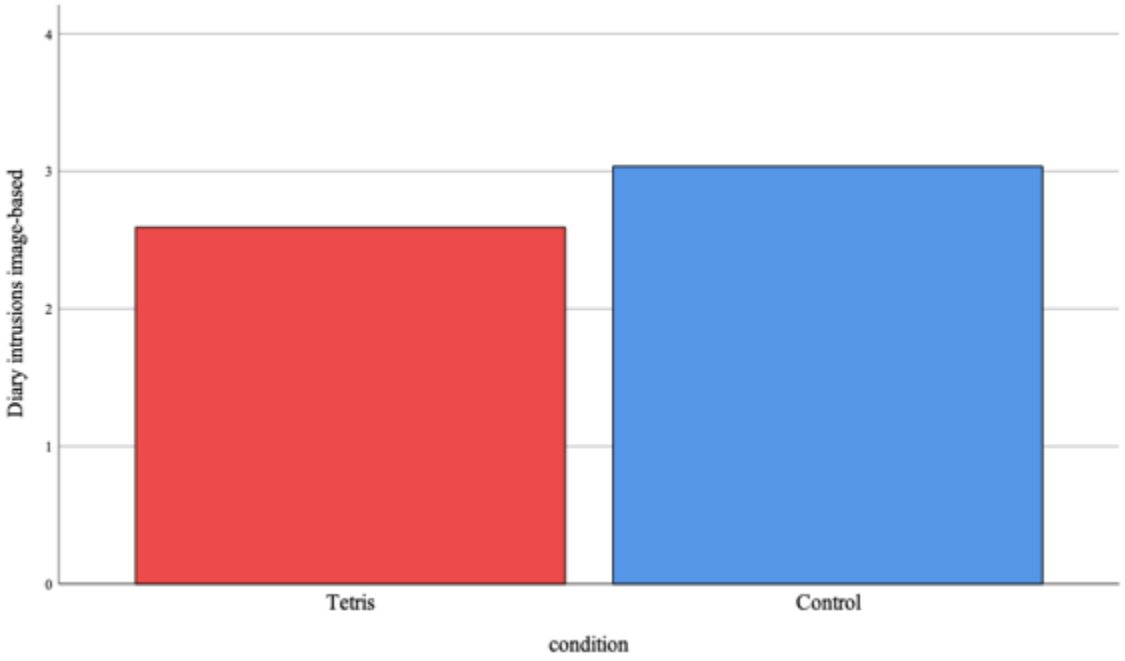
Results of the T-Tests (Excluding Outliers)

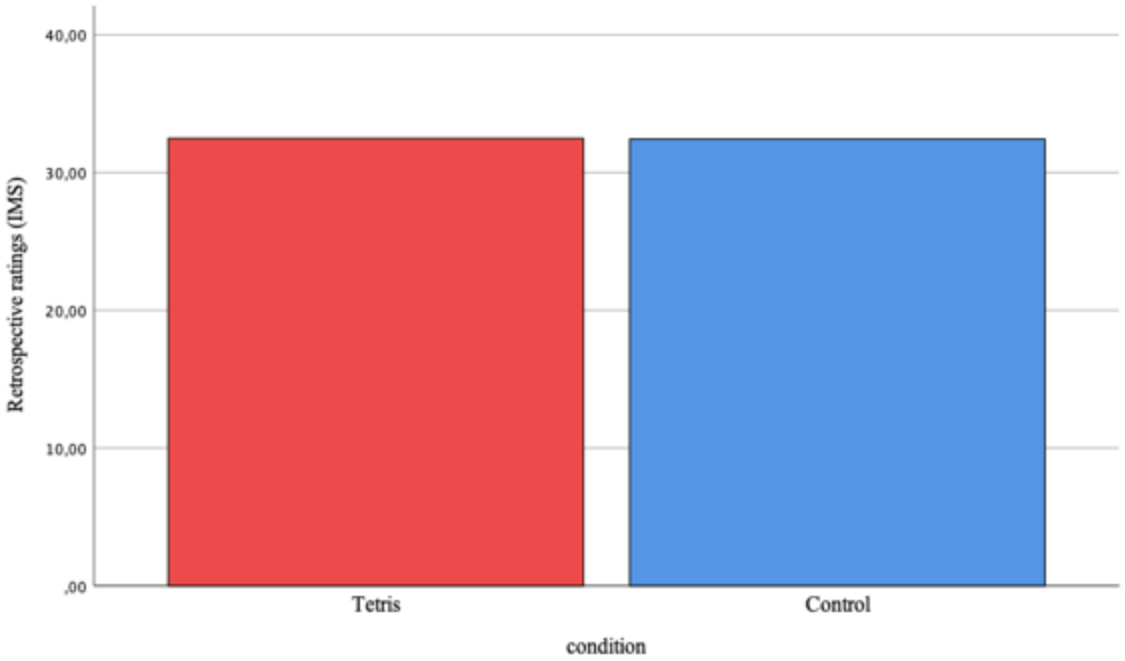
The results of the *t*-tests indicate that there was no statistically significant difference of initial intrusions between the Tetris (n = 26, m = 1.50, SD = 3.44) and the control condition (n = 23, m = 2.26, SD = 3.43), $t(47)$ = -.77, p = .22, d = -.22. Secondly, there was no statistically significant difference of image-based diary intrusions between the Tetris (n = 28, m = 2.61, SD = 2.60) and the control condition (n = 29, m = 3.03, SD = 2.84), $t(55)$ = -.59, p = .28, d = -.16. Lastly, the ratings of the retrospective impact of intrusions (IMS) were not statistically significant different in the Tetris condition (n = 29, m = 32.48, SD = 7.82) compared to the vigilance control task condition (n = 30, m = 32.43, SD = 5.84), $t(57)$ = .03, p = .49, d = .01.

Figure E1

T-tests: Initial intrusion ratings, Diary intrusions image-based, Retrospective ratings (IMS)







Note. Mean differences using the strict exclusion code and excluding outliers.