PSYCHOLOGICAL AND PHYSIOLOGICAL PREDICTORS OF THE DEVELOPMENT AND MODULATION OF INTRUSIVE IMAGES

by

James N.R. Brazeau

M.A. (Clinical Psychology), Lakehead University, Canada, 2012

A DISSERTATION SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENT FOR THE DEGREE OF DOCTOR OF PHILOSOPHY IN CLINICAL PSYCHOLOGY AT LAKEHEAD UNIVERSITY

Department of Psychology, Lakehead University

Acknowledgements

I would first like to thank Dr. Ron Davis for his invaluable advice, effort, and time, all of which were vital to the development and completion of this research. Furthermore, I would like to thank all of the committee members who took the time to provide valued feedback on the project from its inception to its completion. I would also like to acknowledge the efforts put forward by Mr. Chad Keefe and Ms. Paige Pawluk who were involved in aspects of the data collection and extraction.

This research project would not have been possible without the technical advice from several experts. In particular, I would like to thank Dr. Pandelis Perakakis, University of Grenada, for his assistance in extracting and analyzing results related to the cardiac defense response. I would also like to thank Dr. Terry Blumenthal, Wake Forest University, for his suggestions regarding the analysis of EMG responses. In addition, I would also like to thank Dr. John Jamieson and Mr. Bruce Weaver, Lakehead University, for their recommendations in regards to the statistical analyses used in the study. I would like to express my appreciation for the time taken by Ms. Ella James and Dr. Emily Holmes, Oxford University, in assisting me to prepare the methods used within this study.

I would also like to thank the many mentors that have helped me develop my passion for the field of psychology, including: Dr. Gary Brooks, Dr. John McKenna, Dr. Gerald Mundt, & Dr. Mike Wesner. Finally, I would like to thank my family and friends for their encouragement throughout my life and academic career. Without your support, this research would not have been possible.

Abstract

Researchers have suggested that engaging in visuospatial tasks, such as the videogame Tetris™, following a trauma may interfere with the development of intrusive images associated with posttraumatic stress disorder (PTSD). The present study attempted to replicate this finding using a trauma film paradigm. Furthermore, we were interested in identifying if participants who played Tetris would show changes in other symptoms associated with PTSD, such as enhanced startle responses. Participants (*N* = 129) were asked to view a film with traumatic content and were then randomly assigned to play either Tetris or to sit quietly for 10 min. Psychological reactivity (positive affect, negative affect, and dissociation) and physiological reactivity (cardiac measure of sympathetic and parasympathetic activity, heart rate, and salivary alpha amylase) were examined as potential predictors of the frequency of intrusive images. Our findings indicated that intrusive images occurred significantly less often amongst individuals assigned to the Tetris game-play condition. We were able to identify that the frequency of intrusive images was modulated by patterns of sympathetic arousal, dissociation, and affective reactivity. Furthermore, our results indicated that individuals who engaged in the Tetris task showed a heightened startle response to aversive material. These findings are discussed in terms of their relevance to etiological models, and the prevention of PTSD.

List of Tables

List of Figures

List of Appendices

Contents

Psychological and Physiological Predictors of the Development and Modulation of Intrusive Images

Throughout our daily activities, humans are constantly bombarded with an overwhelming amount of incoming sensory information. In order to make sense of this information our brains are constantly filtering out irrelevant information and storing the relevant in memory. The storage process generally acts in an adaptive manner whereby emotional states can enhance the consolidation of certain memories. For example, human memory tends to be improved for situations that are deemed positive and provide some type of reward. Drawing from an evolutionary example, while searching for food our ancestors would likely have excellent memory for where good sources of food were to be found, as memory for these locations was associated with positive outcomes (finding food) that contributed to their survival. However, memory is not only improved through positive outcomes, it is also potentiated through negative emotional states and attributions. For example, imagine that while searching for food our ancestors follows a certain path where they are viciously attacked by a wild animal and barely survive the encounter. Based on this event, our ancestors would likely remember the incident very clearly and would avoid following the same path again as it would be associated with a threat to their survival. In both examples, the emotional reaction to the situation would enhance memory, thus improving their chances of survival. The utility of this type of facilitated memory continues to exist today and, in most situations, it acts in an adaptive function that facilitates survival.

In recent years, the underlying physiological processes that lead to memory enhancement have received significant attention by researchers. These processes involve cognitive factors, such as the emotional interpretation of the event, and a diverse range of neurological events. When faced with an arousing event the body produces neurohormones and neurotransmitters, most notably cortisol and noradrenalin, that interact with structures within the brain and effectively strengthen the memory. This proposition was originally tested in animal models using conditioning paradigms, whereby learning tasks (e.g., how to navigate through a maze) were enhanced by providing rewards (e.g., food). Similarly, when rats are exposed to aversive stimuli (e.g., mild electrical shocks) in certain locations within a cage, they tend to avoid these locations. The biological underpinnings for this learning process suggest that, regardless of the negative or positive stimuli, changes in neurochemicals can predict the extent to which animals learn from these experience (for reviews of these topics see van Stegeren, 2008; Wolf, 2008). This process also extends to human learning and memory, particularly as it relates to memory associated with positive and negative events.

Although generally adaptive, the preferential encoding of emotionally relevant events can go awry. This is particularly evident in the extreme example of posttraumatic stress disorder (PTSD). PTSD occurs when individuals are faced with an overwhelming event that poses actual or threatened death or injury (American Psychiatric Association, 2000). Symptoms of PTSD include reexperiencing (e.g., intrusive recollections of the event, nightmares, and feeling as if the event were recurring), avoidance of stimuli associated with the trauma, and symptoms of increased arousal (e.g., difficulty sleeping and concentrating, irritability, hypervigilance, and enhanced startle responses). Amongst these symptoms, those most commonly reported by individuals with PTSD are feelings that the event is reoccurring (i.e., reexperiencing) and enhanced startle responses (Davidson, Hughes, Blazer, & George, 1991).

Following the occurrence of a trauma, it is not uncommon for individuals to experience many of these symptoms that are generally considered to be adaptive in the context of a recently experienced trauma. For example, this information is strongly consolidated into memory in order to avoid, or deal with, similar situations should they occur in the future. For the majority of individuals, these symptoms tend to decline over a period of weeks to months following the trauma (Resick et al., 2008). For this reason, PTSD is not diagnosed in individuals who show symptoms in a period of one month following the trauma. Indeed, estimates suggest that less than 10% of individuals will develop PTSD following a trauma and that this may be dependent on the type and severity of the trauma (Breslau, 2009; Kessler, Sonnege, Bromet, Hughes, & Nelson, 1995). For individuals who do develop PTSD, the consequences are often severe and symptoms regularly interfere with daily functioning (American Psychiatric Association, 2000). Furthermore, many individuals with PTSD suffer the consequences of the disorder without ever seeking treatment (Davidson et al., 1991). Therefore, it would be of great value to identify a method that would prevent the development of PTSD following the occurrence of a trauma.

Currently, several models have been proposed that seek to explain the development of PTSD. These include conditioning models (e.g., Amstadter Nugent, & Koenen, 2009; Pitman, 2006), cognitive models (e.g., Ehlers & Clark, 2000; Foa, Steketee, & Rothbaum, 1989), and biological models (e.g., McFarlane, Yehuda, & Clark, 2002; Rauch, Shin, & Phelps, 2006). Although each of these models emphasizes different aspects of the development of PTSD, they do share at least four common tenets. First, each of these models acknowledges that physiological stress responses at the time of trauma contribute to the development of the disorder. Second, the consequence of this response is increased coding and/or encoding of trauma-related memories. Third, activation of these memories is associated with many of the symptoms of PTSD, particularly reexperiencing. Fourth, the development of PTSD is likely due to adaptive responses that have become over-active, leading to pathological consequences such as avoidance and increased physiological reactivity. Based on these theories, physiological stress responses have an important role in the development and maintenance of PTSD through their influence on memory. However, many factors related to the development of PTSD remain unknown. For example, the exact physiological mechanisms that lead to the development of symptoms such as reexperiencing and hyperarousal have yet to be identified. This is unfortunate, as understanding how these mechanisms operate will likely be a key factor in preventing the development of PTSD following a trauma.

Recently, it has been suggested that use of certain cognitive interventions may interfere with the formation of trauma memories associated with PTSD (e.g., Holmes, Brewin, & Hennessy, 2004; Holmes, James, Coode-Bate, & Deeprose, 2009; Stuart, Holmes, & Brewin, 2006). These findings are based on the dual representation theory of PTSD that proposes to explain the memory processes underlying both the development and maintenance of PTSD (Brewin, 2008; Brewin, Dalgeish, & Joseph, 1996). Based on this theory, the authors have attempted to interfere with the development of PTSD-like symptoms through the use of visuospatial cognitive tasks and this approach has shown some promise. For example, asking people to engage in something as simple as playing the videogame Tetris™ has been shown to decrease the frequency of intrusive thoughts related to a traumatic film (Holmes et al., 2009). However, the underlying psychological and biological mechanisms that contribute to the reduction of intrusive thoughts have not been thoroughly evaluated. Furthermore, it has not yet been determined if the dual representation theory explains the development of other symptoms of the disorder, such as factors related to the development of increased arousal.

The current study intended to build on the findings reported by researchers that have used propositions drawn from the dual representation theory to reduce intrusive thoughts following a trauma. Specifically, the present study examined how both biological and psychological factors could contribute to the development of intrusive thoughts in response to a trauma film, and how these responses may be altered through the use of a cognitive task. An additional goal of this study was to examine the extent to which the dual representation theory may apply to other features of PTSD, particularly increased defensive responses. In order to examine these issues, it is first necessary to review the dual representation theory and the research that supports it. Following this review, a discussion will be provided regarding the physiological mechanisms that contribute to the development of intrusive thoughts. Based on this information, specific hypotheses are made that provide the opportunity to further support the applicability of preventative strategies in reducing intrusive thoughts. Finally, the possibility that the dual representation theory may also apply to symptoms related to increased arousal will be explored. Collectively, the current study provides an opportunity to further our understanding of PTSD and, more importantly, provide additional information on how the development of PTSD may be avoided.

Dual-Representation Theory of the Development of PTSD

Intrusive memories, or flashbacks, are defined as recollections relating to traumatic events that occur spontaneously and without deliberate recollection (Holmes & Bourne, 2008). These memories tend to have sensory components and often consist of visual images (Brewin, Dagleish, et al., 1996). Furthermore, these intrusive thoughts are often accompanied by the same emotions that occurred at the time of trauma. Although most healthy individuals experience intrusive thoughts on a daily basis, it is the frequency and severity of these thoughts that make them pathological (Brewin, Christodoulides, & Hutchinson, 1996; Holmes & Bourne, 2008). Dual representation theory suggests that the intrusive thoughts that occur in PTSD develop due to an imbalance between representations that are coded through two different memory systems at the time of trauma (Brewin, Gregory, Lipton, & Burgress, 2010).

The first of these is the contextual memory (C-memory) system and representations within this type of memory are referred to as C-reps. According to Brewin et al. (2010) C-reps are thought to contain information that is abstract, declarative, contextual, and autobiographical. Furthermore, C-reps are said to be accessed either voluntarily through purposeful recollection or involuntarily through associative cues. The neural basis of C-memory includes regions such as the medial temporal lobe (MTL) and associated systems related to declarative information, the hippocampus for spatio-temproal contextual information, and interactions between the hippocampus and neocortex for information related to semantic information.

Although the C-reps can explain some aspects of trauma related memory memories (e.g., the purposeful retrieval of the event), a second system is proposed to explain the presence of flashback memories that are involuntarily. This second system, the sensory memory (S-memory) system and its associated representations (S-reps) primarily process lower level perceptual information. During the encoding of episodic memory, the S-memory system is proposed to code perceptual information that is then used as the basis for the creation of higher-level representations. Therefore, S-reps are conceptualized as consisting of sensory based information and include visual and auditory information related to the event.

In the context of nonstressful events, S-reps are said to quickly decay and become relatively inaccessible. However, during stressful events S-reps are enhanced through the interaction of areas of the brain. Of particular relevance to this enhancement are the insula, sensory association areas, and the amygdala (Craig 2002; Critchley, Wiens, Rothstein, Ohman, & Dolan, 2004). The consequence of this enhancement includes the addition of information related to autonomic markers of affective values related to the event, such as fear and disgust. S-reps are thought to be reactivated through incoming perceptual information or associative cues from higher level representations related to the event, a process that is proposed to occur in the precuneus (Brewin et al., 2010).

The dual representation theory suggests that individuals who experience a stressful event normally develop on association between the relevant S-reps and corresponding C-reps via representations in the precuneus. The result of this association is that the event can be integrated into sematic and autobiographical contexts. In other words, individuals can appropriately recognize that the event occurred in the past and that they are now safe and removed from danger. Furthermore, the association between S-reps and C-reps allows top-down control over these representations which permits conscious processing of the events, the ability to distinguish the event from other similar events, and deliberate suppression of retrieval (Brewin 2007; Brewin, et al., 2010). This top-down control is proposed to occur through connections from the prefrontal cortex to the MTL, visual cortex, thalamus, hippocampus, and amygdala (e.g., Depue, Curran, & Banich, 2007; Flectcher & Henson, 2001).

Collectively, the association that develops between a S-rep and C-rep is likely adaptive as it allows individuals to consciously process the stressful event. However, dual representation theory suggests individuals who develop flashbacks associated with PTSD fail to develop the appropriate associations between a S-rep and a C-rep. The nature of this pathological encoding is proposed to be due to the effects of stress on memory that can impair hippocampal functioning (associated with C-reps) and potentiate amygdala influences on memory (associated with S-reps). For example, stressful experiences can produce dendritic atrophy and memory deficits within the hippocampus while also producing dendritic arborisation within the amygdala and enhanced affective memories (Howland, & Wang, 2008; Roozendaal, McEwen, & Chattarji, 2009; Vyas, Mitra, Rao, & Chattarji, 2002). As a result of these mechanisms pathological encoding occurs which is characterized by stronger S-reps, relatively weaker C-reps, and impaired connections between the two (Brewin et al., 2010). The combination of these processes is thought to result in individuals' perception of reexperiencing the trauma, as the temporal and contextual information within the C-reps is not available to offset the enhanced S-rep.

The basis for pathological processing of information has been suggested to occur via two processes (Brewin, 2008; Holmes et al., 2004). First, some individuals experience peritraumatic dissociation, a process thought to be caused by the prefrontal cortex going "off-line" in response to an excessive stressor which leads to feelings of depersonalization, disengagement, and psychological numbing. As the C-reps allow for the conscious processing of contextual information, which relies on the prefrontal cortex, dissociation is thought to disrupt this encoding process (Brewin, 2008). Since the development of S-reps do not rely on the prefrontal cortex and conscious processing, they can be produced at the time of trauma without interference. Several studies have suggested that dissociation plays a role in the development of PTSD. These studies indicate that individuals who report that they have higher levels of dissociation during, and following, a trauma are at a greater risk for developing PTSD (Halligan, Tanja, Clark, & Ehlers, 2003; Murray, Ehlers, & Mayou, 2002; Ozer, Best, Lipsey, & Weiss, 2003). It has been suggested that this process may be related to a *decrease* in physiological arousal at the time of trauma and immediately following the trauma (Brewin, 2008; Holmes et al., 2004).

The second pathway that may lead to an imbalance between C-reps and S-reps relates to an *increase* in arousal. When faced with a traumatic situation some individuals experience a decrease in physiological arousal associated with dissociation and freezing behaviour, while others experience a significant increase in arousal thought to be associated with the fight-or-flight response (Brewin, 2008; Holmes et al., 2004). This increase in arousal is most commonly reported in terms of an increase in heart rate (HR), sympathetic arousal, and activation of the hypothalamic-pituitary-adrenal (HPA) axis (Pitman, 2006). For example, several studies suggest that an increase in HR immediately following a trauma is associated with an increased risk of developing PTSD symptoms (Bryant, 2006; Bryant, Creamer, O'Donnell, Silove, & McFarlane, 2008; Kuhn, Blanchard, Fuse, Hikcling, & Broderick, 2006). The dual representation theory contends that an increase in arousal may contribute to the over-consolidation of S-reps, an effect that is likely due to physiological stress responses and their influences on the amygdala. Furthermore, the detrimental effects of stress on hippocampal structures may impact the development of C-reps or their availability to connect with associated S-reps (Brewin, 2008; Brewin et al., 2010).

Evidence for the Dual Representation Theory

Based on the dual representation theory, several recent studies have provided support for the use of visuospatial tasks in impeding the development of intrusive memories. As discussed by Holmes et al. (2009), the logic behind these interventions is based on the following rationale. First, trauma flashbacks generally consist of sensory-perceptual images with visuospatial components. Second, visuospatial cognitive tasks are thought to compete for limited resources with visuospatial trauma images in terms of memory consolidation. In other words, the S-memory system can only process a limited amount of information and visuospatial cognitive tasks may be used to replace trauma-related material. Third, research on the neurobiology of memory consolidation indicates that there is a 6-hr time frame after an event during which the level of consolidation can be modified. Therefore, it has been proposed that during this 6-hr interval, the use of visuospatial tasks can compete with the consolidation of trauma-related memories, thus reducing the saliency of these memories. Recently, researchers have examined the possibility of modulating intrusive memories that are proposed to be analogous to the symptoms of reexperiencing that occur in PTSD.

One of the landmark studies in this area was conducted by Holmes et al. (2004). This study made use of a trauma film paradigm whereby healthy participants were asked to view a movie that consisted of scenes from a road accident, injured victims screaming, dead bodies being moved, and body parts among car wreckage. The main outcome variable was the number of intrusive images from the film recorded in a diary throughout the week following viewing the film. In their study, the authors conducted three experiments. In the first experiment, the authors attempted to identify the influence of a visuospatial task and a dissociation manipulation task. Participants were assigned to three separate groups. The first group was asked to continuously tap a five-key sequence on a keyboard while viewing the film (visuospatial condition). The second group was asked to stare at a small dot while viewing the film (dissociation condition). The third group served as a control condition and simply viewed the film without conducting any additional task. The authors also examined self-report measures of state and trait dissociation to identify the extent to which scores on these measures were related to intrusive thoughts. Furthermore, the authors recorded heart rate (HR) data, hypothesizing that individuals who had a reduced HR during film viewing would experience more intrusive thoughts. The major findings of this study indicated that individuals who were in the visuospatial condition experienced fewer intrusive thoughts as compared to the control or dissociation group; there was no difference between the latter two groups. However, an increase in state dissociation across all conditions was correlated with an increase in intrusive thoughts. Finally, the authors found that there was a significant reduction in HR while viewing the films and that this was most evident during periods of the film associated with individual reports of intrusive thoughts. The authors suggest that this observation may be due to a defensive physiological "freezing response" that occurs when individuals view particularly disturbing scenes from the film. Collectively, these findings did support the first pathway to the development of intrusive images given that they provided evidence of a link between intrusive images, decreased arousal, and increased dissociative responses.

The second experiment examined the influence of increasingly complex visuospatial tasks on reported intrusive thoughts following the experiment. The same methodology used in the first experiment was implemented. However, participants were randomly assigned to conditions that carried out visuospatial tasks of varying difficulty. Results of this study indicated a linear relationship existed between task difficulty and reductions in intrusive thoughts. This finding supported the notion that visuospatial tasks compete for resources within the S-memory system. The finding that the frequency of reported intrusive images was related to dissociative responses and decreased HR was also replicated.

The final experiment in this Holmes et al. (2004) study examined whether tasks that impair or enhance verbal processing would influence the occurrence of intrusive thoughts. The authors made use of the same film paradigm as in the previous experiments. In this experiment, one group was assigned to count backwards in threes (interference group) while the other group were asked to verbalize details of the film scene while watching it (enhancement group). The authors also included a no-task control group. Results from this experiment indicated that, as expected, participants in the verbal interference task reported significantly more intrusions as compared to the control condition. However, there did not appear to be an increase in intrusions in the enhancement group. The authors suggest that this lack of enhancement may be due to lack of compliance to the task instructions. It is important to note that this study failed to replicate the findings related to state dissociation that were reported in experiment one and two. Furthermore, the association between decreased HR and dissociation were not significant in this experiment.

Collectively, the findings of Holmes et al. (2004) study provided some support for the dual processing theory of intrusive memory formation. Specifically, the study consistently demonstrated that visuospatial tasks that were carried out concurrently while watching the trauma film reduced the occurrence of intrusive thoughts throughout the following week. In addition, the study also found some support for the role of dissociation in increasing the occurrence of intrusive thoughts, although this was not consistent across all experiments.

There are some elements of this intriguing study that could be examined in more detail. For example, in the first experiment all participants were screened to ensure that they were able to dissociate. Not surprisingly, this study showed the strongest correlation between changes in dissociation and increased intrusive thoughts, as compared to other experiments in the study. Therefore, this experiment may have selected a group of participants that would have overemphasized the first pathway (i.e., flashbacks are increased due to dissociation influences and decreased arousal) over the second pathway (i.e., flashbacks are increased due to augmented physiological reactivity) to the development of intrusive thoughts and images.

The relationship between dissociative reactions and physiological activity was not the main goal in the Holmes et al. (2004) study. Therefore, the study did not report on the relationship between changes in HR and dissociative reactions. However, decreases in HR may have been expected to be negatively correlated with increases in dissociation; this would be expected given the first pathway discussed above. The Holmes et al. (2004) study also examined HR activity during film exposure. As discussed below, HR is a measure that is frequently used to assess physiological arousal. However, it has been criticized for providing an imperfect measure of overall arousal. Although it may appear contradictory, decreases in HR may be associated with increases in sympathetic activity combined with increases in parasympathetic activity. Therefore, although it is possible that there are two independent pathways that contribute to intrusive thoughts, there is some evidence that these two pathways may not be independent. For example, there is a substantial amount of research in both animal and human models to suggest that an increase in physiological reactivity would be expected to contribute to overactive memory consolidation (for reviews see van Stegeren, 2008; Wolf, 2008), the opposite of what was observed in the Holmes et al. (2004) study. Recently, Holmes and Bourne (2008) have emphasized that the relationship between physiological reactivity and intrusive thoughts, as they relate to the trauma film paradigm, are in much need of further examination.

Several additional studies have been conducted using the trauma film paradigm (for a review see Holmes & Bourne, 2008), many of which have provided additional support for the dual representation theory and the ability to influence the frequency of intrusive thoughts experienced through the use of various cognitive tasks. Of particular relevance to the present study is the work conducted by Holmes et al. (2009). This study made use a trauma film paradigm and attempted to identify if a visuospatial task implemented following, rather than during, film presentation would impact the frequency of intrusive memories. In this study participants first viewed a trauma film and then completed a 30 min filler task, after which they were randomly assigned to one of two groups. The first experimental group was assigned to play the popular videogame Tetris for a period of 10 min. The authors indicated that Tetris has several desirable characteristics of a visuospatial task as it draws on skills related to mental rotation and requires visual and spatial processing. The second group consisted of a control condition in which participants sat quietly for 10 min. During the 10-min period, both groups recorded the frequency of intrusive thoughts that they experienced. Participants were also asked to record the number of intrusive images they experienced in a diary over the following week. As expected, participants in the visuospatial Tetris condition experienced fewer intrusive images as compared to the control condition over the seven-day period. Crucially, the authors found that individuals in the visuospatial condition also reported lower scores on a measure of clinical symptomatology of trauma based on the Impact of Events Scale (Weiss & Mamar, 1997). In addition, the authors reported that voluntary memory for the film, based on a recognition memory task, did not differ across groups. This would suggest that although trauma flashbacks were reduced, memories for the actual event appeared unaffected.

An additional study by Holmes, James, Kilford, and Deeprose (2010) replicated and extended the findings described by Homes et al. (2009). Specifically, Holmes et al. (2010) made use of a similar experimental paradigm but assigned participants to either play Tetris, play a verbal trivia computer game, or to be in the no-task control group. In this study the authors made use of two experiments that used almost identical procedures.

The only difference between the two experiments was the timing of the task. Participants engaged in the task 30 min postfilm in the first experiment and 4 hr postfilm in the second. Results from this study indicated that individuals in the Tetris condition experienced fewer intrusions over the following week as compared to the other two conditions across both experiments. Furthermore, individuals who engaged in the verbal videogame experienced more intrusions as compared to the other two groups, but only when they engaged in the task 30 min postfilm. The authors propose that this finding may be due to verbal/conceptual interference worsening flashback-like memories during consolidation. Based on Brewin et al.'s (2010) dual representation theory, this finding could be interpreted to be the result of the verbal videogame occupying memory resources that would normally lead to the development C-reps. From this perspective, the lack of adequate C-reps would lead to more frequent image intrusions for individuals engaged in the verbal videogame. In contrast, engaging in the visuospatial game of Tetris would occupy memory resources normally used to develop S-reps, thus reducing the frequency of intrusive images in the week following the film.

Taken together, the studies by Holmes et al. (2009, 2010) provide additional support for the dual processing theory of traumatic memory development. Furthermore, these findings have successfully applied this theory to create a method of modulating the frequency of intrusive images by simply asking individuals to play Tetris. Unlike the earlier study described (Holmes, et al., 2004), these studies did not examine HR or any other physiological variable. In the present study we made use of a similar methodology while also assessing physiological indices as well as extending the study to incorporate other factors that are relevant to the development of intrusive memories.

The dual representation theory of intrusive thought development appears to have a substantial evidence base. However, there are certain aspects of the theory that could benefit from further elaboration and experimental inquiry. Specifically, although it has been suggested that there are underlying physiological and neurological contributions to the development and modulation of intrusive thoughts, these have not been thoroughly examined. Indeed, the finding that viewing a trauma film is associated with a decrease in physiological (HR) reactivity and an increase in intrusive thoughts appears to contradict a great deal of research that suggests an *increase* in physiological reactivity is associated with stress and may predict the development of PTSD (e.g., Bryant, 2006; van Stegeren, 2008). In addition, Brewin and Holmes (2003) indicate the theory is currently limited to providing an explanation for the development of only one symptom of PTSD: reexperiencing. However, it is also likely that similar mechanisms and physiological processes underlie the development of other types of symptoms. Of particular interest is the possible contribution of these processes to PTSD symptoms related to hyperarousal. In the following sections, the relationship between physiological arousal and these symptoms will be examined in more detail.

Physiological Contributions to Intrusive Memories

As previously discussed, evidence for the dual representation theory of intrusive image formation has provided some conflicting evidence in terms of the physiological contributions to this process. With the exception of the one study that was described above (Holmes et al., 2004) which examined HR data, there has been little direct assessment of the physiological processes that may underlie the creation of intrusive images based on this theory. In fact, Holmes and Bourne (2008) have indicated that this is an area that requires further elaboration. Brewin et al. (2010) draw extensively from neurobiological studies of memory and suggest a role for the physiological stress response systems in the development of intrusive images. Furthermore, the two pathways that have been proposed to lead to the development of intrusive images likely rely on physiological reactivity in response to trauma related material (Brewin, 2008; Holmes & Bourne, 2008). However, this proposition has not been thoroughly tested.

As previously discussed, Holmes et al. (2004) reported what would appear to be a decrease in physiological activity by way of an overall reduction in HR and this was associated with an increase in intrusive thoughts. This finding is at odds with the considerable animal and human research in regards to stress responses related to emotional memory. In order to gain a better understanding of this area, it is necessary to review the relevant findings related to physiological reactions to stressful events and clinical research related to the physiological contributions to the development of PTSD. However, the influences of stress on the body is a very complex topic and will only be briefly summarized as there are several recent comprehensive reviews providing a much more detailed account of these processes (e.g., Pitman, 2006; van Stegeren, 2008; Wolf, 2008).

In general, in response to a stressor the human body follows a typical response pattern that involves two phases. In the first phase, a rapid response from the sympathetic nervous system (SNS) occurs resulting in the activation of various noradrenergic systems. A cascade of signals originating from the hypothalamus and extending to the adrenal medulla characterizes this primary response. In response to this signal the adrenal medulla rapidly releases adrenalin and noradrenalin. The result of these processes is an increase in HR, breathing frequency, and sweat production (de Kloet, Marian, & Florian, 2005; Wolf, 2008). Activation of the sympathetic nervous system also stimulates the vagus nerve that increases the noradrenergic tone in the brain through interactions with such regions as the locus coeruleus and the nucleus of the solitary tract. In turn, these regions stimulate various areas of the brain, most notably the amygdala. A second slower response occurs through activation of the HPA axis. This slower reaction is characterized by the release of stress hormones such as corticotrophin releasing hormone (CRH), vasopressin, adrenocorticotrophin (ACTH), and eventually cortisol (Charney, 2004; de Kloet et al., 2005). The SNS and the HPA axis activate a diverse range of neurotransmitter systems (e.g., cholinergic, noradrenergic, sertonergic and dopaminergic systems) and have a range of effects on neuronal functioning including increased neuronal excitability, neuronal plasticity, dendritic remodelling, and neurogenesis (Wolf, 2008).

One of the many consequences of this stress response is an increase in processing and storage of emotional information (LaBar & Cabeza, 2006). From an evolutionary perspective this process is adaptive as the brain seeks to process information that is most relevant to survival, such as real or potential threats to survival. As a result, it is not surprising that human memory for emotional information is generally better than it is for neutral information, as this improves defensive reactions to similar situations that may occur in the future (Cahill & McGaugh, 1998; McGaugh, 2000). However, under certain circumstances this mechanism becomes maladaptive. This has been observed across a number of psychiatric disorders characterized by an overactive stress response such as mood and anxiety disorders, especially PTSD (Wolf, 2008). Of particular relevance to the present study is first phase of the stress response, the activation of the sympathetic nervous system, which would appear to be a necessary component in the facilitation of emotional memory processing, particularly in the case of PTSD. Evidence for this proposition stems from studies that have examined fear and stress responses in both animals and humans.

In animal studies, noradrenergic agonists administered during encoding has been repeatedly shown to increase memory performance in all types of stress tasks (Roozendaal, McEwen, & Chattarji, 2009; Sandi & Pinelo-Nava, 2007; van Stegeren, 2008). Additional evidence stems from animal research that has made use of adrenergic antagonists, which effectively lead to decreased memory performance on the same tasks. Van Stegeren (2008) summarized results of several decades of research in this area and concluded that increased (nor)adrenaline leads to improved memory performance at the time of encoding, and shortly post-training, in a time- and dose-dependent fashion.

Similar results have also been found in human studies. For example, Nielson and Jensen (1994) examined elderly participants who were chronically taking β-receptor antagonists, which block adrenergic activity, to control hypertension. The researchers then compared their performance on a long-term word recognition task while engaging in an activity designed to induce muscle-tension arousal. Results from this study indicated that participants taking β-adrenergic receptor antagonists performed significantly worse as compared to individuals who were not taking these antagonists. However, several studies indicate that reduction of emotional memories caused by β-adrenergic receptor antagonists is dependent on the level stress at the time of consolidation. This suggests that stress hormones, such as glucocorticoids, may interact with the adrenergic system in order to improve emotional memory consolidation (Cahill & Alkire, 2003; Cahill, Gorski, & Le, 2003; van Stegeren, Everaerd, & Gooren, 2002). Glucocorticoids, such as cortisol, appear to have a dual effect on memory consolidation. On one hand, glucocorticoids appear to be associated with enhanced long-term memory (Roozendaal, 2000). On the other hand, glucocorticoids appear to decrease memory retrieval and impair working memory performance (de Quervain, Roozendaal, Nitsch, McGaugh, & Hock, 2000). Based on these findings, it has been suggested that the interaction between the noradrenergic system and glucocorticoids may explain the nature of PTSD symptoms that include both the enhancement of unwanted memories as well as deficits related to recall of information related to the trauma. Indeed, van Stegeren (2008) proposes that a peak in noradrenergic activity may be responsible for the intrusive thoughts and recall of unwanted information in PTSD whereas memory deficits related to trauma are likely attributable the influence of cortisol.

The mechanisms underlying memory enhancement likely consists of complex interactions between glucocorticoids and the adrenergic system. However, there is evidence that the effects of cortisol on memory necessitate the influences of the noradrenergic system as well as the basolateral amygdala, as has been demonstrated in ablation studies in animals and fMRI studies in humans (Elzinga & Toelofs, 2005; Roozendaal, Okuda, de Quervain, & McGaugh, 2006; van Stegeren et al., 2007). Indeed, the amygdala appears to be a critical structure involved in enhanced emotional memory as well as the dual representation theory. Brewin et al. (2010) suggest that the selective memory processes associated with the S-reps, which are thought to be responsible for intrusive images, relies on the diffuse connections between the amygdala and various regions of the brain responsible for memory and sensory processing. This hypothesis is congruent with the animal and human studies discussed so far. Indeed, there is ample evidence that the amygdala provides the "affective flavour" to memories and damage to this region leads to impaired emotional memory, particularly memories related to aversive material (Adolphs, Tranel, & Denberg, 2000; Cahill, Babinsky, Markowitsch, & McGaugh, 1995; Zald, 2003).

An ingenious study has been carried out in order to further examine the role of the amygdala in the processing of emotional memory (van Stegeren et al., 2005). Participants were presented with emotional and neutral pictures after they had taken a β-receptor antagonists or a placebo drug. During the presentation of images, participants were scanned with an fMRI. The authors proposed that if the noradrenergic activity is essential for processing emotional information within the amygdala, then individuals administered the β-adrenergic receptor antagonists should show significantly reduced activation in this area. In order to establish if the arousal manipulation did produce a stress response the researchers took samples of salivary alpha amylase (sAA), a proposed marker for the activation of the noradrenergic system as well as the HPA-Axis (Rohleder, Nater, Wolf, Ehlert, & Kirschbaum, 2004; van Stegeren, Rohleder, Everaerd, & Wolf, 2006). Results from this study indicated that individuals in the placebo condition showed a significant elevation in sAA following exposure to negative emotional pictures. This effect was not apparent in the group that received the β-receptor antagonists. Importantly, individuals in the placebo group showed significantly elevated activation of the amygdala while watching emotional versus neutral pictures. This effect was not apparent in the group administered β-receptor antagonists group. The authors concluded that their findings support the role of noradrenalin in mediating activation within the amygdala during the encoding of emotional material. It is also important to note that additional studies have found evidence that administration of β-adrenergic receptor antagonists interferes with aspects of memory related to the encoding and retrieval of emotional material (e.g., Chamberlain, Muller, Blackwell, Robbins, & Sahakian, 1999; Kroes, Strange, & Dolan, 2010; O'Carroll, Drysdale, Cahlil, Shajahan, & Ebmeier, 1999).

Given the significance of these findings, the extent to which they apply to clinical models of PTSD have been examined by various researchers. In fact, the contribution of physiological stress responses to the formation of traumatic memories and flashbacks are incorporated, to varying degrees, across almost every contemporary model of PTSD (Brewin, 2008; Ehlers & Clarke, 2000; Elzinga & Bremner, 2002; Pitman, 2006). In particular, activation of noradrenergic systems at the time of trauma is suggested to be a key factor in the development of trauma memories and flashbacks (Bryant, 2006; Pitman, 2006). There exists substantial evidence to indicate that individuals with PTSD often demonstrate enhanced physiological arousal immediately following a traumatic incident as well as in periods of weeks or months following a trauma. To date, research in this area has come primarily from three different types of studies. First, many correlational studies have examined physiological arousal and stress responses in individuals who have been diagnosed with PTSD. Second, there exist several prospective studies that have examined the extent to which physiological arousal immediately following a trauma can be used to predict the development of PTSD. Finally, several recent studies have suggested that interventions that reduce physiological stress responses following trauma decrease the likelihood of the development of PTSD. Results from each of these lines of research will be briefly summarized.

A multitude of studies have examined physiological arousal in individuals who have been diagnosed with PTSD. Traditionally, researchers have examined increased physiological arousal in individuals with PTSD through using four different paradigms: resting baseline approaches, startle studies, standardized trauma cue studies, and idiographic trauma cue studies. In the first meta-analysis to examine each of these types of studies, Pole (2007) examined the relationship between PTSD and the following physiological variables: facial electromyography (EMG), HR, skin conductance (SC), and blood pressure (BP). Findings from this study indicate an overall elevation in physiological responses among individuals with PTSD, with effect sizes generally ranging from small to medium. In addition, Pole reported that these variables differed across different study paradigms. For example, for individuals in resting baseline studies only HR and SC were related to PTSD. In startle studies, individuals with PTSD were found to have enhanced responses as assessed by EMG, HR, and SC. Across standardized trauma cue studies only increases in HR were found among individuals with PTSD. In idiographic trauma cue studies several measures were associated with PTSD including EMG, HR, and SC. An additional finding of interest is that individuals with more severe PTSD symptoms tended to have increased levels of physiological arousal across all parameters. Overall, results from Pole's (2007) meta-analysis are in agreement with earlier meta-analyses, all of which indicate individuals with PTSD can often be characterized as having a heightened level of physiological arousal and reactivity (e.g., Brewin, Andrews, & Valentine, 2000; Buckley & Kaplouek, 2001; Metzger, Orr, Berry, Anhern, Lasko, & Pitman, 1999; Ozer Best, Lipsey, & Weiss, 2003).

Recently, researchers have started to examine the extent to which immediate physiological reactions that occur in response to a trauma can predict the development of PTSD. This research is in line with most theories that highlight the role of physiological arousal in general, and adrenergic influences in particular, as key contributors to the development of PTSD at the time of trauma (e.g., Bryant et al., 2006; Elzinga & Roelofs, 2005; Pitman, 2006). Two separate reviews of these studies have indicated that an increase in physiological arousal immediately following a trauma appears to be associated with increased risk of developing PTSD (Bryant, 2006; Delahanty & Nugent, 2006). Specifically, Bryant's review reported that eight of ten studies found evidence for the relationship between increased HR following a trauma and an increased risk of developing PTSD within the next year. A recent multisite study of over 1,000 individuals exposed to trauma provided supportive evidence for this proposition, indicating that increased heart and respiration rate doubled the likelihood of an individual meeting diagnostic criteria for PTSD when assessed three months later (Bryant, Creamer, O'Donnell, Silove, & McFarlane, 2008). An additional review conducted by Delahanty and Nugent (2006) reported similar findings, but also highlighted the fact that individuals who develop PTSD often show a decrease in cortisol levels immediately following a trauma, and this is predictive of PTSD at follow-up. These findings suggest that an increase in adrenergic activity at the time of trauma, combined with a lack of an appropriate cortisol response, may lead certain individuals to be at an increased risk of developing PTSD.

The clinical implication of the research summarized thus far suggests a key role of adrenergic system activation and the development of PTSD. Recently, several innovative studies have attempted to draw on this proposition in order to prevent the development of PTSD through the administration of pharmacological agents that inhibit the adrenergic system and reduce physiological arousal. Certainly, there has been ample evidence from animal studies suggesting that inhibition of the adrenergic system can lead to decreased fear conditioning responses (for reviews see Kindt, Soeter, Vervliet, 2009; Pitman, 2006; Rodrigues, LeDoux, & Sapolsky, 2009). This approach has only recently been applied to humans who have experienced a trauma. In an early study, individuals with PTSD were administered propranolol (a β-adrenergic receptor antagonist) immediately following the trauma. This led to a decreased conditioned fear response when tested three months later (Pitman et al., 2002). Two additional studies have provided evidence that the administration of propranolol immediately following a trauma may reduce the risk of developing PTSD (Stein, Kerridge, Dimsdale, & Hoyt, 2007; Vaiva, et al., 2003). Furthermore, there is some evidence that other agents known to interfere with adrenergic activity may also reduce the risk of developing PTSD: opioids, α-2-adrenergic agonists, and γ-amino butyric acid (GABA)-ergic agents (Pitman, 2006).

The pharmacological approach to preventing PTSD may eventually prove to be an effective means of reducing the risk of developing PTSD. However, it is important to note that the studies described here were generally exploratory and often consisted of small sample sizes and lacked random assignment and appropriate control conditions. Well controlled, large-scale studies are underway to further evaluate the utility of this preventive approach (Searcy, Bobadilla, Gordon, Jacques, & Elliott, 2012). It is also important to note that this approach is not without its critics who suggest this type of intervention can be criticized on moral, ethical, and legal grounds (e.g., Aoki, 2008; Henry, Fishman, & Youngner, 2007). For example, these agents could interfere with recollections of a trauma that would be important if an individual were to testify in court. Alternatively, it has been argued that these agents may also interfere with normal day-to-day memory functions. As such, alternative approaches to prevention of PTSD through noninvasive cognitive tasks have been suggested. To date, this approach has been successful at reducing the frequency of intrusive memories that occur within laboratory research paradigms (e.g., Brewin, 2008; Holmes et al., 2009; Holmes et al., 2004).

Given the breadth of experimental and theoretical research summarized above, there would appear to be a link between physiological arousal in general, and (nor)adrenergic activity specifically, to the development of PTSD. This link extends to most facets of PTSD, including the development of flashbacks and increased fear responses. How, then, can the apparently contradictory findings reported by Holmes et al. (2004) be integrated into these findings? Recall that in Holmes' analogue trauma film study, participants showed a decrease in HR while watching the trauma film and this was related to an increase in the occurrence of intrusive thoughts over the ensuing week. When the data were further analysed, the researchers identified that instances of the film that were associated with the content of flashbacks tended to occur during periods of decreased HR. The authors suggest that this effect may be due to a dissociative "freezing" stress response aimed at increasing awareness of the environment and preparation of resources in the face of overwhelming stress.

Current perspectives acknowledge that HR is not modulated in a strictly antagonistic manner between sympathetic and parasympathetic systems. Instead, it is currently accepted that HR is the function of three patterns of activity by the autonomic nervous system, which include parasympathetic and sympathetic influences. The first pattern of activity is referred to as the *reciprocal modes*, where one branch's activity increases as the other decreases. Alternatively, in the *coactivated mode,* both systems increase together to varying degrees. Finally, in the *uncoupled mode*, one branch can increase with no corresponding change in the other system (Berntson et al., 1997; Berntson, Cacioppo, & Quigley, 1991). Furthermore, parasympathetic influences on HR greatly exceed those of the sympathetic system with parasympathetic influences exerting a wider range of chronotropic control relative to the sympathetic influences. Statistical models based on pharmacological blockade and physical challenges indicate that the influence of parasympathetic to sympathetic contributions to changes in heart rate is of the magnitude of 7:1 (Berntson, Cacioppo, & Quigley, 1993).

Therefore, it is possible that what Holmes et al. (2004) observed was a decrease in HR attributable to a coactivated increase in both sympathetic and parasympathetic systems. Given the overwhelming influence of the parasympathetic influence on HR, a decrease in HR may have been expected. This interpretation provides a parsimonious explanation of Holmes et al.'s findings; it is also in line with the vast majority of research that has emphasized the necessity of sympathetic contributions to emotional memory facilitation and in its role in the development of PTSD. This proposition is one of the major issues that the present study attempted to clarify through assessing both branches of the autonomic nervous system.

The importance of this proposition was emphasized in a recent study (Hopper, Spinazzola, Simpson, & van der Kolk, 2006) where the authors argued that the relationship between sympathetic activity and HR may have been overemphasized in PTSD research. The authors contend that HR is the result of any of the three processes discussed above, and that only through assessing both branches of the autonomic nervous system is it possible to understand the underlying mechanisms that are responsible for HR. Hopper et al. suggest that the use of heart rate variability (HRV), which can be assessed noninvasively through traditional electrocardiogram techniques, provides a method to explore parasympathetic influences. The variability in HR is associated with both sympathetic and parasympathetic influences can be examined by measuring indices of HRV. It has been proposed that higher levels of vagally mediated HRV (i.e., increased parasympathetic tone) are often associated with better affective and attentional regulation (e.g., Appelhans & Luecken, 2006; Lane et al., 2009; Thayer & Brosschot, 2005). For example, individuals with increased vagally mediated HRV tend to have faster habituation to non-threat stimuli as opposed to those with low HRV that is associated with hypervigilance and defensive reactions when exposed to threat-related words (Thayer & Lane, 2000). The neural origins of cardiac modulation that have been suggested to involve both cortical and subcortical structures have been collectively named the central autonomic network. The primary output of this network is suggested to occur through preganglionic sympathetic and parasympathetic neurons that innervate the heart. The interaction of these sympathetic and parasympathetic influences thus collectively contributes to the variability in HR.

The need to examine the relative contributions of the autonomic nervous system has been highlighted recently by several authors (e.g., Bryant et al., 2008; Hopper et al., 2006; Pole, 2007). Ideally, this would occur through examining the independent contributions of parasympathetic and sympathetic influences on cardiac activity. In the present study, cardiac measures that are proposed to index both parasympathetic and sympathetic activity were measured in order to examine their relative contribution to the development of intrusive images.

Hypotheses Related to the Development of Intrusive Memories

The present study aimed to replicate some of the findings reported by Holmes et al. (2004) and Holmes et al. (2009). Similar to what was conducted in these studies, participants were asked to view a film with traumatic content during which psychological and physiological measures were taken. The main goal of this study was to replicate the overall finding that when participants are asked to participate in a visuospatial task (Tetris) following a trauma film they will show a reduction in the frequency of intrusive thoughts in the week following exposure to the trauma film (Hypothesis 1).

In the Holmes et al. (2009) study, participants who engaged in the Tetris task reported fewer symptoms related to PTSD as compared to those in the control condition. This finding was based on a clinical scale that assessed PTSD symptoms, the Impact of Events Scale (IES; Horowitz, Wilner, & Alvarez, 1979). In the present study, we attempted to replicate this finding. Furthermore, it has been suggested that preexisting affect, such as trait anxiety, may contribute to the development of PTSD (Ozer et al., 2003; Regambal & Alden, 2009). Therefore, we proposed that trait anxiety would contribute to scores on the IES. Furthermore, we suggest that one mechanism by which Tetris may exert its positive effect is through moderating the relationship between trait anxiety and scores on the IES (Hypothesis 2). In other words, we expected that Tetris would interfere with the natural tendency for highly anxious people to experience PTSD-related symptoms in response to the film.

The present study also examined the extent to which psychological reactivity to the film, and recovery following the film, would be related to the frequency of reported intrusive memories. Trauma film studies have often been used to examine these contributing factors as they are not easily assessed in individuals at the time of an actual trauma. For example, Regambal and Alden (2009) reported that various mood states, assessed both prior to and following viewing a trauma film, were related to the frequency of intrusive thoughts about the film's content. These mood states included happiness, depression, anxiety, anger and rumination. As previously mentioned, dissociation at the time of viewing the film is another factor that has been associated with the development of intrusive memories. Therefore, consistent with dual representation theory as well as cognitive models of PTSD development, we hypothesized that psychological reactivity to the film would predict the frequency of reported intrusive images and that engaging in the Tetris task would attenuate this reactivity (Hypothesis 3).

Given that the role of physiological influences on the development of intrusive images has not been thoroughly explored, we further proposed that changes in cardiac measures of sympathetic and parasympathetic activity would predict the frequency of intrusive images. We also examined a proposed salivary marker of sympathetic activity for its potential to predict on the frequency of intrusive images. Together, we expected that physiological measures would be associated with the frequency of reported intrusive images (Hypothesis 4). In addition, given the mixed findings related to physiological underpinnings of dissociative reactions, we explored the extent to which dissociation was related to measures of physiological arousal. We proposed that dissociative responses would be related to increased sympathetic and parasympathetic activity (Hypothesis 5).

Application of the Dual Representation Theory to the Phenomena of Increased Arousal

In addition to the hypotheses listed above, the present study also examined the extent to which the dual representation theory could explain the development of increased arousal that is often observed in individuals with PTSD. As previously discussed, individuals with PTSD often express an enhanced level of physiological arousal at rest. In addition, researchers have examined this phenomenon within a laboratory environment making use of various startle paradigms. Generally, the startle reflex is measured by presenting loud white noise through headphones at random intervals and recording physiological reactivity by facial electromyography (i.e., eyeblink startle responses), skin conductance, and HR. Although most individuals show a startle reaction, defined as an increase in physiological reactivity across all measures, individuals with PTSD generally show an exaggerated response. Two meta-analyses have provided evidence for this proposition. The first meta-analysis examined 11 studies and reported an increase in reactivity on measures of eye blink responses, HR, and skin conductance (Metzger, et al., 1999). Furthermore, Pole's (2007) analysis of 25 studies suggests that significantly elevated reactivity across all of the same variables. Collectively, it would appear that studies using startle paradigms generally produce some of the most consistent results related to increased physiological reactivity in PTSD. This is not necessarily surprising as an increase in arousal is one of the required diagnostic features of PTSD (American

Psychiatric Association, 2000) and experiences of exaggerated startle are among the most commonly reported by individuals with PTSD (Davidson et al., 1991).

The nature of exaggerated startle responses are, as of yet, poorly understood. Explanations of this feature of PTSD often depend on the theoretical background of the researcher. Current theories suggest it may be due to overactive unconditioned responses (Guthrie & Bryant, 2005), neuronal sensitization (Shalev et al., 2000), and/or excessive negative emotions due to hypersensitivity to contextual threat cues (Lang, Bradley, & Cuthbert, 1998; Pole, Neylan, Best, Orr, & Marmar, 2003). Although direct evidence for any of these propositions has yet to be firmly established, it is important to mention that these propositions are not mutually exclusive and may collectively contribute to explaining the phenomena of increased startle responses.

What has been made clear in the past decade is that the magnitude of the startle reaction can be modulated through exposing individuals to emotionally valenced stimuli prior to the onset of startle stimuli. A motivational priming model has been proposed that suggests that aversive and appetitive motivational systems interact with the defensive startle response (Lang, 1985). For example, when individuals are exposed to aversive images prior to an auditory startle stimulus, the magnitude of the eyeblink startle response tends to be significantly increased. In contrast, presentation of appetitive images decreases the magnitude of the startle response (Bradley, Considpoti, Cuthbert, & Lang, 2001). This paradigm has been used across multiple clinical groups and researchers suggest that this effect is more pronounced among individuals who have difficulty in emotional regulation and dysregulated fear responses, such as those with anxiety disorders and depression (Allen, Trinder, & Brennan, 1999; Grillon, 2002).

In addition to the startle response, affective modulation of arousal has also been demonstrated to occur on the cardiac defence response (CDR). When faced with an intense auditory stimulus of relatively long duration (similar to those used in eyeblink startle studies) the cardiac response tends to show a predictable reaction pattern (Villa et al., 2007). Initially there is a short acceleration in HR followed immediately by a period of deceleration. This initial response tends to occur between 3 - 5 s following the presentation of a stimulus and has been suggested to involve primarily parasympathetic influences. Specifically, an initial withdrawal of parasympathetic influences increases HR that is followed by renewed parasympathetic input that decreases HR. The second response tends to occur between 10 - 50 s following exposure to the stimulus and also involves a period of acceleration in HR followed by a deceleration. This second part of the response has been proposed to involve sympathetic and parasympathetic influences, among which sympathetic influences appear to be dominant. Specifically, sympathetic influences are largely responsible for the second acceleration component and the deceleration is due to a decrease in sympathetic activity and an increase in parasympathetic activity (Reyes Del Paso, Godoy, & Vila, 1993; Vila et al., 2007). Similar to what has been found in eyeblink startle studies, when individuals are exposed to aversive images prior to the onset of the auditory stimulus the CDR is clearly potentiated (Ruiz-Padial, Mata, Rodriguez, Fernandez & Vila, 2005; Ruiz-Padial & Vila, 2007).

As previously summarized, there exists substantial evidence that an interaction between sympathetic activation and enhanced emotional encoding occurs within the amygdala (e.g., McGaugh, 2004; Roozendaal, et al., 2009). Based on the startle and cardiac defence studies discussed here, it would appear possible that this same interaction may be responsible for the development of affect modulated startle responses. This proposition is in line with Brewin et al.'s (2010) perspective that the enhancement of S-reps relies on amygdala activation. Therefore, affect modulated defensive responses provide an opportunity to examine the application of the dual representation theory in explaining the development of this feature of PTSD. It is possible that the same mechanisms that are involved in the development of intrusive memories play a role in the development of increased arousal in general and exaggerated startle responses in particular. Specifically, preferential encoding of S-reps may contribute to the exaggerated startle response to images that have been encoded with affect-laden associations.

Hypotheses Related to Increased Defensive Responses

Based on the information reviewed, there is both a theoretical and physiological basis to suggest the dual representation theory may explain the acquisition of enhanced defensive reactions in individuals following a trauma. Based on this premise, we proposed that individuals who carried out a visuospatial task following a trauma film would have a decreased pattern of physiological startle responses. In order to examine this proposition, participants were asked to engage in an affect-modulated startle task. This task involved presenting participants with either neutral or aversive images taken from a trauma film prior to the onset of the auditory startle stimuli. If the visuospatial task interfered with the consolidation of emotionally laden memories related to the film, individuals who engaged in this task were expected to show a blunted physiological reaction to the CDR trial (Hypothesis 6) as well as to the eyeblink startle task (Hypothesis 7), relative to their counterparts in a resting control condition.

Method

Study Design

The procedures used in the study are depicted in Figure 1. In the preliminary phase, participants were asked to go to a website that provided them with a description of the study and presentation of consent forms. Participants were also asked to provide basic demographic information and complete a preliminary measure. The experimental component of the study consisted of two distinct phases. In the first phase, participants attended a laboratory session. During this session, participants completed baseline measures and then viewed a film with traumatic content. After viewing the film, participants were then randomly assigned to either sit quietly or play Tetris for 10 min. Following this task, participants were asked to stay seated for an additional 5 min. Throughout the experiment, participants were asked to complete self-report measures, provide saliva samples, and were monitored using electrocardiography.

At the end of the first session, participants were provided with a diary to monitor the frequency of intrusive images they experienced over a period of seven days. Participants returned the diary on the seventh day and completed a measure to assess the psychological impact of the film. The dependent variable of interest in this phase of the study consisted of the number of reported intrusive images experienced by participants. In Phase 2 of the study, participants completed two tasks designed to elicit defensive responses. This included a single CDR trial followed by a series of eyeblink startle trials. For CDR trials, change in heart rate from baseline in response to the startle stimuli was

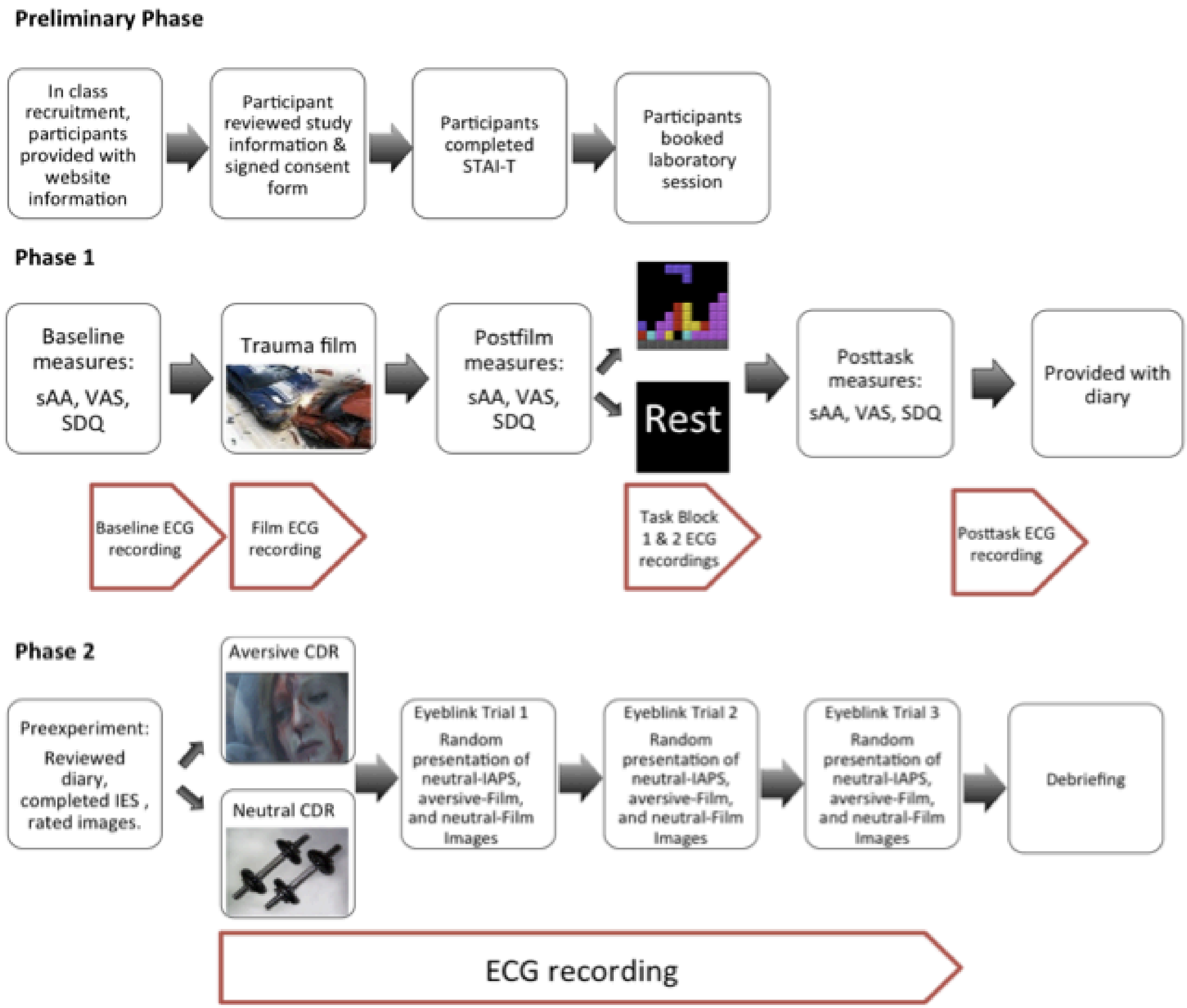


Figure 1. Experimental procedures carried out through both phases of the study. STAI-T = State Trait Anxiety Inventory – Trait ; sAA = salivary α-amylase; VAS= visual analog scale ; SDQ = State Dissociation Questionnaire; IES = Impact of Events Scale; IAPS = International Affective Picture System; CDR = cardiac defense response.

used as the dependent variable of interest. For eyeblink startle trials, the magnitude of the startle response was main dependent variable that was examined.

Participants

Participants were recruited from the Introductory Psychology courses at Lakehead University and had the opportunity to earn bonus marks towards their final grade. As part of the consent procedure participants were fully informed about the nature of the study and the content of the film (see Appendices A and B for the introductory letters and the consent form). Figure 2 provides details in regards to participant enrolment, random assignment, and retention. The mean age of participants was 21.11 years (SD = 5.63) and consisted of 81 females (62.8%) and 48 males (37.2%). Experimental conditions did not differ in terms of their age $t(118) = 1.14$, $p = .256$ or the distribution of males and females in each experimental condition,$X^2(1) = .194$, $p = .660$.

Self-Report Measures

Measures of affect. In order to assess trait anxiety the trait version of the State-Trait Anxiety Inventory – Trait version (STAI-T; Spielberger, 1983) was used. The STAI-T contains 20 items (see Appendix C) which describe how anxious people feel; items are rated on a 4-point scale ranging from 1 (*almost never*) to 4 (*almost always)*. The reliability and validity of the STAI has been reported across numerous studies that have demonstrated adequate psychometric properties (e.g., Barnes, Harp, Jung, 2002; Bieling, Antony, & Swinson, 1998; Spielberger, 1983). In the present study, Cronbach's alpha was .944 for the entire sample. In order to examine state changes in affect a series of visual analog scales (VAS) were used to assess state feelings of depression, happiness, anger, and anxiety (Regambal & Alden, 2009; see Appendix D).

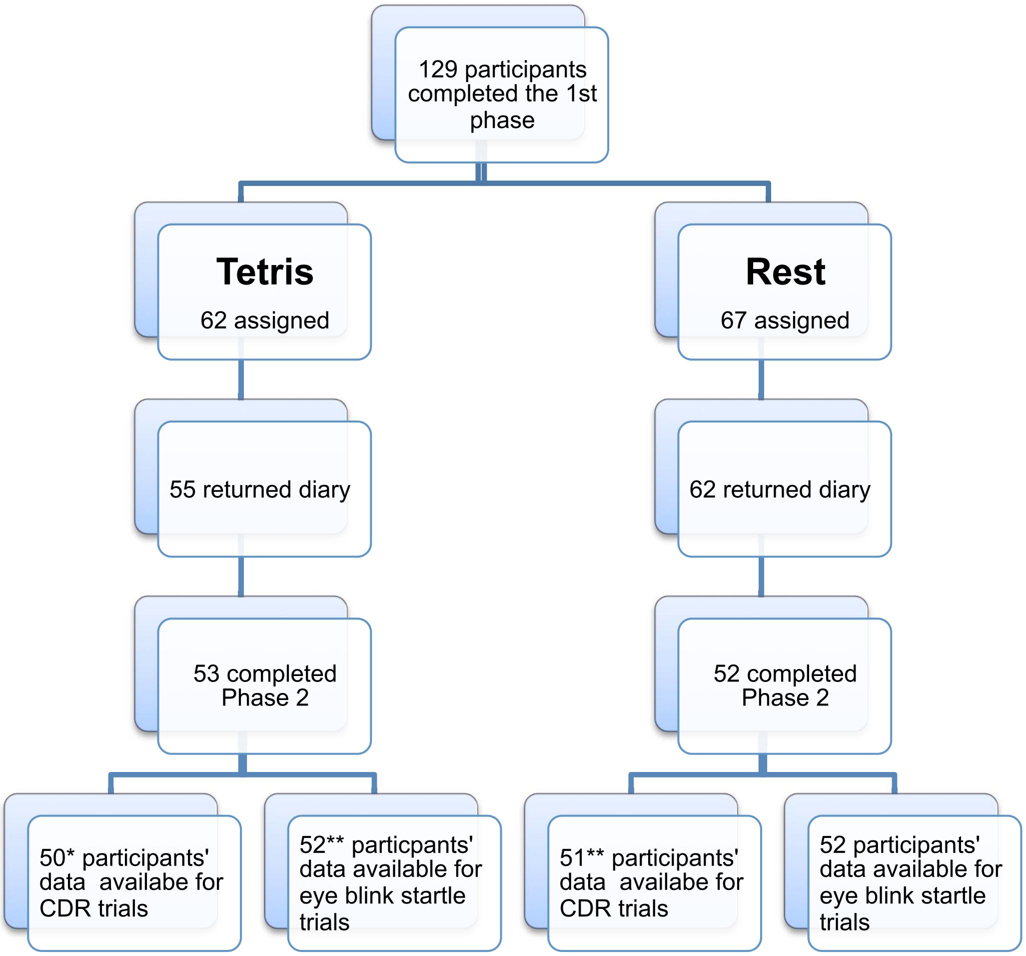


Figure 2. Participant flow diagram showing the number of participants within each experimental condition across different phases of the study. * = data for three additional participants was not included in analyses due to unstable recording patterns. ** = data from one additional participant removed due to recording error.

State Dissociation Questionnaire. Dissociative responses were examined through the use of the 9-item State Dissociation Questionnaire (SDQ; Ehlers, 2002). Participants were asked to rate their current perception of dissociative symptoms based on how much each statement was true for them on a 0 (*not at all*) to 4 (*very much*) scale. This scale has been validated across several studies in both clinical and non-clinical student populations and has demonstrated reliability and validity (Halligan, Clark, &

Ehlers, 2002; Murray, Ehlers, & Richard, 2002). The items are included in Appendix E. In the present study, Cronbach alpha's were calculated to be .896 at baseline, .845 postfilm, and .854 at the final measurement period.

Intrusion Diary. Participants recorded the number of intrusions experienced using a tabular diary identical to the one used in a previous study by permission of the authors (Holmes et al., 2009; see Appendix F). Following completion of the first laboratory session, participants were given verbal and written instructions on how to complete the diary. Participants were provided with a definition of intrusive thoughts indicating that they were "spontaneously occurring recollections or sensory experiences that were not deliberately recalled". Participants were asked to carry the diary with them and complete it on a daily basis. In the diary, participants were to indicate the number of intrusive thoughts, images, and co-occurring thoughts and images they experienced on a daily basis. Participants were also asked to write out a brief description of each intrusion. When participants returned the diary, the experimenter reviewed each entry and ensured that the content of their reports was spontaneous and described a scene taken from the film. Following the methodology employed in previous research (Holmes et al., 2009), the frequency of reported image intrusions were used as the main dependent variable of interest from this diary.

Impact of Events Scale. Participants were asked to complete the Impact of Events Scale -Revised (IES-R; Weiss & Mamar, 1997) based on their experience of watching the trauma film. The IES-R is a measure of symptoms associated with experiencing stressful life events and is based on symptoms related to PTSD (see

Appendix G). Items on this scale are answered based on a 5-point scale ranging from 0 (*not at all*) to 4 (*extremely*). Psychometric properties of this instrument have been established across several studies indicating acceptable levels of reliability and validity (e.g., Morina, et al., 2010; Weiss, 2007). In the present study, Cronbach's alpha was calculated to be .891 across the entire sample.

Self-monitored intrusions. Participants in both conditions were asked to monitor the frequency of intrusive thoughts and images they experienced while playing Tetris or resting quietly. Participants were provided with a description of what intrusive thoughts consisted of prior to engaging in this task. In order to monitor these intrusions, participants were given a hand tally clicker and were instructed to press the button every time they had a thought or image enter their mind that was from the movie. The use of a hand tally clicker has been used in previous studies (Davies & Clark, 1998) although this varies from the method used by Holmes et al. (2009) who asked participants to draw out a tally of the number of intrusions using a pen and paper.

Self-Assessment Manikin. The Self-Assessment Manikin (SAM; Bradley & Lang, 1994; Appendix H) is an instrument that can be used to assess the emotional valence a person experiences in response to a situation or stimuli. The instrument makes use of a series of facial expressions in which individuals are asked to indicate which image most closely resembles their current feelings based on a 9-point scale. Participants rated their feelings using the SAM while viewing each of the images. Ratings of these images were based on affective valence (unhappy to happy) and arousal (excited to calm) that each image elicited. The SAM can be used as a reliable and valid measure of affective balance and arousal, as demonstrated across several studies (e.g., Bradley & Lang, 1994; Lang, Bradley, & Cuthbert, 1997).

Biometric Data

Salivary α-amylase (sAA)**.** In order to avoid confounding the assays, participants were asked to abstain from food, caffeine, and tobacco for a period of 1 hr prior to the laboratory session. Saliva samples were collected using the "passive drool" technique (Navazesh, 1993) at three different time intervals. Participants were provided with three 1.8mL vials, three small straws, both of which were placed in a small cup. Participants were provided with instructions prior to collecting the first sample and were asked to provide additional samples at the appropriate phase of the study. In order to collect sufficient sample participants were asked to provide 1mL of saliva in each vial. Upon completion of the saliva collection, vials were placed in a Sorvall Legend RT+ centrifuge (Fisher Scientific Company, Toronto, ON) at 1500 x g (@3000 rpm) for 15 min after which the vials were stored in a freezer that maintained a constant temperature of -20°C. sAA analysis was conducted on the samples using a standard assay kit (Salimetrics, State College, PA, Catalog No.1-1909). The standard assay procedure provided by the manufacturers of the kit was followed (Salimetrics, 2012). A SpectraMax Plus 384 plate reader (Fisher Scientific, Sunny Vale, CA) was used to assess optical densities of the assay using a 405 nm filter.

Electrocardiogram & electromyogram data collection. Identical procedures were used to monitor cardiac activity throughout the first phase of the study and during the CDR trials in the second phase of the study. A set of snap-on Ag-AgCl electrodes were placed below the right clavicle and below the left rib cage (i.e., a lead II) to collect electrocardiogram (ECG) data. Ground electrodes were placed on the participants' right leg for ECG data. These electrodes were connected to a 72-channel amplifier (Advanced Neuro Technology, Enschede, Netherlands) via shielded wires. All data was sampled at 1024 Hz using ASA-Lab software (Version 16) running on a PC. Prior to applying the electrodes, the area to which they were applied was cleaned with an alcohol solution to remove any dirt or debris. Signals for facial electromyography (EMG) were collected on the same apparatus through the placement of two Ag-AgCl electrodes over the orbicularis oculi muscle of the left eye. For EMG trials, the ground electrode was placed on the center of the participants' foreheads.

Two cardiac metrics were of particular interest in the first phase of the study. The first of these was respiratory sinus arrhythmia (RSA), a well-established measure of heart rate variability that has been described as one of the best markers for parasympathetic influences on cardiac activity (Allen, Chambers, & Towers, 2007; Lewis, Furman, McCool, & Porges, 2012). The second measure of interest was the Cardiac Sympathetic Index (CSI), a metric proposed to assess sympathetic influences on heart rate. The validity of this measure has been demonstrated through pharmacological blockage (Toichi, Sugiura, Murai, & Sengoku, 1997). These two markers provide unique information related to autonomic influences on HR and HRV, a finding that has been confirmed through recent factor analysis study (Allen et al., 2007).

Experimental Tasks

Trauma film. The enacted trauma film used in this study consisted of a video that depicts the dangers of sending text messages while driving a motor vehicle (Watkins-

Hughes, 2009). This film has been broadcast as a public services announcement and was made in collaboration with law enforcement officials in order to deter individuals from using cellular phones while driving. The film consists of a three females who get into a car accident resulting in bodily harm to themselves and others. The duration of the film is 4 min 53 s. The film ends with the individuals being taken away by emergency medical services. The film was displayed on a 72-inch Samsung DLP television.

Rest task. In order to provide a no-task control condition, participants assigned to this condition were provided with the following instructions: “We are now going to ask you to sit quietly for 10 minutes. If at any time you think of the movie you just watched, click the counter. Remember, thoughts of the movie can either take the form of words and phrases (i.e. verbal thoughts), or it they can be mental pictures (images) in your mind’s eye. Thoughts can include any of the five senses, so you can include sounds too.”. Participants were asked to monitor only intrusive thoughts and images and were reminded of the difference between these and purposefully recollected thoughts.

Tetris task. The popular video game Tetris (Tetris Zone, Version 1.2.1, Tetris Holding, LLC) was used as the main experimental condition in the study. As previously discussed, Tetris is a game that relies on visuospatial skills and was previously used in Holmes et al.’s (2009) study. Participants were given a numeric keypad and asked to play the game with their dominant hand for a period of 10 min. The same instructions were provided to participants in regards to monitoring thoughts and images related to the film. Tetris was displayed on a 72-inch Samsung DLP television. All participants in this condition received instructions and a brief demonstration on how to play the game prior to participating in the task.

Defensive response tasks. Stimuli used to elicit the cardiac defense response and the eyeblink startle were presented on a 72-inch Samsung DLP television. Stimuli were presented through Eevoke software (version 1.05) that was synchronized with the ASA-Lab software. This combination of software allows for the onset of stimuli to be automatically indicated on the recordings of physiological responses. In order to elicit the CDR, participants were seated in front of the television screen and fitted with sound-isolating headphones (Sony, MDR-XD-300). Following the procedures described by Vila et al. (2007), a 15-s baseline recording occurred prior to the onset of an image that was displayed for 6 s. Participants were randomly assigned to first view either a neutral image from the International Affective Picture System (IAPS; Lang, 1997) or an aversive image taken from the trauma film. Following this, participants then viewed the other image. However, given the rapid habituation of the CDR response, only the first trial was analyzed. The neutral-IAPS was image #7042. The aversive-film image consisted of the one of the actor’s faces covered in blood. Following 3.5 s after the onset of the picture, the eliciting auditory stimulus consisting of 105 dB of “white” noise lasting 500ms with near-instantaneous rise time was administered through the earphones. The white noise consisted of an auditory test file with a frequency distribution of 1 as reported by the developer (Nechabur, 2002). The auditory stimuli were calibrated using an Audioscan RM500 real ear analyzer to verify the output of the headphones. Although the auditory stimulus is intended to elicit a startle response, the volume and exposure time that participants endure are well within safe limits (Canadian Centre for Health and Safety, 2009). Cardiac responses were continuously measured for a period of 80 s following the presentation of the picture for the each of the CDR trials.

A similar procedure was used to elicit the emotion-modulated eyeblink response immediately following the CDR task. This procedure followed that described by Lang (1995). This part of the experiment consisted of three blocks of stimulus presentations. Each block consisted on one neutral-IAPS image, one aversive-film image, and one neutral-film image. Presentation of these stimuli was randomized within each block. All image presentations were displayed for a period of 6 s. The onset of the acoustic stimuli occurred randomly between 2-5 s following the onset of the picture presentation. Neutral-IAPS images consisted of images #7002, #7013, and #7034. Aversive-film images consisted of a windshield covered in blood, a fireman attending to a victim, and two victims sitting in a car following the crash. Neutral-film images consisted of pictures of a baby, a map, and the back of a man's head. Acoustic stimuli consisted of 105 dB "white" noise with a duration of 50 ms and virtually instantaneous rise time. The interval between trials varied randomly between 19 and 26 s.

Experimental Procedures

Preliminary Phase. During recruitment process, the experimenter visited classrooms and provided potential participants with a description of the study. Participants were informed that the purpose of the study was to examine intrusive thoughts and that these may be experienced by participants following the viewing of the film. All participants were informed that the study had been reviewed and had received ethical approval from the Lakehead University Research Ethics Board.

Initially, potential participants were asked to visit a website for more details. Upon arriving at the secure website (www.surveymonkey.com) participants were asked to read a written description of the experiment (see Appendix A) and to electronically sign a consent form (see Appendix B). Participants were then asked to provide demographic information (see Appendix I) and to complete the STAI-T. In order to schedule a laboratory session participants were directed to a secure website book a time slot (http://www.sona-systems.com/).

Phase 1. Upon arrival at the laboratory for the first session, participants were once again provided with a detailed description of the study. ECG recording devices were then applied. From this point on, the experimenter was in an adjacent room and all instructions were provided via a slideshow presentation. The experimenter was available to participants via a walkie-talkie in cases where they had questions or concerns. Participants were asked to seat themselves comfortably and a 2-min rest period occurred prior to collecting baseline data that consisted of a 5-min recording of cardiac activity. Participants were then asked to complete the SDQ, the VAS for affective states, and provide the first saliva sample.

The next step in the study was to ask participants to view the trauma film that lasted for 4 min 53 s. Following the end of the film, participants provided another saliva sample and again completed the SDQ and VAS. Following this, participants were randomly assigned to either the rest condition or Tetris condition. In both conditions, participants were asked to monitor the frequency of thoughts they had related to the movie. In addition, cardiac recordings occurred throughout the task. Following the 10-min period, participants provided a final saliva sample and again completed the SDQ and VAS. An additional recording block of cardiac activity occurred for a final period of 5 min. Prior to leaving the laboratory, all participants were provided with a copy of the intrusion diary and given explicit instructions on how to keep track of intrusive thoughts and images.

Phase 2. Upon returning to the laboratory, the experimenter reviewed the completed diary with the participant. In order to assess the impact of the trauma film, participants were asked to complete the IES. Following completion of this measure, physiological recording devices were attached in order to collect both cardiac and EMG data. Participants were fitted with headphones (Sony model MDR-XD-300) and given instructions to stay seated and to keep their eyes on the screen throughout the tasks.

All participants underwent the cardiac defense trial task first. The CDR consisted of two trials whereby that participant was presented with either the aversive or neutral image paired with the auditory tone. Following this trial, participants were then presented with the nine eyeblink startle response trials. Finally, participants were debriefed on their experience and provided with a debriefing letter (see Appendix J).

Data Preparation and Reduction

Self-report measures. All questionnaire data were entered directly into SPSS (version 20) and screened for missing responses. On the SDQ three individual items were missing from the total sample from the posttask assessment and three individual items were missing responses from the postfilm assessment, representing less than 0.01% percent of the total data on these scales. In these cases, missing items were replaced with the participant's average of all other items on the scale. For the visual analog scales, no more than three items were missing at any given time point, on any of the individual scales, for the entire sample of 129 individuals, representing less than 0.05% of the total responses on these scales. Given that all missing data points on the VAS scales occurred following the baseline measure, the last available data point was carried forward to replace the missing observations. Prior to entering the data related to intrusive images, all diary entries were reviewed to ensure participants accurately recorded the frequency of intrusive images they experienced. Two main criteria were required for an intrusive image to be counted. First, participants were required to report intrusive images that were actually part of the film as opposed to a related thought or image that was not in the film. Second, the intrusive image was required to not have been deliberately recalled. In total, 119 participants returned their diaries completed; of these, two participants appeared to not have understood the instructions (e.g., reported purposefully recollected memories of the film as opposed to intrusive thoughts/images). The data from these two participants was not included in the analyses. No missing data was found for the IES.

Biometric data from phase 1. For sAA, four participants provided insufficient or obviously contaminated saliva. As a result, data from these participants were excluded from analyses that required this variable. Two additional participants failed to provide any sample for analysis.

Given that the film was displayed for only 4 min 53 s, recording blocks taken in Phase 1 of the study were shortened to be of equivalent length. Baseline recording blocks and the final recording blocks were shortened to 4 min 53 s in which the middle segment was chosen (i.e., 3.5 s were removed from the beginning and end of each block). In addition, the 10-min recordings taken while participants engaged in the rest or the Tetris task was divided into two segments of 4 min 53 s each; these blocks of data started immediately once the task began and lasted for 4 min 53 s after which the next block started immediately. In total, five recording blocks were then available for further analysis; baseline, film, task Block 1, task Block 2, and posttask. Each recording block was saved as an individual file for each participant.

Following the methodology described by Allen et al. (2011), cardiac data was imported into QRSTool (version 1.2.2, available from psychofizz.org) and manually reviewed and screened for recording errors and ectopic beats. Inter-beat intervals (IBIs) were created through automatic r-r wave interval detection routines within QRSTool. This routine requires that the experimenter identify a series of valid r-peaks over a 30 s period for each recording period. Based on these peaks, the software determines an appropriate threshold for each individual series and automatically detects additional r-peaks. Recording errors were defined as recording blocks with IBIs that could not be clearly differentiated from the rest of the signal. A total of nine individual recording blocks failed to record appropriately, representing less than .01% of total recording blocks; missing data for these participants were replaced with the last valid data point from the previous block (for eight replacements) or carried backwards from the subsequent block (for one replacement). However, for three participants more than two recording blocks were missing. The data for these individuals was not included in the analyses.

Possible ectopic beats were observed in 16% of the total blocks. Amongst these blocks, ectopic beats generally accounted for less than 5% of the total IBIs and were corrected using the standard procedures recommended by the authors of the software (Allen et al., 2007). Amongst the entire sample, the data for one participant was not included due to a large number of ectopic beats observed in the data (consisting of over

15% of total beats across each block). Once the integrity of the data was verified, the IBIs for each block were imported into CMetX (version 2.63) and the standardized conversion process and filters were applied, as recommended by Allen et al. (2007). CMetX converted the IBI series to a time series sampled at 10 Hz. The data was then filtered using a 241-point optimal finite impulse response filter with half-amplitude frequencies of 0.12 and 0.40 Hz, and the natural log of the variance of the filtered waveform was used as the estimate of RSA. The CSI metric was calculated using the method described by Toichi et al. (1997). This method plots each IBI plotted against the subsequent IBI for each participant and divides the length of the transverse axis of these data points by the length of the longitudinal axis to calculate the CSI. CMetX automatically analyzed and produced the relevant cardiac measures for each recording period including RSA, CSI, and overall HR.

Biometric data from phase 2. The data for one participant in this phase of the study was deemed invalid due to technical recording errors for both the CDR and eyeblink trials. For the CDR measure, the data from an additional three participants were excluded due to significant artifacts in the data, rendering the IBI series not suitable for analysis. IBI series that were required for CDR trial analysis were extracted from the recordings using ASA-Lab's automatic r-r peak detection algorithm. IBI series and event marker data was then imported into KARDIA (version 2.8). Following standard procedures for CDR analysis (Vila et al., 1992), weighted averaged second-by-second HR was measured for 80 s following the onset of the auditory stimuli and expressed in terms of a difference in HR from a 15 s baseline period that occurred prior to the onset of the auditory stimuli. Each of the 80-s values was then reduced to 10 medians of 10 progressively longer intervals in order to facilitate statistical analysis. The median values therefore cover two periods of 3 s, two of 5 s, three of 7 s, and three of 13 s. These 10 intervals were then used as the main dependent variables for the CDR analysis.

Eyeblink startle data was amplified and integrated using ASA-Lab software with custom designed extraction algorithms. The guidelines set forth by Blumenthal et al. (2005) were used to apply appropriate rectification and filtering procedures. The signal for each response was first rectified and filtered using a frequency band of 28-400 Hz with a 75-msec time constant. The time constant was selected as it provides a balance between accuracy in detection rates and suppression of random error in peak amplitudes due to multiple peaks in a recording. The magnitude of the blink response was defined as the difference in microvolts between peak response occurring between 20-120 ms following the onset of the auditory startle stimuli and the average of a 15-ms prestimulus period. Each response was analyzed individually and approximately 5% of individual eyeblink responses were excluded from analysis due to unstable recording periods, lack of response, and/or delayed onset of the responses. Following the methodology described by Blumenthal et al. (2005), individual EMG responses were transformed to relative *z* scores within the range of individual participant responses to all nine startle tasks. One participant who had more than two missing values in one of the image categories was not included in the analysis due to the limited range of *z* scores that could be calculated based on the responses. *Z* scores for each trial within each image category (i.e., Neutral-IAPS, Aversive-Film, Neutral-Film) were then averaged for each participant. The average score for each image category was then used as the main dependent variable for the eyeblink startle responses.

Analytical Approach

The data were examined for missing values and prepared as discussed above. Replacement of missing values was conducted in order to allow for an equal number of data points to be used across analyses, particularly to allow equivalent regression models to be created using all participants. This process allowed model fit statistics to be compared across analyses. Tabachnick & Fidel (2007) suggest that replacement of missing values is appropriate if they represent less than 5% of the data; in the present study less than 1% of the data was found to be missing. However, in order to ensure the replacement of missing values did not have an effect on the reported results, all analyses were conducted with, and without, these replacement values. A comparison of these analyses did not suggest any appreciable differences in probability values, parameter estimates, or measures of variance/covariance.

Once missing values had been addressed, outliers within the data were identified for each measure prior to analysis. Univariate outliers were defined as transformed scores equivalent to $z > \pm 3.29$ (Tabachnick & Fidel, 2007). In cases where univariate outliers were identified and where significant skewness in its distribution was observed, statistical transformation were applied to correct for their impact on the normality of distributions. If outliers continued, they were replaced with the next highest value with a z-score < 3.29 plus a specified constant (as was appropriate for the data). Multivariate outliers were assessed through examination of Mahalanobis distances for data used in regression models, defined as values that exceeded a X^2 in which $p < .001$ (Tabachnick & Fidel, 2007). Univariate and multivariate outliers are described for each analysis below. For analyses that required univariate normality, $z_{\text{skewness}} = \text{skewness} - 0/SE_{\text{skewness}}$ which exceeded 1.96 (consistent with $p < .05$) identified variables that were then transformed using the methods described by Tabachnick and Fidel (2007) until skewness was reduced to an acceptable level.

In order to examine change across different sampling periods in Phase 1 of the study, a series of mixed model ANOVAs was used where assumptions related to normality were met. For these analyses, multivariate Wilks' Λ criterion and associated *F* statistics are reported. Box's *M* test was used to test for homogeneity of covariance matrices wherein values with $p < .001$ were considered to be unacceptable (Tabachnick & Fidel, 2007). Given that it was expected that differences would occur across measurement periods, repeated planned contrasts were carried out which compared each response to the previous response. When interactions between experimental conditions (Tetris or rest) and phase were expected, follow-up ANCOVAs were used to identify differences between conditions at each measurement period while controlling for baseline values on the dependent variable of interest. McNemar tests and Chi-Square analyses were used to examine changes in dissociative responses (based on the SDQ) given that assumptions related to normality were severely violated (see pages 62-63).

Once the effects of the manipulations were examined, specific analyses were conducted in order to address each of the study's main hypotheses. Hypotheses related to the development of intrusive memories were examined through the use of negative binomial regression models. Negative binomial models are a form of regression modeling that is suited to the prediction of frequency data particularly when distributions are over dispersed and/or highly skewed (Hilbe, 2011). Similar to other approaches to statistical regression, negative binomial models produce model fit statistics describing the extent to which the data match the expected model. In the present case the Bayesian information criteria (BICs) are reported as the primary model fit statistic, whereby lower values signify better model fits. Statistical tests of the entire model were reported using the omnibus test and reporting the likelihood ratio χ^2 statistic. Specific tests for main effects and interactions of predictors were examined using the model effect likelihood ratio $\chi^{2,}$ test. In addition, Incident Rate Ratios (IRRs) were produced that described the relative increase in the frequency of intrusive thoughts between conditions, based on the set of predictors. In the present study, this method was used to assess the increased risk of experiencing intrusive images for individuals in the rest condition as compared to the Tetris condition. Furthermore, psychological and physiological responses were examined for their ability to predict the frequency of intrusive images. In order to create comparable models across analyses, the same number of participants was used for each set of analyses. Specifically, in models 1 - 3 the same 117 participants were used. For models 4 - 7 data from the same 113 participants was used. Predictor variables were block entered into each equation based on theoretical predictions, as were the relevant interactions.

For the measure that examined the psychological impact of the film (IES), independent-sample *t* tests were used to compare experimental conditions. Furthermore, Moderation analysis was used to examine the impact of the experimental condition (Tetris vs. rest) on the relationship between trait anxiety (STAI-T) and self-reported reactions (IES) to the film. Data related to defensive reactions (CDR and EMG responses) were analyzed through the use of mixed model ANOVAs. Posthoc tests on data from the defensive response tasks were analyzed through one-way ANOVAs or independent-sample *t* tests. An additional moderation analysis was used to examine the impact of the experimental condition (Tetris vs. rest) on the relationship between scores on the IES and the magnitude of the eyeblink response to aversive-film images.

Results

Reactivity Check

Visual analog scales. Four VASs (see Appendix D) were used to assess psychological reactions to the film; depression, anger, anxiety and happiness. Preliminary analysis of these indicated high positive intercorrelations at all time periods, ranging from .461 - .728 for three of the scales (depression, anger, and anxiety). Consequently, a single composite variable of negative affect was created by adding scores on these three scales. A square root transformation was then applied to address the high level of positive skewness (see Table 1). Following the transformation no outliers were detected at any time point.

A 2-between (condition [Tetris, rest]) × 3-within (time [baseline, postfilm, posttask]) mixed model ANOVA was used to examine changes in this composite measure over time. Box's *M* Test for the assumption of homogeneity of covariance matrices was not significant, $p = .835$. A significant main effect of time was found, $F(2, 126) = 70.29$, $p < .001$, partial $\eta^{2} =$ .53 as was the interaction of Condition × Time , $F(2, 126) = 5.47$, $p = .005$, partial $\eta^2 = .08$ (see Figure 3). Repeated planned contrasts for the entire sample indicated a significant difference between baseline and postfilm, $F(1,127) = 125.07$, $p < .001$, and between postfilm and posttask $F(1,127) = 9.28$, $p = .003$.

The first ANCOVA examined differences on the measure of negative affect at postfilm while controlling for baseline values. Levene's test indicated that the data did

Table 1

Descriptive Statistics for the Measure of Negative Affect

			Range		
Time	*M*	*SD*	Potential	Actual	$z_{Skewness}$
		Untransformed			
Baseline	39.26	40.53	300	218	9.27
Postfilm	80.81	59.83	300	266	4.46
Posttask	51.96	52.12	300	204	6.07
		Square Root Transformed			
Baseline	5.42	3.14	17.32	14.76	1.86
Postfilm	8.29	3.49	17.32	16.31	0.01
Posttask	6.19	6.19	17.32	14.28	1.28

not violate the assumption of homogeneity of variance $F(1,127) = 0.44$, $p = .509$. Results did not indicate a significant difference between conditions $F(1, 126) = 0.81$, $p = .374$, partial $\eta^2 = .01$. The second ANCOVA examined differences between conditions at posttask while controlling for baseline values. Results again revealed that assumption of homogeneity of variance was not violated $F(1, 127) = 0.07$, $p = .793$. This analysis did indicate a significant difference between conditions, $F(1, 126) = 8.52$, $p = .004$, partial $\eta^2 = .06$. This analysis indicated that individuals in the Tetris condition reported lower scores (*M* = 5.69, *SD* = 3.89) on negative affect as compared to individuals in the rest condition (*M* = 6.46, *SD* = 3.54), while controlling for baseline negative affect.

The fourth VAS scale related to happiness was not highly correlated with the other VAS. This variable is henceforth referred to as positive affect. Nontransformed raw scores were analyzed given that none of the distributions possessed significant skew (see Table 2). No outliers were observed in the data.

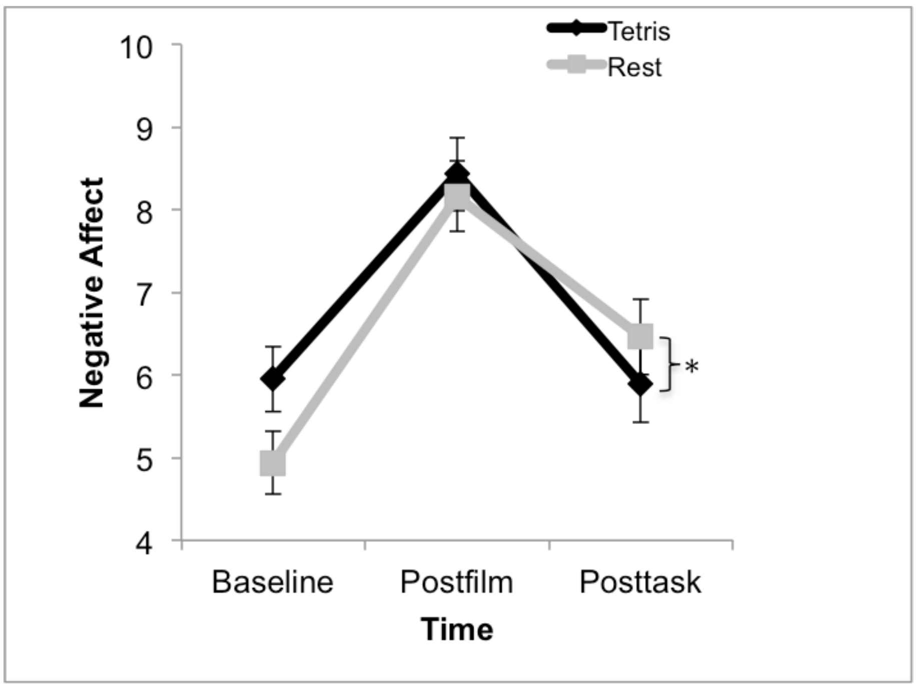


Figure 3. Negative affect plotted as a function of time and experimental condition. Error bars represent +/- 1 standard error. * $p = .004$, represents a significant difference between conditions.

A 2-between (condition [Tetris, rest]) × 3-within (time [baseline, postfilm, posttask) mixed model ANOVA was used to examine changes in positive affect. Box's *M* Test for the assumption of homogeneity of covariances matrices was not significant, $p = .386$. Results of this analysis indicated there was a significant main effect for time, $F(2, 126) = 89.70$, $p < .001$, partial $\eta^2 = .59$, and an interaction of Condition × Time $F(2, 126) = 6.77$, $p = .002$, partial $\eta^2 = .09$ (see Figure 4). Repeated planned contrasts for the

Table 2

Descriptive Statistics for the Measure of Positive Affect

			Range		
Time	*M*	*SD*	Potential	Actual	$z_{Skewness}$
Baseline	49.99	18.35	100	94	-1.49
Postfilm	29.40	20.81	100	79	1.84
Posttask	42.51	23.42	100	94	-0.07

entire sample indicated a significant change in score from baseline to postfilm, $F(1,127) = 175.33$, $p < .001$, and from postfilm to posttask $F(1,127) = 19.44$, $p < .001$.

Two follow-up ANCOVAs were used to analyze differences between conditions occurred at postfilm and posttask while controlling for positive affect at baseline. The assumptions regarding homogeneity of regression were met. Levene's test for violation of the assumption of homogeneity of variances were nonsignificant for the first and second ANCOVA, $F(1,127) = 2.22$, $p = .139$, and $F(1,127) = 0.01$, $p = .920$, respectively. The first ANCOVA did not indicate a significant difference between conditions on positive affect at postfilm, $F(1,126) = 0.30$, $p = .583$, partial $\eta^2 < .01$. However, the second analysis did produce a significant difference between conditions at posttask, $F(1,126) = 9.22$, $p = .003$, partial $\eta^2 = .07$. These results indicated that individuals in the Tetris condition had a higher level of positive affect ($M = 44.42$, $SD = 24.91$) as compared to individuals in the rest condition ($M = 40.76$, $SD = 21.86$), while controlling for baseline positive affect.

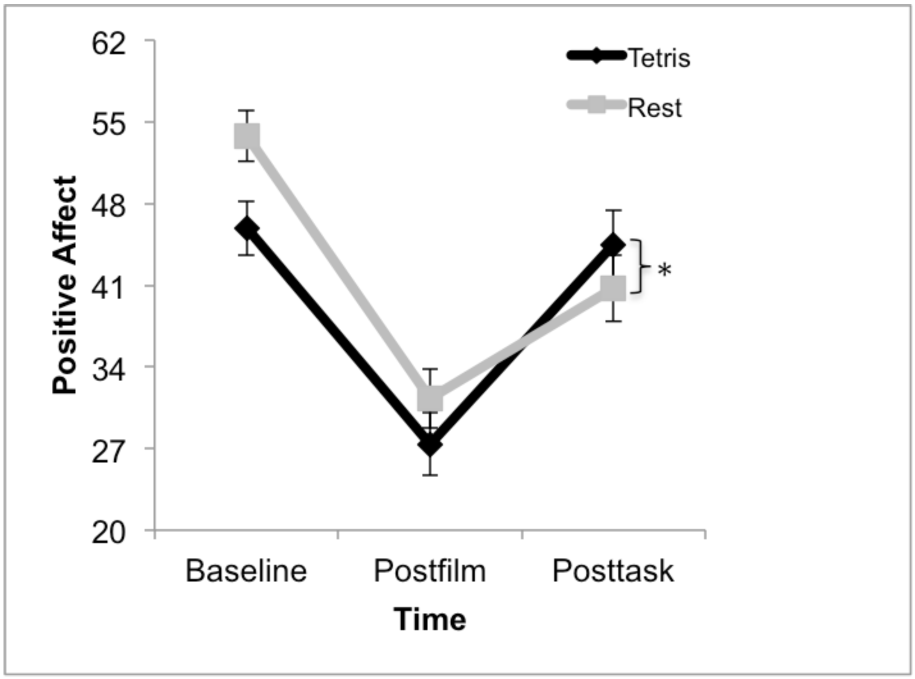


Figure 4. Positive affect plotted as a function of time and experimental condition. Error bars represent +/- 1 standard error. * p = .003, represents a significant difference between conditions.

State dissociation. Responses on the SDQ (see Appendix E) indicated that 37% (n=50) of participants did not report any dissociative symptoms on this 9-item scale at any of the four measurement occasions. Given the high level of skewness of this data (see Table 3), standard statistical transformations were not able to sufficiently normalize the data. Therefore, for the purpose of this specific analysis, the raw data was transformed into a dichotomous variable (Tabachnick & Fidel, 2007) indicating whether individuals rated themselves as having any level of dissociation versus none, coded as 1 and 0, respectively. In order to assess changes in reported dissociation from baseline to postfilm and from postfilm to posttask, McNemar Tests were used. Results of the first analysis revealed a significant increase in the number of participants reporting any dissociation, $\chi^2(1)$= 5.28 p =.022, as did the second analysis , $\chi^2(1)$= 6.62, p = .010 (see Figure 5).

Table 3

Descriptive Statistics for the State Dissociation Questionnaire

Time	*M*	*SD*	α	No. of items	Range: Potential	Range: Actual	$z_{Skewness}$
Baseline	2.98	4.49	.854	9	36	25	9.67
Postfilm	3.80	4.77	.845	9	36	20	6.72
Posttask	2.98	4.49	.854	9	36	25	9.81

In order to explore the potential differences between conditions, the Pearson's Chi-Square Test was calculated at each of the three time points. Results did not indicate a difference between conditions (*p*s $> .05$) on the number individuals experiencing any dissociative symptoms at baseline (53.3% vs. 59.7%, for Tetris vs. rest), postfilm (66.1% vs. 68.7%, for Tetris vs. rest), or posttask (66.1% vs. 56.7%, for Tetris vs. rest). Thus, viewing the trauma film increased dissociative experiences. Following the task dissociative experiences were reduced, although no differences between conditions were observed.

Cardiac responses. Cardiac indices were examined to ensure univariate normality. HR data was found to be significantly skewed at one time point, $z_{Skewness} = 3.34$; a log transformation was applied that corrected this, $z_{Skewness} = 0.81$. In addition, CSI was found to have a high level of skewness, $z_{Skewness}$ between 2.07 to 5.72, which was improved using a square root transformation , $z_{Skewness}$ between 0.65 to 3.52. Significant skewness was not found on the measure of RSA. No outliers were observed on any of the cardiac indices following required transformation.

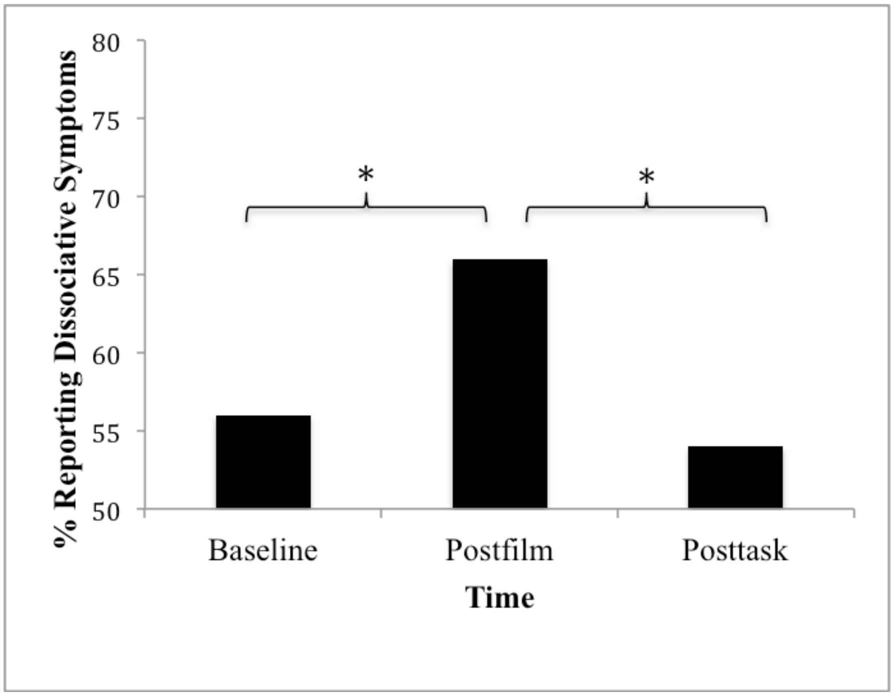


Figure 5. Percentage of total participants who endorsed any item on the State Dissociation Questionnaire. * $p < .05$, for between-time comparisons.

Changes in cardiac indices were examined through three mixed model ANOVAs that assessed HR, RSA and CSI. For HR, a 2-between (condition [Tetris, rest]) × 5-within (time [baseline, film, task Block 1, task Block 2, posttask) mixed model ANOVA was run. Box's *M* Test did not indicate any violations of the assumption of homogeneity of covariances matrices ($p = .018$) using the stringent criteria of $p < .001$. Results revealed a significant main effect for time, $F(4, 118) = 13.47$, $p < .001$, partial $\eta^2 = .31$. However, the Condition × Time interaction was not significant $F(4,118) = 0.27$, $p = .90$, partial $\eta^2 = .01$. Repeated planned contrasts indicated a significant increase from task Block 1 to task Block 2 and from task Block 2 to Posttask, *p*s < .001 (see Figure 6).

RSA data were subjected to the same ANOVA. Box's Test for the assumption of homogeneity of covariances matrices was not significant, $p = .316$. Results from this

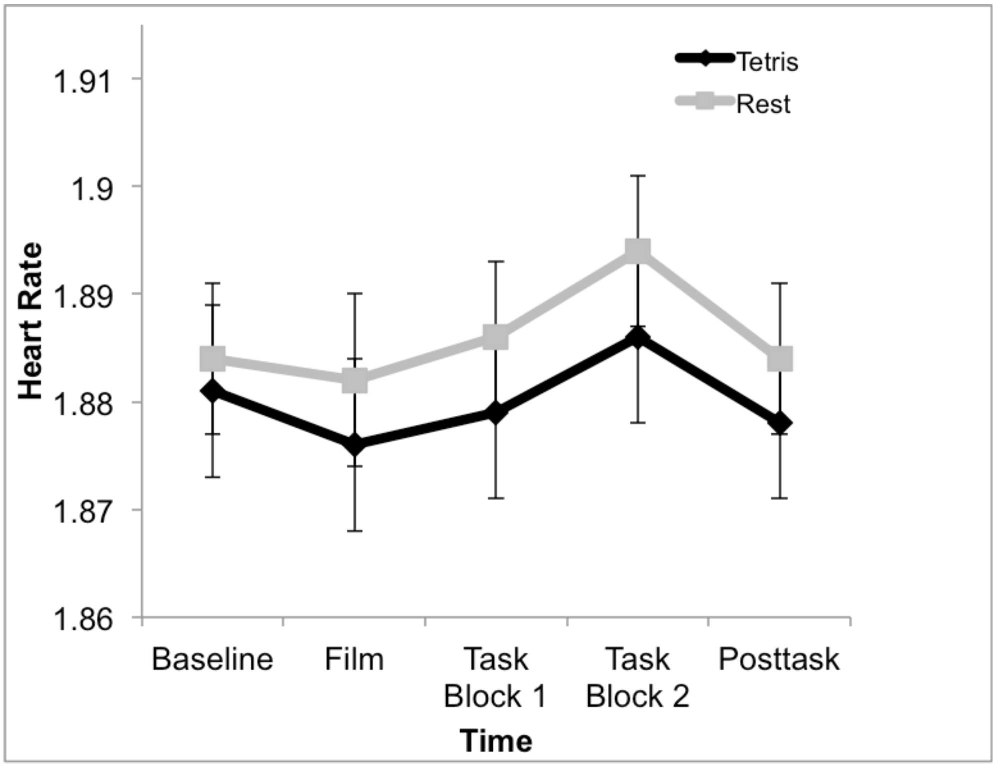


Figure 6. Heart rate plotted as a function of time and experimental condition. Error bars represent +/- 1 standard error.

analysis indicated a significant effect of time $F(4, 118) = 11.06$, $p < .001$, partial $\eta^2 = .27$, that was not qualified by a significant interaction with condition, $F(4,118) = 2.07$, $p = .09$, partial $\eta^2 = .07$. Repeated planned contrasts indicated significant differences occurred between each time point, *p*s < .05.

A series of post-hoc ANCOVAs were calculated, one each at the four time points with baseline covaried in each case. Family-wise Type I error rate of $\alpha = .05$ was maintained by setting Bonferonni adjusted per-comparison error rate to $\alpha/4 = .0125$. These analyses revealed a significant difference between conditions during task Block 1, $F(1, 120) = 10.45$, $p = .002$, partial $\eta^2 = .08$. This finding indicated that the Tetris group had significantly lower RSA ($M = 5.87$, $SD = .89$) during Block 1 as compared to those in the rest condition (*M* = 6.45, *SD* = 1.07), while covarying for baseline RSA. This was also true for true for Block 2, $F(1,120) = 6.93$, $p = .010$, partial $\eta^2 = .06$. Again, individuals in the Tetris condition had lower RSA (*M* = 5.87, *SD* = .89) as compared to individuals in the rest condition (*M* = 6.22, *SD* = 1.07), while covarying for baseline RSA. No differences between conditions were noted at any other time point (*p*s > 05). Therefore, Tetris effectively suppressed RSA while participants engaged in the task relative to their resting counterparts.

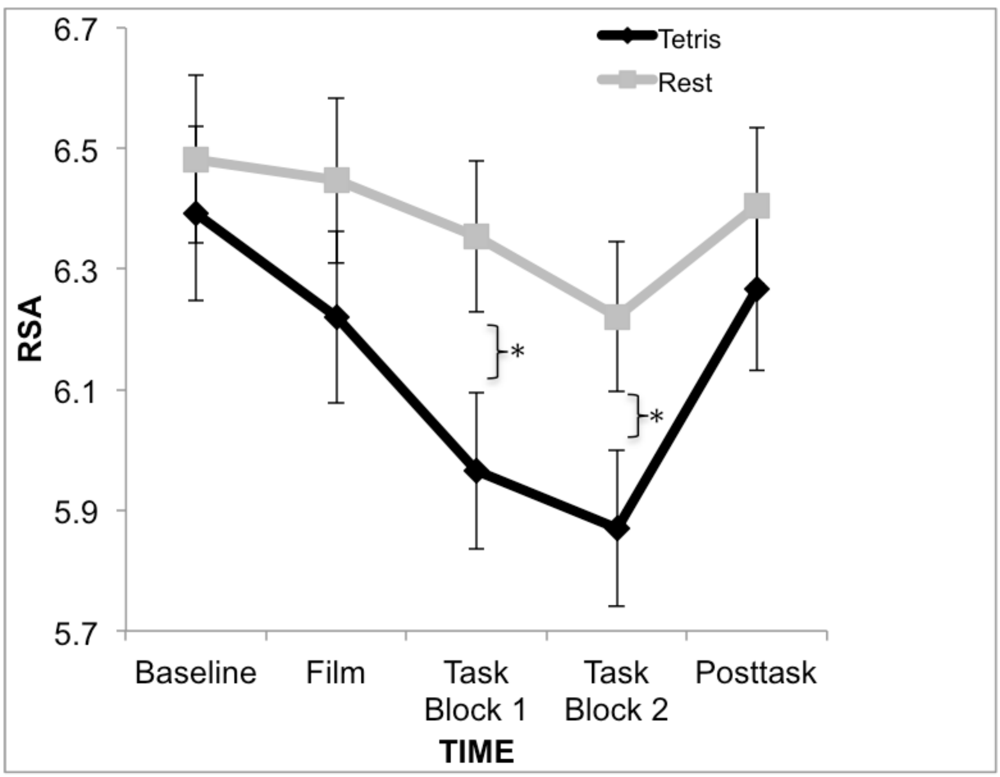


Figure 7. RSA plotted as a function of time and experimental condition. Error bars represent +/- 1 standard error. * Represents a significant difference between conditions at $p < .05$.

CSI data was subject to the same mixed model ANOVA. Box's Test did not indicate any violation of the assumptions of the homogeneity of covariances matrices (*p*

= .223). The significant main effect for time, $F(4,118) = 5.38$, $p = .001$, partial $\eta^2 = .15$, was qualified by its significant interaction with condition, $F(4, 118) = 8.26$, $p < .001$, partial $\eta^2 = .22$ (see Figure 8). Repeated planned contrasts for the entire sample indicated a significant difference between CSI scores taken during task Block 2 and posttask ($p < .01$).

Follow-up ANCOVAs revealed significant differences between conditions during the first block of the task, $F(1,120) = 25.17$, $p <.001$, partial $\eta^2 = .17$. These results indicated that individuals in the Tetris task had lower CSI ($M = 1.64$, $SD = .29$) as compared to individuals in the rest condition ($M = 1.79$, $SD = .26$), while covarying for baseline CSI. This finding also true for the second block of the task $F(1,120) = 22.92$, $p < .001$, partial $\eta^2 = 16$. Again, individuals in the Tetris group had lower CSI ($M = 1.64$, $SD = .29$) as compared to individuals in the rest condition ($M = 1.79$, $SD = .30$). No differences between conditions were noted at either of the remaining two time points (*p*s > 05). As with RSA, Tetris effectively suppressed CSI.

Salivary α-amylase. Prior to analysis, the raw optical densities (OD) of the sAA values scores were examined to assess the intra-assay coefficient of variation. The manufacturer's intra-assay coefficient of variation (CV% = [*SD*/*M*]%) for 10 replicates of high (474.6 U/mL) and low (17.7 U/mL) concentration of sAA ranged between 2.5% and 7.2%, respectively (Salimetrics, 2012). In the present study, the intra-assay CV% was calculated based on eight replicates randomly drawn from our sample. The obtained average CV% was 5.8%. These results were comparable to the manufactures results, indicating that the derived results would appear to be reliable.

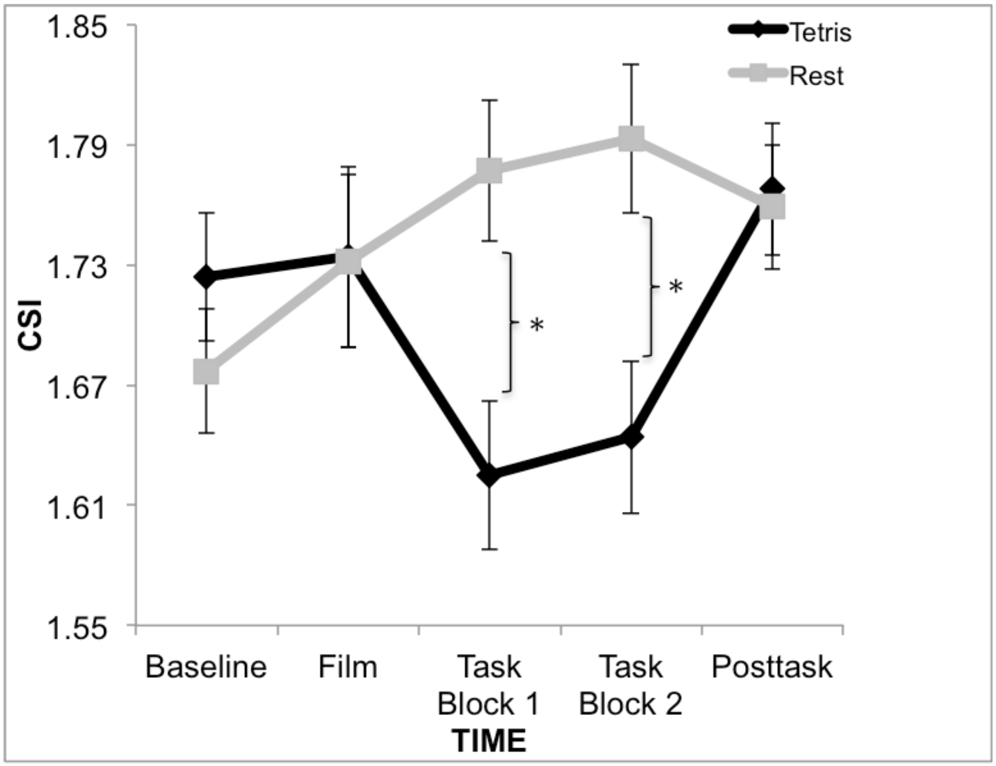


Figure 8. CSI plotted as a function of time and experimental condition. Error bars represent +/- 1 standard error. * Represents a significant difference between conditions at $p < .001$.

sAA data were then inspected in order to examine normality and identify potential outliers. Given the high level of skewness ($z_{skewness}$ range = 9.1 to 10.56) and multiple outliers (i.e., two at baseline, two postfilm, and two posttask), a square-root transformation was conducted on the data. Following this transformation, three outliers remained and were therefore modified to represent the next highest value in the data set plus a constant of .10. Skewness was reduced following the transformation ($z_{skewness}$ between 2.67 to 2.86).

A 2-between (condition [Tetris, rest]) × 3-within (time [baseline, postfilm, posttask) mixed model ANOVA was calculated. Box's Test did not indicate any violation of variance-covariance matrices (p = .001). Results from the analyses did not reveal a significant time main effect, $F(2, 122) = 1.38$, $p = .25$, partial $\eta^2 = .02$, or an interaction between time and condition $F(2,122) = 0.99$, $p = .34$, partial $\eta^2 = .02$.

To summarize the results thus far, physiological responses to the task were noted whereby RSA and CSI were lower while participants engaged in the Tetris task as compared to those resting. However, sAA and HR were unresponsive to the experimental manipulation. Regarding psychological responses, Tetris produced less negative affect and more positive affect than the rest condition.

Main Hypotheses

Hypothesis 1 – Reproducing the findings of Holmes et al. (2009). In an effort to replicate the findings of Holmes et al. (2009), it was predicted that individuals in the Tetris condition would report fewer intrusive images in the week following film exposure compared to the those in the rest condition. To address this question, a negative binomial regression model was tested wherein task (Tetris [coded 1] vs. rest [0]) was entered as a binary predictor of the frequency of intrusive images.

As can be seen in Table 7 (see page 75 Model 1), the overall model was significant and the Incident Rate Ratio (IRR) was calculated to be 1.54, 95% CI (1.01, 2.34) for individuals in the rest condition as compared to the Tetris condition. These results indicate that the incident rate of intrusive images within the rest condition was 1.54 times the incident rate of the Tetris condition. Incident rates for the frequency of intrusions were estimated to be 3.95, 95% CI (2.99, 5.22) for the rest condition and 2.56, 95% CI (1.88, 3.5) for the Tetris condition. Therefore, Tetris effectively suppressed intrusions over followup.

Hypothesis 2 – Differences between conditions on the Impact of Events Scale. In effort to replicate Holmes et al.'s (2009) finding, differences between conditions were investigated on the IES (see Appendix G). Preliminary screening indicated that the IES was significantly positively skewed. A log transformation was applied that corrected the skewness (see Table 4). No outliers were observed following this transformation. An independent samples *t* test on the IES transformed values did not indicate a significant difference between conditions, $t(103) = .83$, $p = .410$.

Table 4

Descriptive Statistics for the Impact of Events Scale

					Range		
Scale	*M*	*SD*	α	No. of items	Potential	Actual	$z_{Skewness}$
Raw score	34.87	10.03	.891	22	110	70	3.74
Log transformed	1.85	1.53	.891	22	2.04	1.85	1.63

A second analytic goal for the IES data was to determine if engaging in Tetris would moderate the relationship between trait anxiety and PTSD symptoms (IES). A moderation model was tested using PROCESS macro (Hayes, 2012) with STAI-T (see Appendix C) as the predictor X variable, IES as the Y criterion variable, and experimental condition (Tetris [coded 1] vs. rest [0]) serving as the binary moderator M variable. Prior to conducting the analysis, the STAI-T was examined for outliers and normality. Significant skewness was found, and scores were transformed using a logarithmic transformation (see Table 5). No outliers were identified following the transformation.

Table 5

Descriptive Statistics for the State-Trait Anxiety Scale - Trait Version

Scale	*M*	*SD*	*α*	No. of items	Range: Potential	Range: Actual	$z_{Skewness}$
Raw Scores	42.05	11.8	.944	20	80	74	2.25
Log Transformed	1.61	.12	.944	20	1.87	1.90	-.68

Results from this analysis indicated that the overall model was significant, $F(3, 101) = 2.95$, $p = .04$, $R^2 = .08$, as was the interaction STAI-T × Condition, $F(1, 101) = 5.33$, $p = .02$, R^2 *change* = .05, which is depicted in Figure 9. Additional data from the model is contained in Table 6. Analysis of the simple slopes revealed the prediction of IES from STAI-T was significant for the rest condition, β = .009 (*SE* = .003), $t = 2.80$, $p = .006$, but not for the Tetris condition, β = -.002 (SE = .003), $t = -0.50$, $p = .616$. The respective scatterplots for these two associations are displayed in Figure 10 based on *z* scores of the data. These findings indicate that anxious individuals are more affected by the trauma film, a natural process that Tetris appears to have interfered with.

Hypothesis 3 - Psychological predictors of intrusive images. In addition to examining the effect of Tetris, it was also hypothesized that psychological reactivity to the film would contribute to the development of intrusive memories. Thus, a second negative binomial regression model was tested which included the additional predictor

Table 6

Moderated (Experimental Condition) Multiple Regression Results for the Prediction of IES from STAI-T.

Effect	β	*SE*	*t*	*p*
STAI-T	0.003	0.002	1.15	.132
Condition	0.024	0.053	.45	.65
STAI-T × Condition	-0.010	0.005	-2.31	.023

Note. IES = Impact of Events Scale, STAI-T = State Trait Anxiety Inventory- Trait version

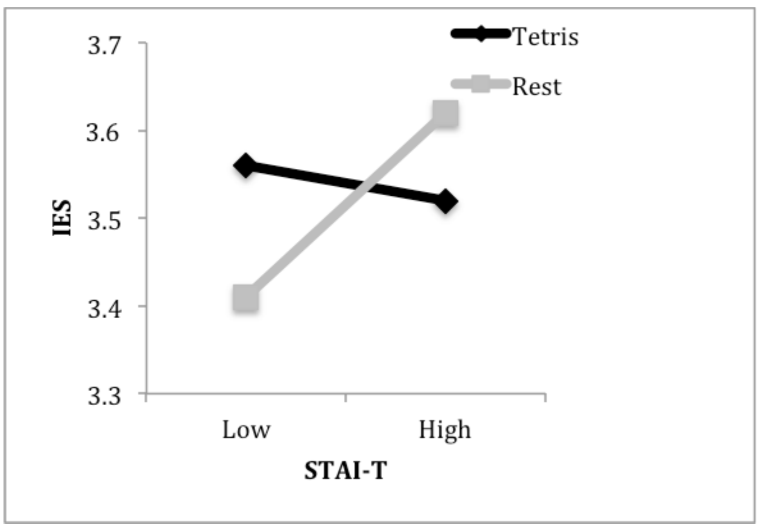


Figure 9. State Trait Anxiety Inventory – Trait version predicting scores on the Impact of Events Scale

variables of negative affect (VAS) reactivity, positive affect (VAS) reactivity, and dissociative (SDQ) reactivity; in each case calculated as postfilm value minus baseline value. Two univariate outliers were identified on negative affect reactivity and one outlier was found dissociative reactivity; outliers were replaced with the next highest value in the data set with a score equivalent to $z < 3.29$ plus one. Mahalanobis distances based on

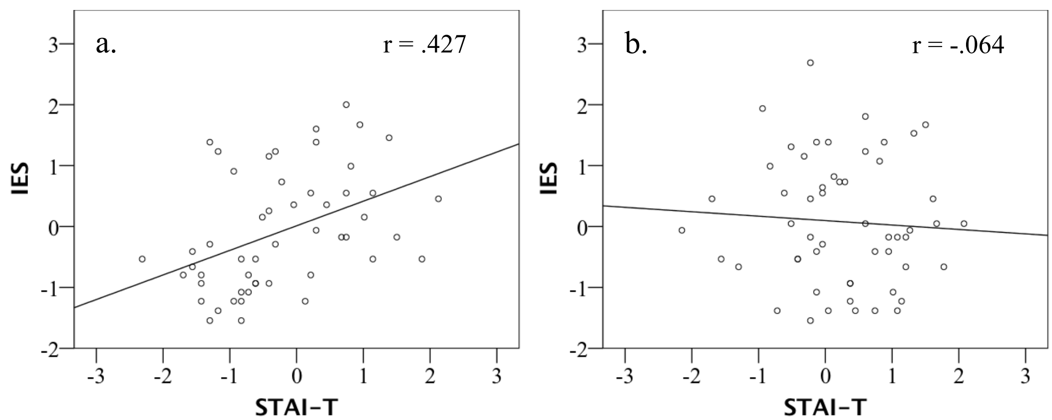


Figure 10. Scatterplots of the data used in the moderation analysis of the effect of Tetris on the relationship between STAI-T and IES. (a) rest condition and (b) Tetris condition. IES = Impact of Events Scale, STAI-T = State Trait Anxiety Scale - Trait version. r = Pearson product moment correlations for each condition. Data represent transformed z scores.

the predictors were examined for each case and no multivariate outliers were detected. Furthermore, examination of the residuals from the analysis did not indicate any obvious violations of normality, linearity, or homoscedacity.

As depicted in Table 6 (see pages 73-74, Model 2), the overall model was significant. However, the only significant predictor was found to be dissociative reactivity. The Incident Rate Ratio (IRR) for SDQ reactivity was calculated to be 1.12, 95% CI (1.03, 1.23). These findings indicate that in this model there was a 12% change in the incident rate of intrusive images for every unit increase in SDQ dissociative reactivity. All other predictors were nonsignificant, as were the interactions between experimental condition and the predictor variables.

A third model was used to examine if changes in psychological variables that occurred in response to the task influenced the frequency of intrusive images. This model examined negative affect recovery (changes in negative affect from postfilm to posttask), positive affect recovery (changes in positive affect from postfilm to posttask), and dissociative recovery (changes on the SDQ from postfilm to posttask). To create these variables, posttask scores were subtracted from postfilm scores. Also included in this model was the frequency of self-monitored intrusions reported while carrying out the task. Within these predictors, three univariate outliers were found on the measure of negative affect recovery, one outlier was found positive affect recovery, one outlier on dissociative recovery, and one outlier on for self-monitored intrusions. Outliers were replaced with the next highest value with a $z < 3.29$ plus a constant that was appropriate for the data. Mahalanobis distances based on the predictors in this model were examined for each case which revealed one multivariate outlier. Examination of the data for this participant indicated elevated scores on several of the predictor variables. In order to avoid the potential bias of this outlier, and to maintain a full sample for comparisons of models, each predictor value for this participant was replaced with the mean value of the entire sample. Examination of the residuals from the analysis did not indicate any obvious violations of normality, linearity, or homoscedacity.

Model 3 was significant (see Table 6). Significant predictors of intrusive images were positive affect recovery (IRR = 0.98), dissociative recovery (IRR = 0.93), and self-monitored intrusions (IRR = 1.12). Interactions between condition and negative affect recovery (IRR = 1.21) and positive affect recovery (IRR = 1.04) was also noted (see Table 6, Model 3). Therefore these interactions suggest that for individuals in the rest condition an increase in affect (positive or negative) predicted an increase in the frequency of intrusive images, whereas an increase in positive or negative affect led to

Table 7

Negative Binomial Regression Model Fit Estimates and Predictors of Intrusive Images for Psychological Measures

Predictors	β	BIC	LLR χ^2 (df)	ME χ^2	IRR, exp(b)	95% CI
			Model 1			
Overall		553.44	5.28(1)*			
Condition	0.43			5.44*	1.54	[1.65, 3.18]
			Model 2			
Overall		571.44	14.84(7)*			
Condition	0.55			3.37	1.73	[0.96, 3.11]
Negative Affect Reactivity	0			0.18	1	[.99, 1.01]
Positive Affect Reactivity	0			0.141	0.99	[0.97, 1.01]
Dissociative Reactivity	0.12			8.04**	1.12	[1.03, 1.23]
Condition × Negative Affect Reactivity	0			0.18	0.80	[0.99, 1.01]
Condition × Positive Affect Reactivity	0			0.10	1.04	[0.98, 1.02]
Condition × Dissociative Reactivity	-0.07			1.56	0.93	[0.83, 1.04]

(continued)

Predictors	β	BIC	LLR χ^2 (df)	ME χ^2	IRR, exp(b)	95% CI
			Model 3			
Overall		545.84	49.97(9)***			
Condition	0.53			2.66	1.70	[0.71, 1.95]
Negative Affect Recovery	-0.13			2.37	0.87	[0.78, 0.97]
Positive Affect Recovery	-0.02			4.98*	.97	[0.96, 0.99]
Dissociative Recovery	-0.07			4.10*	.93	[0.87, 1.00]
Self-Monitored Intrusions	0.05			30.73***	1.05	[1.01, 1.10]
Condition × Negative Affect Recovery	0.19			6.70**	1.21	[1.05, 1.4]
Condition × Positive Affect	0.04			12.07**	1.04	[1.02, 1,06]
Condition × Dissociative Recovery	0.04			0.716	1.04	[-0.95, 1.15]
Condition × Self-Monitored Intrusions	-0.02			2.36	0.98	[0.95, 1.01]

Note. BIC = Bayesian Information Criterion; LLR = Omnibus Likelihood Ratio χ^2 test value; ME χ^2 = Model Effect Likelihood Ratio $\chi^{2,}$ test value; IRR, exp(b) = Exponentiated values indicating predicted Incident Rate Ratios; 95% CI = 95% confidence intervals for the Incident Rate Ratios. All IRRs that examine 'Condition' describe the relative increase/decrease of incident rates for individuals in the rest condition as compared to the Tetris condition. Lower BICs represent better model fits to the data. * $p < .05$. ** $p < .01$. *** $p < .001$.

fewer intrusive images amongst the Tetris condition. In this model, the effect of condition on its own was not significant.

Hypothesis 4 – Physiological predictors of intrusive images. It was predicted that physiological reactivity may also contribute to the development of intrusive images. Furthermore, it is possible that the different tasks could influence physiological reactions and moderate the frequency of reported intrusive images.

Model 4 examined if cardiac reactivity in response to the film influenced the frequency of intrusions. For this model, change scores from the film-viewing phase were subtracted from baseline to create reactivity variables for CSI and RSA. Two univariate outliers were identified for the variable that assessed RSA reactivity; these outliers were replaced with the next highest value in the data set that with a score equivalent to $z < 3.29$, plus .10. No outliers were found on the measure of CSI reactivity. Mahalanobis distances based on the predictors in this model were examined for each case; this process did not indicate the presence of multivariate outliers. Examination of the residuals from the analysis did not indicate any obvious violations of normality, linearity, or homoscedacity. Overall, Model 4 was significant (see Table 7). A significant main effect was found for condition (IRR = 1.68), thereby replicating a previously reported result in Model 1. A main effect for CSI reactivity (IRR = 3.53) was also obtained whereby increases in CSI predicted more frequent intrusive images, regardless of condition.

Model 5 intended to examine the influence of changes in cardiac measures that occurred following the film while at rest or while playing Tetris. Recovery variables were created by subtracting values measured while viewing the film from the values measured during task Block 2. The data from Block 1 were not included to avoid factors associated with acclimatization to the task. Identical procedures were used to examine outliers, violations of normality, linearity, and homoscedacity. No obvious concerns were noted across any of these areas. Overall, Model 5 was significant, as well as significant main effects for condition (IRR = 1.72) and CSI recovery (IRR = 0.41). This model confirmed the effect of condition wherein individuals in the rest condition tended to report more frequent intrusive images. Furthermore, increases in CSI predicted significantly fewer intrusive images at this stage.

The relationship of sAA reactivity (changes from baseline to postfilm) and the frequency of intrusive images was examined in Model 6. Model 7 examined the relationship between of sAA recovery (changes from postfilm to posttask) and the frequency of intrusive images. Identical procedures were used to examine outliers, violations of normality, linearity, or homoscedacity with no abnormalities noted. Model 6 was not significant, Model Effect Likelihood Ratio χ^2 (3) = 6.40, p = .09. Similarly, results of the analysis from model 7 were also not significant, Model Effect Likelihood Ratio χ^2 (3) = 5.15, p = .16. Taken together, these findings indicate that neither sAA reactivity nor recovery significantly predicted the development of intrusive images.

Given that sAA was proposed to be measure of sympathetic arousal, we examined the correlation between cardiac autonomic activity and sAA. We found that sAA was correlated with CSI at baseline $r(117) = .26$, $p = .005$. In addition CSI was correlated with sAA during film viewing $r(117) = .24$, $p = .009$. These two measures were not correlated immediately following the task $r(117) = .08$, $p = .373$. It is important to note that *changes* in sAA and CSI were not significantly correlated in response to the film or task, ps > .05. Furthermore, no significant correlations were found between RSA and

Table 8

Negative Binomial Regression Model Fit Estimates and Predictors of Intrusive Images from Cardiac Measures

Predictors	β	BIC	LLR X^2 (df)	ME X^2	IRR, exp(b)	95% CI
			Model 4			
Overall		547.81	10.89(5)*			
Condition	0.52			7.26*	1.68	[1.77, 3.14]
RSA Reactivity	-0.17			0.37	0.84	[1.15, 2.46]
CSI Reactivity	1.26			3.81*	3.53	[1.17, 10.71]
Condition × RSA Reactivity	0.15			0.22	1.16	[0.63, 2.15]
Condition × CSI Reactivity	-1.13			2.46	0.33	[0.08, 1.32]
			Model 5			
Overall		545.65	13.05(5)*			
Condition	0.54			5.91*	1.72	[1.11, 2.67]
RSA Recovery	-0.13			1.71	.88	[0.56, 1.39]
CSI Recovery	-0.90			7.19**	.41	[0.16, 1.05]
Condition × RSA Recovery	-0.21			0.36	.81	[0.40. 1.62]
Condition × CSI Recovery	0.01			0	1.00	[0.27, 3.75]

Note. BIC = Bayesian Information Criterion; LLR = Omnibus Likelihood Ratio χ^2 test value; ME χ^2 = Model Effect Likelihood Ratio χ^2, test value; IRR, exp(b) = Exponentiated values indicating predicted Incident Rate Ratios; 95% CI = 95% confidence intervals for the Incident Rate Ratios. All IRRs that examine 'Condition' describe the relative increase/decrease of incident rates for individuals in the rest condition as compared to the Tetris condition. Lower BICs represent better model fits to the data. * $p < .05$. ** $p < .01$.

sAA at any time point, *p*s > .05.

Hypothesis 5 - Relationship between arousal and dissociation. The fifth hypothesis predicted that dissociative reactions would be accompanied by increases in physiological arousal. In order to examine this relationship, participants were divided into one of two groups depending on whether or not they reported dissociative symptoms while viewing the film. Independent-sample *t* tests were used to examine differences been these two groups on the measures of RSA reactivity, CSI reactivity, and sAA reactivity. Results of this analysis were not significant for the cardiac measures of RSA, $t(121)= 1.01$, $p = .315$, CSI, $t(121) = 1.05$, $p = .298$, or HR, $t(121) = 0.13$, $p = .90$. The two groups also did not differ on the measure of sAA reactivity $t(123) = 0.271$, $p = .78$.

Correlations among individuals who reported a dissociative response were further examined. Specifically, correlations between change in dissociation in response to the film and measures of physiological activity during the film (CSI, RSA, & sAA during the film) were examined. A significant correlation was found between CSI during the film and self-reported dissociation scores on the SDQ $r(52) = .33$, $p = .017$. The correlation between the SDQ and RSA was not significant $r(52) = -.18$, $p = .20$. Furthermore, SDQ scores were not related to mean HR, $r(52) = .21$, $p = .14$. Finally, the correlation between sAA and SDQ scores was also not significant $r(55)=.01$, $p = .97$. Taken together, these results indicate that *changes* in physiological activity to the film were not related to dissociative reactions. However, individuals with overall higher sympathetic tone while viewing the film experienced more intense dissociative responses.

Hypothesis 6 - Impact of Tetris on the cardiac defense response. It was predicted that individuals in the Tetris condition would have decreased CDR as compared to those in the rest condition. A 2 × 2 × 10 (image type [neutral-IAPS, aversive-film] × condition [Tetris, rest] × time period [10 sample periods]) mixed model ANOVA was conducted. Inspection of the data indicated that no outliers were present, nor were any variables found to be significantly skewed. Box's Test did not indicate any violation of assumptions of homogeneity of the covariance matrices ($p = .151$). Results from this analysis indicated a significant main effect for time, $F(9, 86) = 11.97$, $p < .001$, partial $\eta^2 = .56$. The interaction between time and task was not significant, $F(9,86) = 1.30$, $p = .25$, partial $\eta^2 = .01$. Similarly, the interaction between time and image type was not significant, $F(9,86) = 0.82$, partial $\eta^2 = .08$. However, the three-way interaction of Time × Condition × Image Type was significant, $F\ (9,86) = 2.29$, $p = .023$, partial $\eta^2 = .19$. This interaction is shown in Figure 10, but its meaning is unclear.

To assist in pinpointing the source of the interaction, the analytic conventions suggested by Vila et al. (2007) were followed: four separate 2-within (image type [Neutral IAPS, Aversive Film]) × 2-between subjects (task[Tetris, Rest]) ANOVAs for the time periods at 3 s, 6 s, 30 s, and 37 s were conducted. As previously mentioned, median values are calculated for 10 time intervals of progressively longer lengths that are centered at 3, 6, 11, 16, 23, 30, 37, 50, 63, and 80 s post stimulus. Across these time points, parasympathetic influences on the heart rate responses are thought to be dominant during the 3 s and 6 s periods. In addition, a combined parasympathetic/sympathetic interaction is thought to contribute to changes in heart rate at 20 s and 37 s. Thus, if Tetris modulates autonomic reactivity, differences between experimental conditions should emerge at one or more of these four time points. However, none of these individual analyses reached statistical significance (main effect *p* values ranging from .167 - .868). Consequently, the source of the three-way interaction could not be identified.

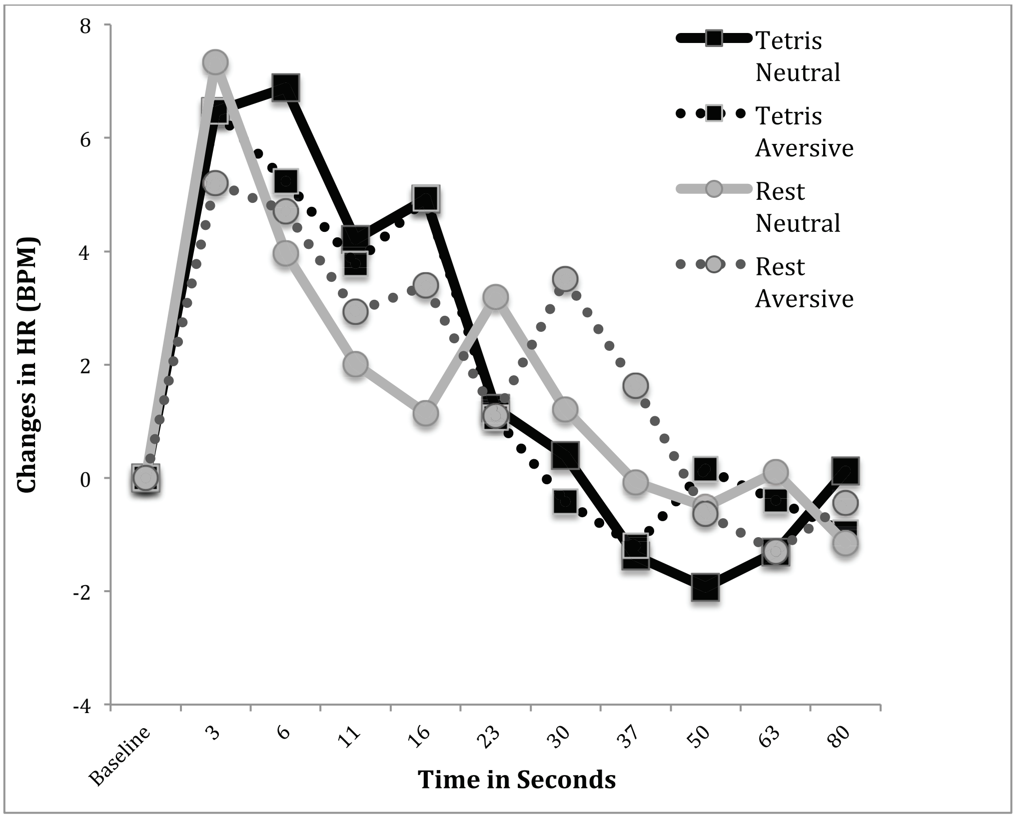


Figure 11. Average median change in heart rate at each time interval following the onset of the auditory tone in cardiac defense response trials.

Hypothesis 7 - Impact of Tetris on eyeblink startle responses. This hypothesis proposed that individuals who engaged in the Tetris task would have a different EMG response pattern as compared to those in the rest condition.

Recall that participants rated the images for affect and arousal using the SAM (see Appendix H) just prior to their presentation in the eyeblink trials. Although these data individual analyses reached statistical significance (main effect *p* values ranging from .167 - .868). Consequently, the source of the three-way interaction could not be identified.

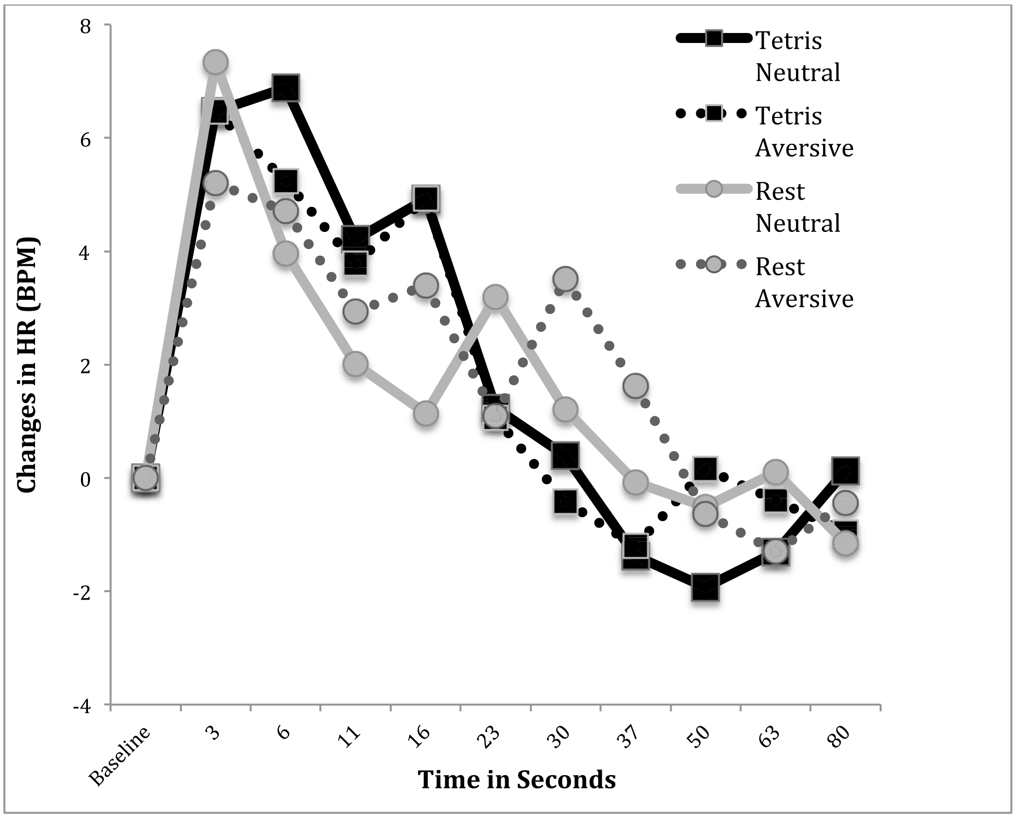


Figure 11. Average median change in heart rate at each time interval following the onset of the auditory tone in cardiac defense response trials.

Hypothesis 7 - Impact of Tetris on eyeblink startle responses. This hypothesis proposed that individuals who engaged in the Tetris task would have a different EMG response pattern as compared to those in the rest condition.

Recall that participants rated the images for affect and arousal using the SAM (see Appendix H) just prior to their presentation in the eyeblink trials. Although these data were significantly skewed on some of the SAM ratings, the direction and severity of the skewness were equivalent for both conditions on each variable, therefore these indices were deemed to be appropriate for parametric between-group analysis (Tabachnick & Fidel, 2007). No outliers were noted on these variables. Eighteen independent-sample *t* tests were used to explore if ratings of affective valence or arousal differed between the two experimental conditions on each of the nine images. No significant differences were found ($ps > .05$). Next, each participant's average response (i.e., the mean response to all three images) for each type of images (i.e., neutral-IAPS, aversive-film, neutral-film) was calculated. Independent-sample *t* tests conducted on this data indicated that the two conditions did not rate the images differently (see Table 9).

In terms of the eyeblink startle data, responses to each of the three image types were examined and no outliers or problems with shape of the respective distributions were noted. A 2-between (condition [Tetris, rest]) × 3-within (image type [neutral-IAPS, aversive-film, neutral-film) mixed model ANOVA was used to analyze the z-score transformed EMG responses. Box's Test did not indicate any violation of assumptions related to the homogeneity of covariance matrices ($p = .151$). Results from the ANOVA indicated a significant main effect for image type, $F(2, 101) = 5.21$, $p = .007$, partial $\eta^2 = .094$. A nonsignificant trend was noted for the interaction between condition and image type $F(2,101) = 2.80$, $p = .06$, partial $\eta^2 = .05$ (see Figure 12). Two planned contrasts were conducted as follows; (a) between the neutral-IAPS and the film-aversive images which was significant, $F(1, 102) = 4.65$, $p = .033$, partial $\eta^2 = .04$ and (b) between the neutral-IAPS stimulus and neutral-film stimulus that was not significant(1,102) = .47,

Table 9

Descriptive Statistics and Results of Independent Sample t Tests on Ratings of Affect and Arousal of Images Presented in the Eyeblink Startle Task.

	Tetris		Rest			
Image Type	*M*	*SD*	*M*	*SD*	*t (df)*	*p*
			Affective Ratings			
Neutral-IAPS	5.26	1.71	5.30	1.47	0.103 (100)	.918
Aversive-film	7.56	1.30	7.19	1.32	-1.32 (100)	.190
Neutral-film	5.72	1.50	5.87	1.36	.429 (100)	.668
			Arousal Ratings			
Neutral-IAPS	6.71	1.45	6.71	1.45	.265 (100)	.792
Aversive-film	8.67	3.79	6.78	1.33	-1.42 (100)	.295
Neutral-Film	5.58	1.73	5.20	1.65	1.05 (100)	.296

p =.50 partial η^2 = .005. These findings indicate that responses to the neutral-IAPS trials and the film-aversive trials were significantly different.

Follow-up independent-samples *t* tests were used to compare whether the two experimental conditions differed in their responses to the different image types. Results revealed a significant difference between conditions only on the trials in which an aversive image was presented $t(102) = 2.13$, $p = .036$. Results from the significant contrast indicated that individuals in the Tetris condition showed a heightened startle response ($M = 0.21$, $SD = 0.42$) as compared to individuals in the rest condition ($M =$

0.04, *SD* = 0.43). Experimental conditions did not differ on neutral images from the IAPS, *t*(102) = 0.385, *p* = .70. Similarly, differences between conditions on the neutral images from the film were not significant *t*(102)= 1.82, *p* = .07.

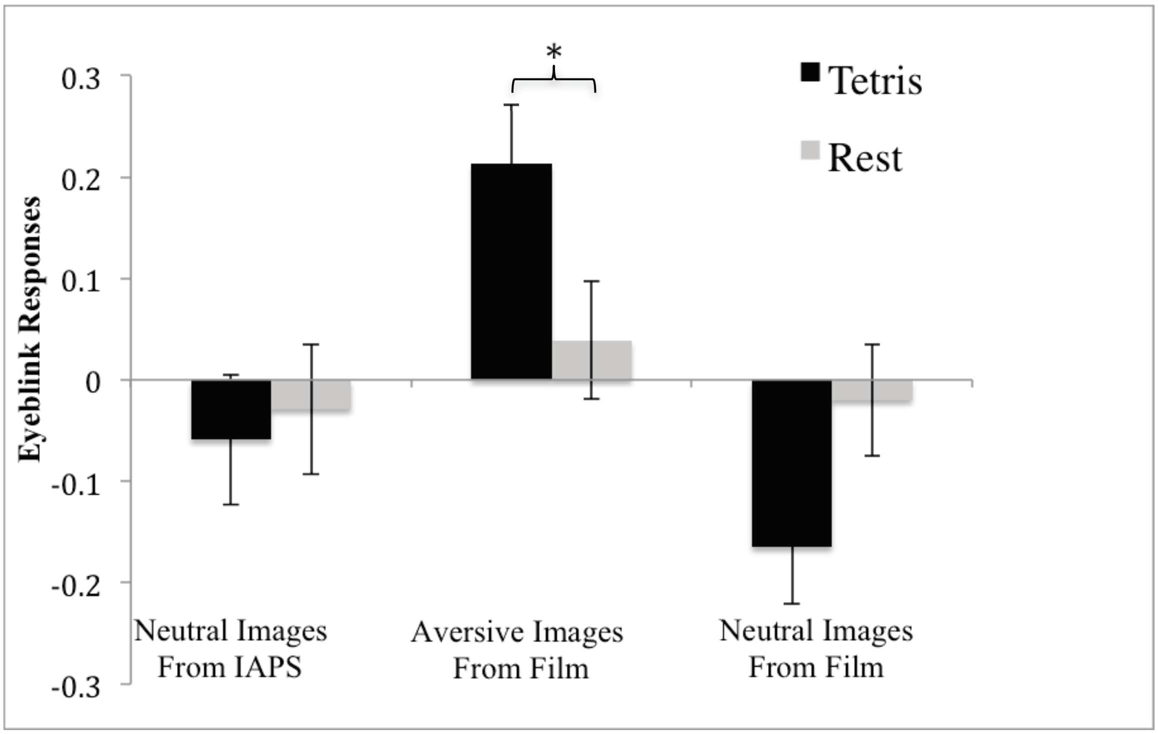


Figure 12. Average *z*-score transformed responses in the eyeblink startle task for each image type. Error bars represent +/- 1 standard error. * $p < .05$.

That Tetris caused increased startle is contrary to expectations. Consequently, exploratory analyses were conducted to examine if the experimental condition moderated the relationship between the measure of the impact of the film (IES) and EMG responses to the aversive-film image. A moderation model was tested using PROCESS macro (Hayes, 2012) with the IES as the predictor X variable, EMG responses to aversive-film images as the Y criterion variable, and experimental condition (i.e., Tetris [coded1]vs. rest [0]) serving as the binary moderator M variable. Results from this analysis indicated that the overall model was significant, $F(3, 96) = 4.40$, $p = .006$, $R^2 = .12$, as was the interaction between IES and condition, $F(1, 96) = 5.79$, $p = .018$, R^2 *change* = .05, which is depicted in Figure 13. Additional data in Table 6 describes the model. Analysis of the simple slopes revealed the prediction of EMG responses from IES scores was significant for the rest condition, β = -0.63 (SE = 0.23), *t* = -2.78, p = .007, but not for the Tetris condition, β = 1.04 (SE = 0.20), *t* = .51, p = .613. The respective scatterplots for these two associations are displayed in Figure 14 based on *z* scores of the data. These results indicate that individuals who report high levels of anxiety are affected more by the trauma film, a natural process that Tetris appears to have interfered with.

Taken together, results from the eyeblink startle trials indicate that individuals in the Tetris condition showed heightened response to the aversive-film image trials. One factor that contributed to this difference was the moderation effect of condition on the relationship between IES and the magnitude of the startle response. Specifically, individuals in the rest condition showed lower startle responses if their scores on the IES scores were high. In contrast, IES scores had little impact on the startle response amongst individuals in the Tetris condition. This would suggest that the more impacted individuals were by the film, the lower their startle responses were, a process that was negated by engaging in the Tetris task.

Discussion

The trauma film paradigm has a rich history in the field of psychology and has been used to study factors that contribute to the development of symptoms associated with PTSD and other pathological conditions (Holmes & Bourne, 2008). In recent years,

Table 10
Moderated (Experimental Condition) Multiple Regression Results for the Prediction of EMG Responses from IES.

Effect	β	*SE*	*t*	*p*
IES	-0.26	.15	1.68	.10
Condition	0.21	.08	2.45	.02
IES × Condition	0.73	.30	2.41	.02

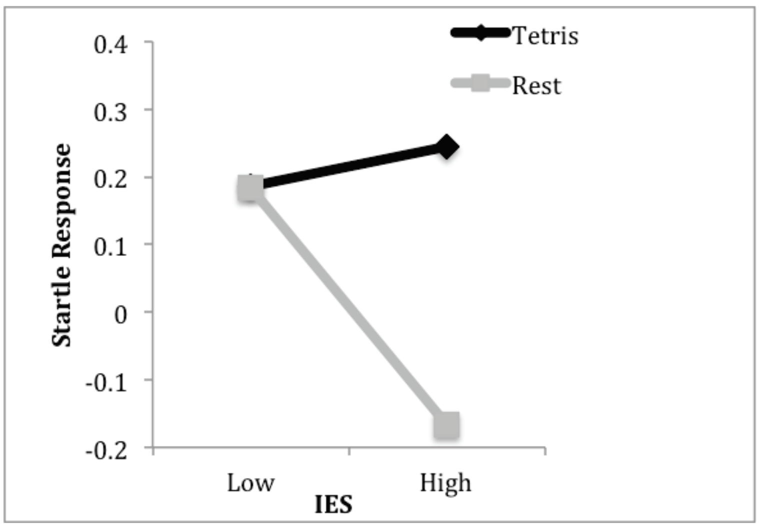


Figure 13. Impact of Events Scale predicting EMG responses to aversive-film Images.

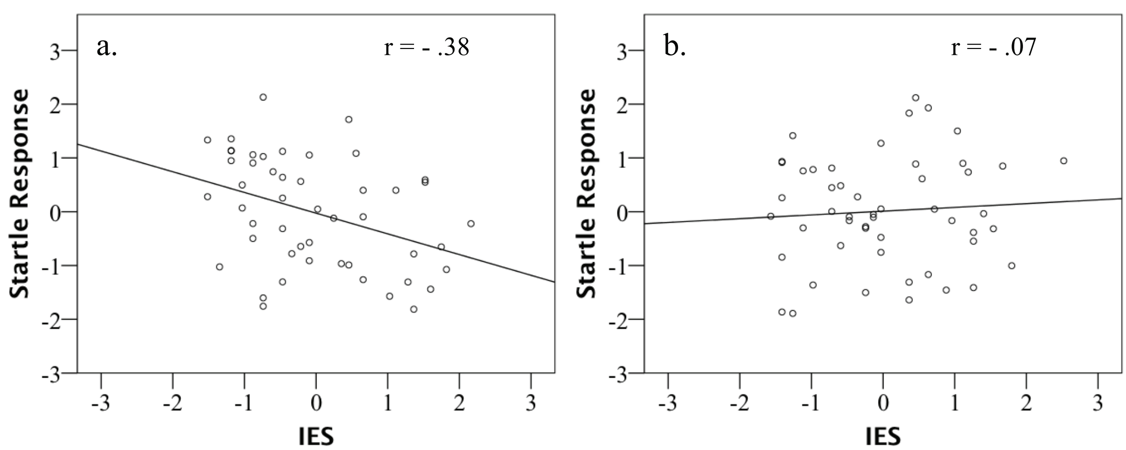


Figure 14 . Scatterplots of the data used in the moderation analysis of the effect of Tetris on the relationship between IES and EMG responses to aversive images. Scatterplots of

the data for (a) rest condition and (b) Tetris condition. IES = Impact of Events Scale. Startle responses = Magnitude of EMG response to aversive-film images. r = Pearson product moment correlations for each condition. Data represents transformed z scores.

this paradigm has served as a model to help investigate the extent to which the development of intrusive memories, similar to those that occur in PTSD, can be modulated through engaging in various cognitive tasks. For example, it has been suggested that engaging in visuospatial tasks, such as the video games Tetris or visuospatial finger tapping, can reduce the frequency of intrusive images individuals experience from watching a trauma film.

Studies that have examined the ability to modulate the development of intrusive memories through visuospatial tasks are often grounded in the dual representation theory (Brewin et al., 2010). This theory suggests that an imbalance in memory processing contributes to the development of intrusive memories. The dual representation theory proposes the existence of the S-memory system that acts to code primary sensory-based information into S-reps. These representations are proposed to be activated through associative cues or through activation of related representations. In contrast, the C-memory system is believed to code primarily contextualized information. Representations from this system, C-reps, are proposed to be activated through purposeful recollection as well as associative cues. The theory proposes that, in PTSD, stress responses influence neuronal functioning the result of which is stronger S-reps, weaker C-reps, and disrupted connections between the S-reps and C-reps (Brewin et al., 2010). The result of these processes is that intrusive flashback-like memories are triggered through activation of S-reps that are not appropriately offset by corresponding C-reps related to the event.

Holmes et al. (2009, 2010) demonstrated that playing Tetris, a videogame that relies heavily on visuospatial skills, can interfere with the development of intrusive memories. In the present study, one of our main goals was to replicate this finding. Furthermore, we were interested in characterizing the role of psychological and physiological factors that may contribute to the development of intrusive images. An additional goal was to attempt to consolidate findings related to the physiological processes that occur when individuals experience a dissociative reaction. Finally, we had hoped to examine the extent to which engaging in a visuospatial task would interfere with other processes known to occur in PTSD, such as increased physiological reactivity.

Validity of Experimental Paradigm

In order to help establish the validity of the trauma film paradigm we first examined changes in response to the film and engaging in the Tetris or rest task. Our results indicated that in response to the film participants experienced increases in negative affect and decrease in positive affect. Furthermore, individuals more commonly reported symptoms related to dissociation while viewing the film as compared to baseline. In terms of physiological reactivity to the film, we found that RSA decreased while participants viewed the film. This would suggest that parasympathetic influences on HR were reduced when individuals viewed the film. No statistically significant changes in heart rate or sympathetic activity were noted.

While engaging in the post-film tasks, both psychological and physiological responses did occur. In terms of psychological variables, individuals who played Tetris showed higher levels of positive affect and lower levels of negative affect, as compared to individuals in the rest condition. In terms of physiological variables, individuals across both conditions showed an increase in heart rate while engaging in Tetris or the rest task. In terms of sympathetic activity, individuals in the Tetris condition showed a decrease in activity while engaging in the task. In contrast, individuals in the rest condition showed an increase in sympathetic arousal, based on CSI measures, throughout the rest task. We also found differences in RSA in response to the post-film tasks. Specifically, individuals in the Tetris condition were found to have lower RSA while engaging in the task as compared to those in the rest condition.

Collectively, these findings suggest that individuals did generally experience expected psychological reactivity in response to the film and the task. Physiological reactivity to the film was only apparent on the measure of RSA. A decrease in RSA in response to the film is in line with several recent studies that suggest that this frequently occurs when individuals view films that instil anger, anxiety, and sadness (Kreiberg, 2010; Overbeek, van Boxtel, & Westerink; 2012). However, a lack of response in overall heart rate differs from some previous findings (e.g., Holmes et al., 2004; Overbeek et al., 2012). However, it is important to note that our results, while not statistically significant, did suggest a decrease in heart rate, and an increase in sympathetic activity, in response to the film. These responses followed what would be expected from a typical physiological response to an aversive situation. The lack of statistical significance may represent variability in individual responses. For example, although some individuals showed a decrease in HR and parasympathetic activity, some individuals showed an increase on these same variables in response to the film. The opposite was also true for the measure of sympathetic activity. Although the characterization of individual response patterns was not the goal of the present study, it does represent an area that is in much need of further evaluation. However, the finding that CSI and RSA were both decreased in the Tetris condition represent novel findings, as this was likely the first study that attempted to characterize cardiac autonomic influences in response to this task.

Replication of Holmes et al. (2009)

Given that the paradigm did appear to have the expected impact on participants, we attempted to replicate the findings of Holmes et al. (2009). Therefore, we expected that individuals who engaged in the Tetris task would experience fewer intrusions. This hypothesis was confirmed and our results indicated that individuals in the rest condition experienced over 1.5 times as many intrusions as compared to individuals who played Tetris. These findings help strengthen the evidence for the "Tetris effect" and also provide support for the proposition that visuospatial tasks have the potential to modulate intrusive trauma-related images. This represents one of the first attempts to replicate the Tetris effect by an independent research group.

However, our results did not replicate all of the findings reported by Holmes et al. (2009). Specifically, Holmes et al. found that participants reported fewer self-monitored intrusions while playing Tetris task as compared to individuals who sat quietly in their rest condition. In the present study, both groups were equivalent on the number of reported self-monitored intrusions. Although this finding does differ from what has been previously reported, it does add support to the proposition that the mechanisms by which the visuospatial tasks influence the development of intrusive images is not simply due to its ability to distract individuals from immediate thoughts related to film. This is a proposition supported by Brewin (2008) and Holmes et al., (2004, 2009, 2010) who suggest that visuospatial tasks have this effect due to their ability to occupy visuospatial resources in memory. An additional difference between our findings and those of Holmes et al. (2009) was that they found that participants in the Tetris condition scored lower on the IES, a measure that assessed PTSD-like reactions at follow-up. In our study, we did not observe any group differences on this measure.

It is important to point out some differences in our methodology that may account for the discrepant findings. One major difference between our study and the Holmes et al. (2009) studies was the content of the trauma film. Our film depicted a single graphic car-crash scene whereas Holmes et al. (2009) made use of numerous graphic scenes over twice the period of time. An additional difference was the timing of the Tetris/rest tasks. Holmes et al. (2009) allowed for a period of 30 min between the film and the start of the task. Furthermore, Holmes et al. (2010) allowed for either 30 min or 4 hr periods between the film and task. In contrast, we shortened the time window to 5 min between film and task in order to explore if this change would impact the results. The change in timing of the intervention may limit direct comparisons between our study and earlier experiments. However, the fact that our intervention was effective provides evidence that the Tetris effect is apparent even when the intervention occurs shortly after the presentation of a trauma film. This finding is inline with the hypothesis put forward by Holmes et al., (2009, 2010) that the intervention should be effective provided it occur at some point within six hours of viewing the film.

Moderating Effect of Condition on the IES

Although the two conditions did not differ on the IES, we had hypothesized that pre-existing trait anxiety would contribute to IES scores. In addition, we had also expected that engaging in the Tetris task would moderate this relationship. Support for this hypothesis was found. Specifically, Tetris would appear to interfere with the relationship between trait anxiety and the impact of the film on individuals, as assessed by the IES. However, it is not clear why no overall differences between conditions were found on the IES. It may be the case that other psychological and physiological vulnerabilities, or the interaction between these vulnerabilities and the task, produced the equivalent between group scores on the IES. For example, Regambal and Alden (2009) provided evidence that in addition to pre-existing affect (such as anxiety), reactions to intrusive films can be influenced by peritraumatic processing, maladaptive coping strategies (i.e. rumination, thought suppression, and safety behaviours), and emotional reactivity.

In the present study, we did examine how scores on the IES were related to some aspects of psychological reactivity to the film. Specifically, we found that scores on the IES were positively correlated with negative affect reactivity and dissociative reactivity to the film. Therefore, it may be the case that while Tetris does impact the relationship between trait anxiety and scores on the IES; the influence of these other psychological may contribute to equivalent group scores. Additional support for the role of these other factors was found in our next set of analyses; these suggested that various other factors altered the impact of the film on participants.

Psychological Contributions to Intrusive Images

As previously mentioned, psychological reactions to traumatic films have been linked to the development of intrusive images in analogue studies of PTSD (e.g., Regambal & Alden, 2009). Furthermore, recent findings suggest that affective reactions to trauma predict the development of PTSD (Klein, Ehlers, & Glucksman, 2012) and that these reactions continue to be present once PTSD has developed (Holmes, Grey, & Young, 2005; Grey & Holmes, 2008). In fact, peritraumatic psychological reactions are a key factor described in some etiological models of PTSD (e.g., Ehlers & Clarke, 2000; Elzinga & Bremner, 2002; Foa, Steketee, & Rothbaum, 1989).

In the present study, we examined how psychological reactions influenced the development of intrusive images. In particular, we examined the psychological reactivity to the film in terms of negative affect, positive affect, dissociation, and in-task intrusions. Results from our analyses indicated that, while viewing the film, an increase in self-reported dissociation was the only psychological variable that significantly predicted the frequency of intrusive images. Therefore, although individuals experienced an increase in negative affect and decrease in positive affect, the magnitude of these changes did not predict the frequency of intrusive images experienced by individuals in either group.

However, after engaging in the post-film task (i.e., Tetris or rest) increases in positive and negative affect did predict fewer intrusions for both groups. When this finding was examined in more detail, an interaction between conditions and affective responses suggested an interesting finding: for individuals in the rest condition an increase in either positive or negative affect during the task (as compared to postfilm response) predicted more frequent intrusions; the opposite was observed within the Tetris condition where increases in affect were associated with fewer intrusions.

Although this interaction may appear puzzling, it is an effect that can be understood through theoretical predictions. Specifically, both negative and positive affective states tend to enhance memory (Hamann, 2001; van Stegeren, 2008; Wolf, 2008). Therefore, for people in the Tetris condition the increase in affect would be expected to enhance their memories for Tetris. Drawing from dual representation theory, this enhancement would be expected to compete for limited resources and decrease the memory consolidation of the film-related images within the S-memory system. In contrast, individuals in the rest condition would not have any obvious visuospatial activity to occupy their S-memory system, thereby enhancing the visual material taken from the film. In Holmes et al.'s (2009) study no group differences were found on measures of negative affect between conditions. However, the authors examined affect immediately following the task and did not report changes from postfilm to post task, as was done in the present study. Therefore, to the best of our knowledge, the present study is the first to suggest that increased negative and/or positive affect that occurs while playing Tetris may decrease the frequency of intrusive images.

An additional novel finding in this study was the relationship between dissociative reactions and the development of intrusive images. While increases in dissociation during the viewing of the film were associated with more frequent intrusions, increases in dissociative responses measured post task were actually associated with fewer intrusions. One possible explanation for this effect is that it may represent an adaptive form of the dissociative response (e.g. Bryant, 2007; DePrince, & Freyd, 2007; Nijenhuis, Van der Hart, & Steele, 2002). If this finding can be replicated, it may provide an important avenue for future studies that could examine the potential adaptive benefits of dissociative responses for some individuals.

In terms of psychological responses to the film, one additional finding of interest was noted. Specifically, we found that one of the most consistent predictors of the frequency of intrusive images was the number of self-monitored intrusions reported while engaging in the task. Our findings suggest that regardless of what task was being carried out the more frequently people reported self-monitored intrusions, the more frequently they would have them over the following week. This finding was expected and may suggest that the immediate impact of the film, or rumination regarding the content of the film, contributes to on going intrusive images over the following week. This finding is in line with Regambal and Alden's (2009) findings that also suggested a role for rumination in the development of intrusive images within a trauma film paradigm. Furthermore, these findings support theories that emphasize the role of cognitive reactions to the development of PTSD.

Physiological Contributions to Intrusive Images.

In addition to psychological contributions, we were also interested in characterizing physiological contributions from the autonomic nervous system to the development of intrusive images. We did not identify a relationship between parasympathetic activity and the development of intrusive images. However, our results indicated that sympathetic reactivity (CSI) to the film predicted the frequency of reported intrusive images. This finding was significant despite the fact that, as a group, most individuals did not show a significant elevation in sympathetic arousal. Therefore, these findings indicate that individuals with a high level of sympathetic reactivity were those who reported the most frequent intrusive images.

This finding is in agreement with a both animal and human research related to stress induced memory enhancement (e.g., Roozendaal, McEwen, & Chattarji, 2009; van Stegeren, 2008; Wolf, 2008). Specifically, noradrenergic activity within the amygdala that is triggered by sympathetic arousal has been implicated in the enhancement of affect-related memory (e.g., Roozendaal et al., 2009; van Stegeren, 2008). Furthermore, sympathetic arousal at the time of trauma has been suggested to contribute to the development of PTSD (Brewin, Andrews, & Valentine, 2000; Bryant, 2006; Buckley & Kaplouek, 2001; Elzinga & Bremner, 2002; Metzger, Orr, Berry, Anhern, Lasko, & Pitman, 1999; Ozer Best, Lipsey, & Weiss, 2003, Pole, 2007). However, sympathetic contributions to the development of intrusive images have not been frequently examined within experimental analogue studies of PTSD. It may be the case that these physiological processes can explain the association between sympathetic reactivity and the frequency of intrusive images observed in our study. This would support Brewin et al.'s (2010) assertion that associations between S-reps and C-reps are related to amygdala function that can be impacted by stressful experiences and physiological reactivity.

An unexpected finding related to sympathetic activity was also found in our analysis. Specifically, higher levels of sympathetic arousal were associated with fewer intrusions while engaging in the post-film task. This effect did not appear specific to either condition, based on the model we used in the present study. This finding would be anticipated amongst individuals in the Tetris group, whereby an increase in sympathetic activity would be expected to increase memory consolidation for visual images associated with Tetris as opposed to the trauma film. However, it would not be expected to have the same effect in the rest condition, which was the case in the present study. Although, it is possible that sustained sympathetic arousal could have enhanced other visual memories amongst the rest condition for information not related to the trauma film (e.g., memories related to the lab environment). Given the fact that this finding was not necessarily congruent with theoretical predictions it would merit further investigation.

In addition to cardiac measures of autonomic activity, we also examined sAA as a putative marker of sympathetic activity. However, we failed to note any significant changes in sAA across the different stages of the study. Furthermore, sAA activity did not predict the development of intrusive images. Given that previous studies had proposed that sAA is a marker of sympathetic activity (Rohleder et al., 2004; van Stegeren et al., 2006), we examined correlations between sAA and the measures of CSI and RSA. These results suggested that although CSI and sAA were correlated at baseline and while viewing the film, reactivity in sAA and CSI were not correlated. This may suggest that while both measures do assess aspects of sympathetic arousal, CSI may be a more sensitive measure of reactivity. Alternatively, it has been recently proposed that sAA reactivity is influenced by a variety of physiological factors other than sympathetic influences (Bosch, Veerman, de Geus, & Proctor, 2011); this may explain our lack of significant findings.

Relationship between Physiological Arousal and Dissociation

Dual representation theory suggests that there are likely two pathways that contribute to the development of intrusive memories. The first of these pathways involves a dissociative response that is characterized by a decrease in physiological arousal. The second pathway is better characterized by an increase in physiological arousal at the time of trauma (Brewin 2007, Holmes et al, 2004). These findings are based on studies that have linked peritraumatic dissociation, and/or peritraumatic physiological arousal, to the development of PTSD (for reviews see Ozer, Best, Lipsey, & Weiss, 2003; Bryant, 2006). Although there is some evidence that dissociative responses are accompanied by a decrease in physiological arousal among some clinical and non-clinical samples (e.g., Holmes, 2004; Griffin, Resick, & Mechanick, 1997) this finding has not been consistently replicated (e.g., Kaufman, et al., 2002; Nixon, Bryant, Moulds, Felmingham, & Mastrodomenico, 2005).

It is important to note that the most common metric used to assess arousal is heart rate. As discussed earlier, the role of parasympathetic and sympathetic influences make heart rate an imperfect measure of physiological arousal. Therefore we had proposed that the decreases in "arousal" occasionally reported in conjunction with dissociative reactions might be the result of increases in both sympathetic activation as well as parasympathetic activation. Given that the parasympathetic system has a more pronounced effect on heart rate (Berntson et al., 1993) a general trend in overall decreases in heart rate in response to stressful situations might be expected. In the present study, our results provided some support for this proposition. As a group, individuals who reported dissociative reactions did not differ from those who did not, based on measures that examined *changes* in autonomic activity or overall heart rate. However, amongst individuals who did report dissociative reactions to the film, a positive correlation was found between increased dissociation and tonic sympathetic measures taken while viewing the film. A nonsignificant negative correlation was also observed in terms of the relationship between RSA while viewing the film and dissociative reactions.

These findings suggest that that two pathways described by Brewin (2007) may not be as distinct as previously suggested. It may be the case that there is overlap between the two processes or, alternatively, that there exists a third pathway characterized by both an increase in dissociation combined with sympathetic arousal. This proposition is in line with findings from studies that have found that dissociation is accompanied by increases in physiological arousal (e.g., Nixon, Bryant, Moulds, Felmingham, & Mastrodomenico, 2005; Seterlini & Bryant, 2002). The proposition that dissociation may be linked to physiological arousal is also supported by a recent study (Sledjeski & Delahanty, 2012) that found that women who experience higher levels of dissociation show heightened physiological arousal in response to providing a narrative of their trauma experiences. Importantly, our study as well as that conducted by Sledjeski and Delahanty both used measures of cardiac activity designed to assess the influence of both branches of the autonomic nervous on cardiac activity. Therefore, these metrics appear to provide a more precise method for assessing physiological arousal related to dissociation that goes beyond examining traditional heart rate metrics. Future studies could use these methods to identify if the expression of dissociation differs across individuals in terms of arousal and provide evidence in regards to the presence of multiple pathways related to the development of PTSD symptoms.

At present, the etiological role of dissociation in PTSD has not been well established and requires further clarification. It is also important to note that the measures used to assess dissociative symptoms vary widely across studies. It has been argued that the many different aspects of dissociation that these measures capture can make it difficult to generalize research findings (e.g., Bryant, 2007; van Der Hart, Nijenhuis, Steele, & Brown, 2004). In the present study, we made use of a measure that is proposed to act as a state measure of dissociation; the results of which were significant. The extent to which our results can be replicated using additional measures of dissociation, including those that examine specific elements of dissociation, warrants further investigation.

Impact of Tetris on Defensive Responses

In addition to replicating Holmes et al. (2009), another goal of the present study was to examine if the observed Tetris-effect extended to other symptoms frequently associated with PTSD. In particular, we wanted to explore if the Tetris effect would extend to tasks designed to elicit defensive startle reactions. We made use of two paradigms the eyeblink startle response and the cardiac defence response.

In terms of the CDR response, our results did not find a clear difference between conditions. However, we did find a three-way interaction between condition, image type (aversive or neutral), and time. This would suggest that a difference between groups might occur in response to the type of image at certain points in time. However, we were not able to locate the specific period of time in which this occurred through statistical approaches. Descriptively, it would appear that individuals in the Tetris condition showed a heightened and more sustained peak within the first 6 s following the auditory startle tone (particularly amongt individuals presented with the aversive image). Based on Vila et al.'s (2007) description of the CDR response, this would suggest a more pronounced release of parasympathetic influences over heart rate. Furthermore, the second peak that typically occurs approximately 30 s. following the auditory tone; this appeared to occur earlier amongst the Tetris group as compared to the rest group. Vila et al. suggest that this peak is attributed to an increase in sympathetic activity as well as a decrease in parasympathetic activity. Therefore, it may be the case that this response occurred more rapidly amongst individuals in the Tetris group.

The findings based on the CDR are tentative, at best, given the lack of statistical support for differences between groups. The power behind this analysis may have been somewhat compromised due to the fact that only the presentation of a single image was possible (given the rapid habituation of the CDR response), thus reducing the number of participants in each of the four groups that were examined. Replication of these findings will be important in order to verify if this effect does exist. Furthermore, it may be useful to make use of films with different content, as it may be the case the films that cause a more profound psychological and physiological response could have an increased impact on the CDR.

For the eyeblink startle response, we had expected that individuals who engaged in the Tetris task would have a different set of startle responses when faced with images related to the trauma film. This hypothesis was confirmed, however the direction of the relationship was opposite of what we had expected based on theoretical predictions. Specifically, individuals in the Tetris condition showed a significantly heightened startle response on trials where aversive images from the film were presented, as compared to individuals who were in the rest condition.

In order to further identify why this may have occurred, we conducted a moderation analysis to examine if the experimental condition impacted the relationship between self-reported negative reactions to the film and the magnitude of the startle response. Results from this analysis indicated that Tetris appeared to interfere with the tendency for individuals who reported feeling disturbed by the film to have a decreased eyeblink response. For individuals in the Tetris condition, no such relationship existed. These findings are at odds with a great deal of literature that suggests that negative images should potentiate eyeblink startle responses (e.g., Lang et al., 1998). However, this finding may be explained by the fact that the measure (IES) used to assess reactions to the film assessed avoidance. Therefore, it may be the case that individuals in the rest condition actively attempted to avoid the aversive stimuli presented in the eyeblink trials. Alternatively, our findings may represent a process that has been recently discussed in the literature: Individuals who attempt to consciously regulate their emotions have a reduced eyeblink response to unpleasant visual stimuli (e.g., Driscoll, Tranel, & Anderson, 2008; Jackson, Malmstads, Larson, & Davidson, 2003). In line with dual representation theory, it may be that their adaptive processing of the trauma film led individuals in the Tetris condition to be able to cope with the images without feeling the need to regulate or avoid their reactions, thus leading to a heightened eyeblink response. This proposition could be investigated in future studies through asking participants to rate their level of self-regulation or through creating groups that actively attempt to regulate their reactions. However, in terms of the relevance of this finding to PTSD, this finding could be interpreted to indicate that engaging in a visuospatial task immediately following a trauma has the potential to increase startle responses. Given that this is the first time findings related to defensive reactions have been reported, it will be important to replicate this aspect of the study.

Limitations

There are several general and specific factors that limit the findings reported in this study. First, the study relied on an analogue approach to examining symptoms resembling those that occur in PTSD. This approach has been criticized by some authors, who have indicated that findings from analogue studies bear no resemblance to what occurs in real-life traumatic situations (Spinhoven, Nijenhuis, & van Dyck, 1999; van der Kolk, 1996). However, there is substantial evidence that intrusive images frequently examined in analogue studies closely resemble those experienced by individuals with PTSD (Holmes et al., 2004; Laposa & Alden, 2006). Furthermore, results from analogue studies have produced findings that are relevant to our understanding the etiology of PTSD. This has been demonstrated when findings taken from analogue studies have been replicated amongst individual within clinical populations (Holmes & Bourne, 2008; Ehring, Kleim, & Ehlers, 2011). Therefore, although analogue approaches do have limitations, they provide an opportunity to examine reactions to traumatic material that would otherwise be impossible to examine.

A challenge with using the trauma film paradigm is the lack of a standardized protocol. In particular, different laboratories often use different trauma films. This may lead to differences across studies based on the content of the film (Weidmann, Conradi, Groger, Fehm, & Fydrich, 2009). In the present study, we used a film that did display graphic content, although how this compares to the graphic content in other studies could not be ascertained. Our findings may not be as generalizable as we wish because physiological and psychological reactivity can differ based on the content of the film. Ongoing research using different film paradigms will be an important element of future research. Ideally, a standardized library of trauma-related films should be developed, similar to what has been constructed for affective laden images (Lang et al., 1997).

In addition to the film paradigm used in the present study, our approach to the analyses we conducted does differ from those implemented in some other studies. In the present study, we examined both physiological and psychological variables separately at different points in time, in the hopes of identifying factors that could predict the development of intrusive images. Some statistical approaches attempt to identify the "best predictor" or "best combination of predictors" in order to understand contributions to the dependent variable, such as intrusive images. However, given that many of the variables we examined have not been used in previous studies of the trauma film paradigm, our analyses were quite narrow and specific. In future studies, examining the interaction amongst psychological and physiological variables provides the opportunity to better understand the relative contribution of these factors to the development of intrusive images. For example, Regambal & Alden (2009) made use of structural equation modeling to examine how psychological variables and psychological reactivity collectively contributed to the development of intrusive images. Similar approaches that integrate physiological variables offer an exciting opportunity to further understand the mechanisms that lead to the development of PTSD-like symptoms.

One final limitation is important to mention. We examined the role of autonomic influences on the development of intrusive images; however, we did not examine the other commonly investigated stress-related pathway, the HPA-axis. The logic behind our focus on the autonomic system was based on major findings that the immediate release of noradrenaline, more commonly associated with sympathetic activity, is considered a necessary component in the strengthening of emotional memory (Cahill, Babinsky, Markowitsch, & McGaugh, 1995; van Stegeren, 2008; Wolf, 2008; Zald, 2003). However, the role of the HPA-axis and stress hormones, such as cortisol, can also influence memory, and may interact with noradrenaline to modulate memory processes (van Stegeren et al., 2007). Therefore, future studies may want to integrate measures of HPA activity in addition to measures of autonomic activity in order to gain a more indepth understanding of how these stress systems collectively contribute to the development of intrusive images.

Conclusion

The present study was able to confirm some findings related to the development, and modulation of, intrusive images associated with a trauma film. The findings presented in this study partially replicated those from Holmes et al (2009); engaging in Tetris did reduce the frequency of intrusive images as compared to a rest condition. However, we were not able to replicate the finding that individuals in the Tetris condition reported fewer negative reactions to the film based on the IES self-report measure. An additional goal of this study was to identify psychological and physiological factors that could influence the development of intrusive images. We were able to demonstrate that during the film dissociative reactions, and increases in sympathetic arousal, predicted more frequent intrusive images. Interestingly, an increase in sympathetic activity and dissociation while engaging in the postfilm tasks was associated with a decrease in the frequency of intrusive images. We also found that increases in both positive and negative affect following the task were related to an increase in the frequency of reported intrusions for individuals in the rest condition, whereas these changes were related to a decrease in the frequency of intrusions amongst the Tetris condition. Finally, we also found that increases in dissociative reactions following the task led to fewer intrusive images. Collectively, these findings highlighted the importance of examining the contribution of both psychological and physiological measures in order to better understand factors that contribute to the development of PTSD. These findings also emphasize the importance of examining these variables following postfilm tasks, as this may help to explain the manner in which these tasks interfere with the development of PTSD-like symptoms.

Results from the eyeblink startle paradigm suggested that a heightened startle response was apparent among individuals in the Tetris group when they were presented with aversive film images prior to the auditory startle stimuli. It may be the case that engaging in the Tetris task could have interfered with the adaptive processing of the trauma-related material from the film, thus leading to a heightened response. Alternatively, these findings could be interpreted to represent a more adaptive response, as individuals' defensive reactions were heightened when faced with only aversive material from the film; whereas responses to neutral images was equivalent across groups. This is supported by our findings using moderation analysis. At present, the relevance of this effect to etiological theories of PTSD is not clear. Additional research using the methods described in this study may provide an opportunity for researchers to explore the ability of interventions to modulate other symptoms associated with PTSD, such as hyper-arousal, in addition to intrusive images.

One major advance put forward by the present study was the utility of using detailed metrics of autonomic influences on cardiac activity to investigate physiological contributions to the development of PTSD-related phenomena. Traditionally, studies that have examined cardiac activity in PTSD, and analogue studies of PTSD, have often examined cardiac responses based on overall heart rate. Indeed, Bryant (2006; 2008) has reported that in general, increased physiological arousal as measured by heart rate is often but not always associated with the development of PTSD. It may be the case that the true effect of physiological arousal (often attributed to sympathetic activation) could be masked by the influences of parasympathetic activity, when heart rate alone is examined. In the present study, models that examined both branches of the autonomic influences on heart rate found a significant relationship between sympathetic arousal and intrusive flashback-like memories. Some studies have started to examine similar cardiac variables amongst individuals with pre-existing PTSD (e.g., Blechert, Michael, Grossman, Lajtman, & Wilhelm, 2007; Cohen, et al., 2000; Hopper, Spinazzola, Simpson, & van der Kolk, 2006). However, little attention has been paid to the potential contribution of these metrics to the etiology of PTSD, or within analogue studies of PTSD. Given the importance of these metrics, the approach used within the present study to analyze cardiac metrics could be applied to data reported in earlier studies by other authors. These methods can also be easily integrated into future studies that collect ECG data. Collectively, this approach would have the potential to significantly improve our understanding of the role of autonomic influences on the development of PTSD.

In conclusion, the present study was successful in replicating previous studies that suggested that the development of intrusive memories could be altered through engaging in visuospatial tasks. This finding provides some additional support for the dual representation theory of PTSD. Furthermore, we were able to identify that both psychological and physiological factors may contribute to the development of symptoms associated with PTSD. Therefore, our results support other etiological models that integrate physiological responses with psychological responses to traumatic events. It is important to note that significant overlap exists among these models. The present study represents an effort to integrate etiological factors drawn from several of these models. Ongoing research in this area has the potential to further integrate these findings in order to better understand the multiple pathways that may lead to the development of PTSD. The creation and validation of comprehensive etiological models of PTSD is a necessary step in the pursuit of minimizing the impact of PTSD on the many individuals who suffer from this devastating disorder. As these models continue to develop, it is hoped that factors that can interfere with the development of this disorder will continue to be better understood in the years to come.

References

Adolphs, R., Tranel, D., & Denburg, N. (2000). Impaired emotional declarative memory following unilateral amygdala damage. *Learning & Memory, 7*, 180-186. doi:10.1101/lm.7.3.180

Allen, B.N., Trinder, J., & Brennan, C. (1999). Affective startle modulation in clinical depression: Preliminary findings. *Biologial Psychiatry, 46*(4), 542-550. doi:10.1016/S0006-3223(99)00025-6

Allen, J.J.B., Chambers, A.S., & Towers, D.N. (2007). The many metrics of cardiac chronotropy: A pragmatic primer and a brief comparison of metrics. *Biological Psychology, 74*, 243-262. doi:10.1016/j.biopsycho.2006.08.005

Allen, J.J.B., Chambers, A.S., & Towers, D.N. (2011). A pragmatic manual for getting started with QRStool: Reducing EKG data and obtaining many metrics with CMetX. Retrieved from: http://jallen.faculty.arizona.edu/resources_and_downloads

American Psychiatric Association, & American Psychiatric Association. Task Force on DSM-IV. (2000). *Diagnostic and statistical manual of mental disorders : DSM-IV-TR* (4th ed., text revision). Washington, DC: American Psychiatric Association.

Amstadter, A.B., Nugent, N.R., & Koenen, K.C. (2009). Genetics of PTSD: Fear conditioning as a model for future research. *Psychiatric Annals, 39*, 358-367. doi:10.3928/00485713-20090526-01

Aoki, C.R.A. (2008). Rewriting my autobiography. *Bulletin of Science, Technology & Society, 28*(4), 349-359. doi:10.1177/0270467608320223

Appelhans, B.M., & Luecken, L.J. (2006). Heart rate variability as an index of regulated emotional responding. *Review of General Psychology, 10*, 229-240. doi: 10.1037/1089-2680.10.3.229

Barnes, L.B., Harp, D., & Jung, W.S. (2002). Reliability generalization of scores on the Spielberger state-trait anxiety inventory. *Educational & Psychological Measurement, 62*(4), 183-603-618. doi:10.1177/0013164402062004005

Beltzer, E.K., Fortunato, C.K., Guaderrama, M.M. Peckins, M.K., Garramone, B.M., & Granger, D.A. (2010). Salivary flow and alpha-amylase: Collection technique, duration, and oral fluid type. *Physiology & Behavior, 101*, 289-296. doi: 10.1016/j.physbeh.2010.05.016

Berntson, G.G., Cacioppo, J.T., & Quigley, K.S. (1991). Autonomic determinism: The modes of autonomic control, the doctrine of autonomic space, and the laws of autonomic constraint. *Psychological Review, 98*(4), 459-487. Retrieved from http://psychology.uchicago.edu/people/faculty/cacioppo/jtcreprints/bcq91.pdf

Berntson, G.G., Cacioppo, J.T., & Quigley, K.S. (1993). Cardiac psychophysiology and autonomic space in humans: Empirical perspectives and conceptual implications. *Psychological Bulletin, 114*(2), 296-322. Retrieved from: http://psychology.uchicago.edu/people/faculty/cacioppo/jtcreprints/cbbquf94.pdf

Berntson, G.G., Bigger, T.J., Eckberg, D.L., Grossman, P., Kaufman, G.D., Malik, M., Nagaraja, H.N., Porges, S.W., Saul, P.J., Stone P.H., & Van der Molen, M.W. (1997). Heart rate variability: Origins, methods, and interpretive caveats.

Psychophysiology, 34(6), 623-648. doi:10.1111/j.1469-8986.1997.tb02140.x

Bileing, P.J., Antony, M.M., & Swinson, R.P. (1998). The state-trait anxiety inventory, trait version: Structure and content re-examined. *Behaviour Research and Therapy, 36*(7-8), 777-788. doi:10.1016/S0005-7967(98)00023-0

Blechert, J., Michael, T., Grossman, P., Lajtman, M., & Wilhelm, F. H. (2007). Autonomic and respiratory characteristics of posttraumatic stress disorder and panic disorder. *Psychosomatic Medicine, 69*, 935-943. doi: 10.1097/PSY.0b013e31815a8f6b

Blumenthal, T.D., Cuthbert, B.N., Filion, D.L., Hackley, S., Lipp, O.V., & van Boxtel, A. (2005). Committee report: Guidelines for human startle eyeblink electromyographic studies. *Psychophysiology, 42,* 1-15. Doi:10.1111/j.1469-8986.2005.00271.x

Bosch, J.A., Veerman, E.C.I., de Geus, E.J., & Proctor, G.B. (2011) Amylase as a reliable and convenient measure of sympathetic activity: Don't start salivating just yet! *Psychoneuroendocrinology, 36*(4) 449-453. doi: 10.1016/j.psyneuen.2010.12.019

Bradley, M.M., &, P.J. (1994). Me Blechert uring emotion: The self-assessment manikin and the semantic differential. *Journal of Behavior Therapy and Experimental Psychiatry, 25*(1), 49-59. doi:10.1016/0005-7916(94)90063-9

Breslau, N. (2009). The epidemiology of trauma, PTSD, and other posttrauma disorders. *Trauma, Violence, & Abuse, 10*(3), 198-210. doi:10.1177/1524838009334448

Brewin, C.R. (2008). What is it that a neurobiological model of PTSD must explain? *Progress in Brain Research, 167*, 217-228. doi:0.1016/S0079-6123(07)67015-0

Brewin, C.R., Christodoulides, J., & Hutchinson, G. (1996). Intrusive thoughts and intrusive memories in a nonclinical sample. *Cognition & Emotion, 10*(1), 107-112. doi:10.1080/026999396380411

Brewin, C.R., Dalgeish, T., & Joseph, S. (1996). A dual representation theory of posttraumatic stress disorder. *Psychological Review, 103*(4), 17. Retrieved from http://www.psycnet.org/journals/rev/103/4/670.pdf

Brewin, C.R., Andrews, B., & Valentine, J.D. (2000). Meta-analysis of risk factors for posttraumatic stress disorder in trauma-exposed adults. *Journal of Consulting and Clinical Psychology, 68*(5), 748-766. doi:10.1037/10022-006X.68.5.748

Brewin, C.R., Gregory, J.D., Lipton, M., & Burgess, N. (2010). Intrusive images in psychological disorders: Characteristics, neural mechanisms, and treatment implications. *Psychological Review, 117*(1), 210-232. doi: 10.1037/a0018113

Brewin, C.R., & Holmes, E.A. (2003). Psychological theories of posttraumatic stress disorder. *Clinical Psychology Review, 23*(3), 339-376. doi:10.1016/S0272-7358(03)00033-3

Bremner, J. D., Krystal, J. H., Putnam, F. W., Southwick, S. M., Marmar, C., Charney, D. S., & Mazure, C. M. (1998). Measurement of dissociative states with the clinician-administered dissociative states scale (CADSS). *Journal of Traumatic Stress, 11,* 125–136. Doi: 10.1023/A:1024465317902

Bryant, R.A. (2006). Longitudinal psychophysiological studies of heart rate: Mediating effects and implications for treatment. *Annals of the New York Academy of Sciences, 1071,* 19-26. doi: 10.1196/annals.1364.002

Bryant, R.A. (2007). Does dissociation further our understanding of PTSD? *Journal of Anxiety Disorders, 21*(2), 183-191. doi: 10.1016/j.janxdis.2006.09.012

Bryant, R.A., Creamer, M., O'Donnell, M., Silove, D., & McFarlane, A.A. (2008). A multisite study of initial respiration rate and heart rate as predictors of posttraumatic stress disorder. *Journal of Clinical Psychiatry, 69,* 1694-1701. Retrieved from http://article.psychiatrist.com.ezproxy.lakeheadu.ca/?ContentType=START&ID=10003738

Buckley, T.C., & Kaloupek, D.G. (2001). A meta-analytic examination of basal cardiovascular activity in posttraumatic stress disorder. *Psychosomatic Medicine, 63*(4), 585-594. doi:0033-3174/01/6304-0585

Cahill, L., & Alkire, M.T. (2003). Epinephrine enhancement of human memory consolidation: Interaction with arousal at encoding. *Learning & Memory, 79*(2), 270-274. doi:10.1101/lm.62403

Cahill, L., Gorski, L., & Kathryn, L.E. (2003). Enhanced human memory consolidation with post-learning stress: Interaction with the degree of arousal at encoding. *Learning & Memory, 10*(4), 5-270-274. doi:10.1101/lm.62403

Cahill, L., Babinsky, R., Markowitsch, H.J., & McGaugh, J.L. (1995). The amygdala and emotional memory. *Nature, 377*(6547), 295-296. Retrieved from http://74.125.155.132/scholar?q=cache:ggNdlYnTHIoJ:scholar.google.com/&hl=en&as_sdt=2000&as_vis=1

Cahill, L., & McGaugh, J.L. (1998). Mechanisms of emotional arousal and lasting declarative memory. *Trends in Neurosciences, 21*(7), 294-299.

doi:10.1016/S0166-2236(97)01214-9

Canadian Centre for Occupational Health and Safety. (2009). Occupational exposure limits in Canada. Retrieved from: http://www.ccohs.ca/oshanswers/phys_agents/exposure_can.html

Chamberlain, S.R., Müller, U., Blackwell, A.D., Robbins, T.W., & Sahakian, B.J. (2006). Noradrenergic modulation of working memory and emotional memory in humans. *Psychopharmacology, 188*(4), 397-407. doi:10.1007/s00213-006-0391-6

Charney, D.S. (2004). Psychobiological mechanisms of resilience and vulnerability: Implications for successful adaptation to extreme stress. *Focus, 2*(3), 368-391. Retrieved from http://focus.psychiatryonline.org/cgi/content/abstract/2/3/368

Clohessy, S., & Ehlers, A. (1999). PTSD symptoms, response to intrusive memories and coping in ambulance service workers. *British Journal of Clinical Psychology, 38*, 251-265.

Cohen, H., Benjamin, Geva, A.B, Matar, M.A., Kaplan, Z., & Kotler, M. (2000). Autonomic dysregulation in panic disorder and in post-traumatic stress disorder: Application of power spectrum analysis of heart rate variability at rest and in response to recollection of trauma or panic attacks. *Psychiatry Research, 96*(1), 368-391. Retrieved from http://www.psy-journal.com/article/S0165-1781%2800%2900195-5/abstract

Cohen, H., Kotler, M., Matar, M.A., Kaplan, Z., Miodownik, H., & Cassuto, Y. (1997). Power spectral analysis of heart rate variability in posttraumatic stress disorder patients. *Biological Psychiatry, 41*(5), 627-629. doi:10.1016/S0006-3223(96)00525-2

Cohen, H., Kotler, M., Matar, M.A., Kaplan, Z., Loewenthal, U., Miodownik, H., & Cassuto, Y. (1998). Analysis of heart rate variability in posttraumatic stress disorder patients in response to a trauma-related reminder. *Biological Psychiatry, 44*(10), 1054-1059. doi:10.1016/S0006-3223(97)00475-7

Craig, A.D. (2002). How do you feel? Interoception: The sense of the physiological condition of the body. *Nature Reviews Neuroscience, 3*, 655-66. doi: 10.1038/nrn894

Critchley, H.D., Wiens, S., Rothstein, P., Ohman, A., & Dolan, R.J. (2004). Neural systems supporting interoceptive awareness. *Nature Reviews Neuroscience, 7*, 189-195. doi: 10.1038/nn1176

Davidson, J.R.T., Hughes, D., Blazer, D.G., & George, L.K. (1991). Post-traumatic stress disorder in the community: An epidemiological study. *Psychological Medicine, 21*, 713-721. doi:10.1017/S0033291700022352

Davies, M.I., & Clark, D.M. (1998). Predictors of analogue post-traumatic intrusive cognitions. *Behavioual and Cognitive Psychotherapy, 26*, 303-314. Retrieved from: http://journals.cambridge.org/action/displayJournal?jid=BCP.

de Kloet, E.R., Joels, M., & Holsboer, F. (2005). Stress and the brain: From adaptation to disease. *Nature Reviews. Neuroscience, 6*(6), 463-475. doi:10.1038/nrn1683

de Quervain, D.J., Roozendaal, B., Nitsch, R.M., McGaugh, J.L., & Hock, C. (2000). Acute cortisone administration impairs retrieval of long-term declarative memory in humans. *Nature Neuroscience, 3*(4), 313-314. doi:10.1038/73873

Delahanty, D.L., & Nugent, N.R. (2006). Predicting PTSD prospectively based on prior trauma history and immediate biological responses. *Annals of the New York Academy of Sciences, 1071*, 27-40. doi:10.1196/annals.1364.003

DePrince, A.P., & Freyd, J.J. (2007). Trauma-induced dissociation. In: M.J. Friendman, T.M. Keana, & P.A. Resick (Eds), *Handbook of PTSD: Science and practice* (pp. 135 -140). New York: The Guilford Press.

Depue, B.E., Curran, T., & Banich, M.T. (2007). Prefrontal regions orchestrate suppression of emotional memories via a two-phase process. *Science, 317*, 215-219. Doi: 10.1126/science.1139560

Driscoll, D., Tranel, D., & Anderson, S. (2008). The effects of voluntary regulation of positive and negative emotion on psychophysiological responsiveness. *International Journal of Psychophysiology, 72*(1), 61-66. doi: 10.10.16/j.ijpsycho.2008.03.012

Ehlers A. (1998). Data-driven versus conceptual processing questionnaire. Unpublished manuscript.

Ehlers, A., & Clark, D.M. (2000). A cognitive model of posttraumatic stress disorder. *Behaviour Research and Therapy, 38*(4), 319-345. doi:10.1016/S0005-7967(99)00123-0

Ehring, T., Kleim, B., & Ehlers, A. (2011). Combining clinical studies and analogue experiments to investigate cognitive mechanisms in posttraumatic stress disorder. *International Journal of Cognitive Therapy, 2*(4), 165-177. doi: 10.1521/ijct.2011.4.2.165

Elzinga, B.M., & Bremner, J.D. (2002). Are the neural substrates of memory the final common pathway in posttraumatic stress disorder (PTSD)? *Journal of Affective Disorders, 70*(1), 1-17. doi:10.1016/S0165-0327(01)00351-2

Elzinga, B.M., & Roelofs, K. (2005). Cortisol-induced impairments of working memory require acute sympathetic activation. *Behavioral Neuroscience, 119*(1), 98-103. doi:10.1037/0735-7044.119.1.98

Fletcher, P.C., & Henson, R.N. (2001). Frontal lobes and human memory: Insights from functional neuroimaging. *Brain, 124*(5), 849-881. doi: *10.1093/brain/124.5.849*

Foa, E. B., Steketee, G., & Rothbaum, B.O. (1989). Behavioral/cognitive conceptualizations of post-traumatic stress disorder. *Behavior Therapy, 20*(2), 155-176. doi:10.1016/S0005-7894(89)80067-X

Grey, N., & Holmes, E.,A. "Hotspots" in trauma memories in the treatment of post-traumatic stress disorder: A replication. *Memory, 16*(7), 788-796. doi:10.1080/09658210802266446

Grey, N., Holmes, E.A., & Brewin, C.R. (2001). Peritruamtic emotional "hot spots" in memory. *Behavioural and Cognitive Psychotherapy, 29*(3), 367-372. doi:10.1017/S1352465801003095

Grillon, C. (2002). Startle reactivity and anxiety disorders: Aversive conditioning, context, and neurobiology. *Biological Psychiatry, 52*(10), 958-975. doi:10.1016/S0006-3223(02)01665-7

Griffin, M.G., Resick, P.A., & Mechanic, M.B. (1997). Objective assessment of peritraumatic dissociation: Psychophysiological indicators. *Journal of Anxiety Disorders,* 154, 1081-1088. Retrieved from: http://psychiatryonline.org/article.aspx?page=1081&Volume=153&journalID=13

Guthrie, R.M., & Bryant, R.A. (2005). Auditory startle response in firefighters before and after trauma exposure. *American Journal of Psychiatry, 162*(2), 8-283. doi:290

Halligan, S.L., Clark, D.M., & Ehlers, A. (2002). Cognitive processing, memory, and the development of PTSD symptoms: Two experimental analogue studies. *Journal of Behavior Therapy and Experimental Psychiatry, 33*(2), 73-89. doi:10.1016/S0005-7916(02)00014-9

Halligan, S.L., Michael, T., Clark, D.M., & Ehlers, A. (2003). Posttraumatic stress disorder following assault: The role of cognitive processing, trauma memory, and appraisals. *Journal of Consulting and Clinical Psychology, 71*(3), 419-431. Retrieved from http://resolver.scholarsportal.info.ezproxy.lakeheadu.ca/resolve/0022006x/v71i0003/419_psdfatcptmaa

Hamann, S. (2001). Cognitive and neural mechanisms of emotional memory. *Trends in Cognitive Sciences, 5*(9), 394-400. Retrieved from: http://tics.trends.com

Hayes, A. F. (2012). PROCESS: A versatile computational tool for observed variable mediation, moderation, and conditional process modeling [White paper]. Retrieved from http://www.afhayes.com/

Henry, M., Fishman, J.R., & Youngner, S.J. (2007). Propranolol and the prevention of post-traumatic stress disorder: Is it wrong to erase the "Sting" of bad memories? *The American Journal of Bioethics, 7*(9), 12-20. doi:10.1080/15265160701518474

Holmes, E.A., & Bourne, C. (2008). Inducing and modulating intrusive emotional memories: A review of the trauma film paradigm. *Acta Psychologica, 127*(3), 553-566. doi:10.1016/j.actpsy.2007.11.002

Holmes, E.A., Brewin, C.R., & Hennessy, R.G. (2004). Trauma films, information processing, and intrusive memory development. *Journal of Experimental Psychology, 133*(1), 3-22. doi:10.1037/0096-3445.133.1.3

Holmes, E. A., Grey, N., & Young, K. A. D. (2005). Intrusive images and ''hotspots'' of trauma memories in post-traumatic stress disorder: An exploratory investigation of emotions and cognitive themes. *Journal of Behavior Therapy and Experimental Psychiatry, 36*(1), 3-17. doi: 10.1016/j.jbtep.2004.11.002

Holmes, E.A., James, E.L., Coode-Bate, T., & Deeprose, C. (2009). Can playing the computer game Tetris reduce the build-up of flashbacks for trauma? A proposal from cognitive science. *PLoS ONE, 4*(1), e4153.

Holmes, E.A., James, E.L., Kilford, E.J., & Deeprose, C. (2010). Key steps in developing a cognitive vaccine against traumatic flashbacks: Visuospatial Tetris versus verbal pub quiz. *PLoS ONE, 5*(11), 1-9. doi: 10.1371/journal.pone.0013706 doi:10.1371/journal.pone.0004153.

Hopper, J.W., Spinazzola, J., Simpson, W., & Van der Kolk, B. (2005). Preliminary evidence of parasympathetic influence on basal heart rate in posttraumatic stress disorder. *Journal of Psychosomatic Research, 60*(1), 83-90. doi:10.1016/j.jpsychores.2005.06.002

Howland, J.G., & Wang, Y.T. (2008) Synaptic plasticity in learning and memory: Stress effects in the hippocampus. *Progress in Brain Research, 169*, 145-158. doi:

10.1016/S0079-6123(07)00008-8

Jackson, D.C., Malmstadt, J.R., Larson, C.K., & Davidson, R.J. (2003). Suppression and enhancement of emotional responses to unpleasant pictures. *Psychophysiology, 37*(4), 515-522. doi: 10.111/1469-8986.3740515

Kaufman, ML., Kimble, M.O., Kaloupek, D.G., McTeague, L.M., Bachrach, P., Forti, A… Keane, T.M. (2002). Peritraumatic dissociation and physiological response to trauma-relevant stimuli in Vietnam combat veterans with posttraumatic stress disorder. *Journal of Nervous & Mental Disease, 190*(3), 167-173.

Kessler, R. C., Sonnega, A., Bromet, E., Hughes, M., & Nelson, C. B. (1995). Posttraumatic stress disorder in the national comorbidity survey. *Archives of General Psychiatry, 52*(12), 1048-1060. Retrieved from http://archpsyc.ama-assn.org/cgi/reprint/52/12/1048

Kindt, M., Soeter, M., & Vervliet, B. (2009). Beyond extinction: Erasing human fear responses and preventing the return of fear. *Nature Neuroscience, 12*(3), 256-258. doi:10.1038/nn.2271

Kleim, B., Ehlers, A., & Gluckman, E. (2012). Investigating cognitive pathways to psychopathology: Predicting depression and Posttraumatic stress disorder from early responses after assault. *Psychological Trauma: Theory, Research, Practice, and Policy*. Advance online publication. doi:10.1037/a0027006

Kreibig, S.D. (2010) Autonomic nervous system activity in emotion: A review. *Biological Psychology, 63*, 394-421. doi: 10.1016/j.biopsycho.2010.03.010

Kroes, M.W., Strange, B.A., & Dolan, R.J. (2010). β-Adrenergic blockade during memory retrieval in humans evokes a sustained reduction of declarative emotional memory enhancement. *The Journal of Neuroscience, 30*(11), 3959-3963. doi:10.1523/JNEUROSCI.5469-09.2010

Kuhn, E., Blanchard, E.B., Fuse, T., Hickling, E.J., & Broderick, J. (2006). Heart rate of motor vehicle accident survivors in the emergency department, peritraumatic psychological reactions, ASD, and PTSD severity: A 6-month prospective study. *Journal of Traumatic Stress, 19*(5), 735-740. doi:10.1002/jts.20150

LaBar, K.S., & Cabeza, R. (2006). Cognitive neuroscience of emotional memory. *Nature Reviews. Neuroscience, 7*(1), 54-64. doi:10.1038/nrn1825

Lane, R.D., McRae, K., Reiman, E.M., Chen, K., Ahern, G.L., & Thayer, J.F. (2009). Neural correlates of heart rate variability during emotion. *Neuroimage, 44*, 213-222. doi: 10.1016/j.neuroimage.2008.07.056

Lang, P. J. (1985). The cognitive psychophysiology of emotion: Fear and anxiety. In A. Tuma & J. Maser (Eds.), *Anxiety and the anxiety disorders* (pp. 131–170). Hillsdale, NJ: Erlbaum.

Lang, P.J. (1995). The emotion probe: Studies of motivation and attention. *American Psychologist, 50*(5), 372-385. Retrieved from http://resolver.scholarsportal.info.ezproxy.lakeheadu.ca/resolve/0003066x/v50i0005/372_tepsomaa

Lang, J.P., Bradley, M.M., & Cuthbert, B.N. (1998). Emotion, motivation, and anxiety: Brain mechanisms and psychophysiology. *Biological Psychiatry, 44*(12), 1248-1263. doi:10.1016/S0006-3223(98)00275-3

Lang, P.J., Bradley, M.M., & Cuthbert, B.N. (1997). *International Affective Picture System (IAPS): Technical manual and affective ratings.* Gainesville, Florida: NIMH Centre for the Study of Emotion and Attention.

McGaugh, J.M. (2004). The amygdala modulates the consolidation of memories of emotionally arousing experiences. *Annual Review of Neuroscience, 27*, 1-28. doi:10.1146/annurev.neuro.27.070203.144157

Laposa, J.M., & Alden, L.E. (2006). An analogue study of intrusions. *Behaviour Research and Therapy, 44*, 925-946. doi: 10.1016/j.brat.2005.07.003

Metzger, L.J., Orr, S.P., Berry, N.J., Ahern, C.E., Lasko, N.B., & Pitman, R.K. (1999). Physiologic reactivity to startling tones in women with posttraumatic stress disorder. *Journal of Abnormal Psychology, 108*(2), 347-352. Retrieved from http://resolver.scholarsportal.info.ezproxy.lakeheadu.ca/resolve/0021843x/v108i0002/347_prtstiwwpsd

Morina, N., Böhme, H.F., Ajdukovic, D., Bogic, M., Franciskovic, T., Galeazzi, G.M., ... Priebe, S. (2010). The structure of post-traumatic stress symptoms in survivors of war: Confirmatory factor analyses of the impact of event scale-revised. *Journal of Anxiety Disorders, 24*(6), 606-611. doi:10.1016/j.janxdis.2010.04.001

Murray, J. (1997). *The role of dissociation in the development and maintenance of post-traumatic stress disorder.* Unpublished doctoral dissertation, Oxford University, Oxford, England.

Murray, J., Ehlers, A., & Mayou, R.A. (2002). Dissociation and post-traumatic stress disorder: Two prospective studies of road traffic accident survivors. *The British*

Journal of Psychiatry, 180, 363-368. Retrieved from http://bjp.rcpsych.org/cgi/content/full/180/4/363

Nijenhuis, E. R. S., Van der Hart, O., & Steele, K. (2002). The emerging psychobiology of trauma-related dissociation and dissociative disorders. In H. D'Haenen, J. A. den Boer, & P. Pillner (Eds.), *Biological Psychiatry* (pp. 1079–1098). New York: John Wiley & Sons, Ltd.

Nechbaur, F. (2002). Audio test files. Retrieved from: http://www.dogstar.dantimax.dk/testwavs/0_readme.txt

Nielson, K. A., & Jensen, R. A. (1994). Beta-adrenergic receptor antagonist antihypertensive medications impair arousal-induced modulation of working memory in elderly humans. *Behavioral and Neural Biology, 62*(3), 190-200. doi:10.1016/S0163-1047(05)80017-2

Nixon, R.D.V., Bryant, R.A., Moulds, M.L., Felmingham, K.L., & Mastrodomenico, J.A. (2005). Physiological arousal and dissociation in acute trauma victims during trauma narratives. *Journal of Traumatic Stress, 18*(2), 107-113. doi: 10.1002/jts.20019.

O'Carroll, R.E., Drysdale, E., Cahill, L., Shajhan, P., & Ebmeier, K. (1999). Stimulation of the noradrenergic system enhances and blockade reduces memory for emotional material in man. *Psychological Medicine, 29*(5), 1083-1088. doi:10.1017/S0033291799008703

Overbeek, T.J.M., van Boxte, A., & Westerink, J.H.D.M. (2012). Respiratory sinus arrhythmia responses to induced emotional states: Effects of RSA indices, emotion induction method, age, and sex. *Biological Psychology, 91*, 128-141. doi: 10.1016/j.biopsycho.2012.05.011

Ozer, E.J., Best, S. R., Lipsey, T.L., & Weiss, D.S. (2003). Predictors of posttraumatic stress disorder and symptoms in adults: A meta-analysis. *Psychological Bulletin, 129*(1), 52-73. doi:10.1037/0033-2909.129.1.52

Peterson R.A., & Reiss S. (1992). *Anxiety Sensitivity Index Manual*, 2nd ed. Worthington, Ohio: International Diagnostic Systems.

Pitman, R.K. (2006). Secondary pharmacological prevention of PTSD: Therapeutic implications of a translational model. In N. Kato, R. K. Lawata & R. K. Pitman (Eds.), *PTSD* (pp. 281-296). Tokyo, American Psychiatric Association: Springer

Pitman, R.K., Sander, K.M., Zusman, R.M., Healy, A. R., Cheema, F., Lasko, N.B., Cahill, L., & Orr, S.P. (2002). Pilot study of secondary prevention of posttraumatic stress disorder with propranolol. *Biological Psychiatry, 51*(2), 189-192. doi:10.1016/S0006-3223(01)01279-3

Pole, N., Neylan, T.C., Best S.R., Orr S.P, & Marmar, C.R. (2003). Fear-potentiated startle and posttraumatic stress symptoms in urban police officers. *Journal of Traumatic Stress, 16*(5), 488-506. doi:10.1023/A:1025758411370

Pole, N. (2007). The psychophysiology of posttraumatic stress disorder: A meta-analysis. *Psychological Bulletin, 133*(5), 725-746. doi:10.1037/0033-2909.133.5.725

Rauch, S.L., Shin, L.M., & Phelps, E.A. (2006). Neurocircuitry models of posttraumatic stress disorder and extinction: Human neuroimaging research-past, present, and future. *Biological Psychiatry, 60*(4), 376-382.

doi:10.1016/j.biopsych.2006.06.004

Regambal, M.J., & Alden, L.E. (2009). Pathways to intrusive memories in a trauma paradigm: A structural equation model. *Depression and Anxiety, 26*, 155-166. doi:10.1002/da.20483

Resick, P.A., Monson, C.M., Rizvi, S.L. (2008). Posttraumatic stress disorder. In D.H. Barlow (Ed.), *Clinical handbook of psychological disorders* (pp. 65-122). New York: The Guilford Press

Reyes del Paso, G.A., Godoy, J., & Vila, J. (1993). Respiratory sinus arrhythmia as an index of parasympathetic cardiac control during the cardiac defense response. *Biological Psychology, 35*(1), 17-35. Retrieved from http://resolver.scholarsportal.info.ezproxy.lakeheadu.ca/resolve/03010511/v35i0001/17_rsaaaicdtcdr

Rodrigues, S.M., LeDoux, J.E., & Sapolsky, R.M. (2009). The influence of stress hormones on fear circuitry. *Annual Review of Neuroscience, 32*, 289-313. doi:10.1146/annurev.neuro.051508.135620

Rodríguez-Ruiz, S., Ruiz-Padial, E., Vera, N., Fernández, C., Anllo-Vento, L., & Vila, J. (2009). Effect of heart rate variability on defensive reaction and eating disorder symptomatology in chocolate craver. *Journal of Psychophysiology, 23*(3), 95-103. doi:10.1027/0269-8803.23.3.95

Rohleder, N., Nater, U.M., Wolf, J. M., Ehlert, U., & Kirschbaum, C. (2004). Psychosocial stress-induced activation of salivary alpha-amylase an indicator of sympathetic activity? *Annals of the New York Academy of Sciences, 1032*, 258-

263. doi:10.1196/annals.1314.033

Roozendaal, B. (2000). Glucocorticoids and the regulation of memory consolidation. *Psychoneuroendocrinology, 25*(3), 213-238. doi:10.1016/S0306-4530(99)00058-X

Roozendaal, B., Okuda, S., de Quervain, D.J.F., & McGaugh, J.L. (2006). Glucocorticoids interact with emotion-induced noradrenergic activation in influencing different memory functions. *Neuroscience, 138*(3), 901-910. doi: 10.1016/j.neuroscience.2005.07.049

Roozendaal, B., McEwen, B.S., & Chattarji, S. (2009). Stress, memory and the amygdala. *Nature Reviews: Neuroscience, 10*(6), 423-433. doi: 10.1038/nrn2651

Ruiz-Padial, E., Sollers, J.J., Vila, J., & Thayer, J.F. (2003). The rhythm of the heart in the blink of an eye: Emotion-modulated startle magnitude covaries with heart rate variability. *Pscyhophysiology, 40*(2), 306-313. doi:10.1111/1469-8986.00032

Ruiz-Padial, E., Mata, J.L., Rodriguez, S., Fernandez, M.C., & Vila, J. (2005). Non-conscious modulation of cardiac defense by masked phobic pictures. *International Journal of Psychophysiology, 56*(3), 271-281. doi: 10.1016/j.ijpsycho.2004.12.010

Ruiz-Padial, E., & Vila, J. (2007). Fearful and sexual pictures not consciously seen modulate the startle reflex in human beings. *Biological Psychiatry, 61*(8), 996-1001. doi: 10.1016/j.biopsych.2006.08.046

Salimetrics. (2012). Salivary α-amylase assay kit procedure. Retrieved from http://www.salimetrics.com/documents/Amylase_Kit_Insert.pdf

Sandi, C., & Pinelo-Nava, M.T. (2007). Stress and memory: Behavioral effects and neurobiological mechanisms. *Neural Plasticity, 2007, 1-20.* doi:10.1155/2007/78970.

Sandin, B., Chorot, P., & McNally, R.J. (2001). Anxiety sensitivity index: Normative data and its differentiation from trait anxiety. *Behaviour Research and Therapy 39*(2), 213-219. doi: 10.1016/S0005-7967(00)00009-7

Searcy, C.P., Bobadilla, L., Gordon, W.A., Jacques, S., & Elliott, L. (2012). Pharmacological prevention of combat-related PTSD: A literature review. *Military Medicine, 177*(6), 649-654. Retrieved from: http://search.proquest.com/docview/1032532576

Sterlini, G.L., & Bryant, R.A. (2002). Hyperarousal and dissociation: A study of novice skydivers. *Behaviour Research and Therapy, 40*(4), 431-437. doi: 10.1016/S0005-7967(01)00021-3

Shalev, A.Y., Peri, T., Brandes, D., Freedman, S., Orr, S.P., & Pitman, R.K. (2000). Auditory startle response in trauma survivors with posttraumatic stress disorder : A prospective study. *The American Journal of Psychiatry, 157*(2), 255-261. Retrieved from http://ajp.psychiatryonline.org/cgi/reprint/157/2/255.pdf

Sledjeski, E.M., & Delahanty, D.L. (2012). Prior peritraumatic dissociative experiences affect autonomic reactivity during trauma recall. *Journal of Trauma & Dissociation, 13*(1), 32-50. doi: 10.1080/15299732.2011.608628

Spielberger, C. D. (1983). *Manual for the State-Trait Anxiety Inventory*. Palo Alto, CA: Consulting Psychologists Press.

Stein, M.B., Kerridge, C., Dimsdale, J.E., & Hoyt, D.B. (2007). Pharmacotherapy to prevent PTSD: Results from a randomized controlled proof-of-concept trial in physically injured patients. *Journal of Traumatic Stress, 20*(6), 923-932. doi:10.1002/jts.20270

Stiglmayr, C., Schmahl, C., Bremner, J.D., Bohus, M., & Ebner-Priemer, (2009). Development and Psychometric Characteristics of the DSS-4 as a short instrument to assess dissociative experience during neuropsychological experiments. *Psychopathology, 42,* 370-374. doi: 10.1159/000236908

Stuart, A.D.P., Holmes, E.A., & Brewin, C.R. (2006). The influence of a visuospatial grounding task on intrusive images of a traumatic film. *Behaviour Research and Therapy, 44*(4), 611-619. doi:10.1016/j.brat.2005.04.004

Tabachnick, B.G., & Fidell, L.S. (2007). Using multivariate statistics (5th ed.). Boston, MA: Pearson.

Tarvainen, M.P., & Niskanen, J. (2006). *Kubios HRV analysis users guide*. Kuopio, Finland: Biosignal Analysis and Medical Imaging Group.

Thayer, J.F., & Brosschot, J.F. (2005). Psychosomatics and psychopathology: Looking up and down from the brain. *Psychoneuroendocrinology, 30*(10), 1050-1058. doi:10.1016/j.psyneuen.2005.04.014

Thayer, J.F., & Lane, R.D. (2007). The role of vagal function in the risk for cardiovascular disease and mortality. *Biological Psychology, 74*(2), 224-242. doi:10.1016/j.biopsycho.2005.11.013

Toichi, M., Sugiura, T., Murai, T., Sengoku, A. (1997). A new method of assessing cardiac autonomic function and its comparison with spectral analysis and coefficient of variation of R–R interval. *Journal of Autonomic Nervous System, 62*(1/2), 79–84. doi:10.1016/S0165-1838(96)00112-9

Vaiva, G., Ducrocq, F., Jezequel, K., Averland, B., Lestavel, P., ... Marmar, C. R. (2003). Immediate treatment with propranolol decreases posttraumatic stress disorder two months after trauma. *Biological Psychiatry, 54*(9), 947-949. doi:10.1016/S0006-3223(03)00412-8

van der Hart, O., Nijenhuis, E., Steele, K., & Brown, D. (2004). Trauma-related dissociation: Conceptual clarity lost and found. *Australian & New Zealand Journal of Psychiatry, 38*(11-12), 906-914. doi: 10.1080/j.1440-1614.2004.01480.x

van Stegeren, A.H., Wolf, O.T., Everaerd, W., Scheltens, P., Barkhof, F., & Rombouts, S. A.R.B. (2007). Endogenous cortisol level interacts with noradrenergic activation in the human amygdala. *Neurobiology of Learning and Memory, 87*(1), 57-66. doi:doi:10.1016/j.nlm.2006.05.008

van Stegeren, A., Rohleder, N., Everaerd, W., & Wolf, O.T. (2006). Salivary alpha amylase as marker for adrenergic activity during stress: Effect of betablockade. *Psychoneuroendocrinology, 31*(1), 137-141. doi:10.1016/j.psyneuen.2005.05.012

van Stegeren, A.H. (2008). The role of the noradrenergic system in emotional memory. *Acta Psychologica, 127*(3), 532-541. doi:10.1016/j.actpsy.2007.10.004

van Stegeren, A.H., Goekoop, R., Everaerd, W., Scheltens, P., Barkhof, F., Kuijer, J.P. A., & Rombouts, S.A.R.B. (2005). Noradrenaline mediates amygdala activation in men and women during encoding of emotional material. *NeuroImage, 24*(3), 898-909. doi:10.1016/j.neuroimage.2004.09.011

van Stegeren, A.H., Everaerd, W., & Gooren, L.J.G. (2002). The effect of beta-adrenergic blockade after encoding on memory of an emotional event. *Psychopharmacology, 163*(2), 202-212. doi:10.1038/nrn1825

Vila, J., Guerra, P., Munoz, M.A., Vico, C., Viedma-del Jesus, M.I., Delgado, L.C., Perakakis, P., Kley, E., Mata, J.L., & Rodriguez, S. (2007). Cardiac defence: From attention to action. *International Journal of Psychophysiology, 66*(3), 169-182. doi:10.1016/j.ijpsycho.2007.07.004

Vyas, A., Mitra, R., Rao, B.S.S., & Chattarji, S. (2002). Chronic stress induces contrasting patterns of dendritic remodelling in hippocampal and amygdaloid neruons. *Journal of Neuroscience, 22*(15), 6810, 6818. Retrieved from: http://www.jneurosci.org/content/22/15/6810.full

Watkins-Hughes. (2009). *Text & Driving*. Available from http://www.gift-uk.org/.

Watson, D., & Clark, L.A. (1997). Measurement and mismeasurement of mood: Recurrent and emergent issues. *Journal of Personality Assessment, 68*(2), 267. doi:10.1207/s15327752jpa6802_4

Weidmann, A., Conradi, A., Groger, K., Fehm, L., & Fydrich, T. (2009). Using stressful films to analyse risk factors for PTSD in analogue experimental studies- which film works best? *Anxiety, stress, & coping, 549-569. 22*(5). doi: 10.1080/10615800802541986

Weiss, D. (2007). The impact of event scale: Revised. *Cross-Cultural Assessment of*

Psychological Trauma and PTSD, 2, 219-238. doi:10.1007/978-0-387-70990-1_10

Weiss, D.S., & Marmar, C.R. (1997). *The Impact of Event Scale-Revised*. In J.P Wilson & T.M. Keane (Eds.), Assessing psychological trauma in PTSD (pp. 339-411). New York, New York: Guilford Press.

Wolf, O.T. (2008). The influence of stress hormones on emotional memory: Relevance for psychopathology. *Acta Psychologica, 127*(3), 513-531. doi:10.1016/j.actpsy.2007.08.002

Zald, D.H. (2003). The human amygdala and the emotional evaluation of sensory stimuli. *Brain Research Reviews, 41*(1), 88-123. doi:10.1016/S0165-0173(02)00248-5

Zinbarg, R.E., Barlow, D.H & Brown, T.A. (1997). Hierarchical structure and general factor saturation of the anxiety sensitivity index: Evidence and implications. *Psychological Assessment, 9*(3), 277-284. Retrieved from http://www.sciencedirect.com/science?_ob=ArticleURL&_udi=B6WYX-46P4R1220&_user=10&_coverDate=09%2F30%2F1997&_rdoc=1&_fmt=high&orig=search&_sort=d&_docanchor=&view=c&_rerunOrigin=scholar.google&_acct=C000050221&_version=1&_urlVersion=0&_userid=10&md5=c52089396b7006dd922505b40a837301

Appendices

Appendix A- Letter of Introduction

Dear Potential Participant,

Thank you for your interest in the study entitled "Physiological contributions to the development intrusive thoughts and increased arousal". The purpose of this study is to examine how the body responds to a frightening movie (i.e., a film depicting a traffic accident that involves people getting injured) and how physiological reactions influence memory of this film. In order to examine this issue, we require individuals to volunteer their time to participate.

We are particularly interested in how bodily reactions influence the development of intrusive memories. Intrusive memories often consist of images and internal monologues that occur spontaneously within our minds. Most individuals experience intrusive memories between 1-5 times a day and these contain both positive and negative thoughts. In our study, we are asking individuals to complete some questionnaires online and then come into the laboratory for two sessions. During the first session, participants will be fitted with non-invasive instruments that measure things like heart rate and respiration. Participants will then be asked to view the film while we record their physiological reactions. At the end of the first session, participants will be given a diary and asked to report the number of times they thought of the film over the following week. When participants return to the laboratory they will be asked to do another task that involves at looking at pictures of the film while listening to loud noises. During both sessions participants will be asked to complete some more questionnaires. Collectively, participation in the study should take no more than 2 hours of your time.

Participation in this study is completely voluntary. If you choose to participate in this study you can withdraw at any time without penalty. Also, we will be asking participants to complete questionnaires and you can choose not to answer any question if you do not feel comfortable answering it.

One of the goals of our study is to examine how often participants have thoughts about the movie once they have left the laboratory. So, as a result of viewing the film you may occasionally think of the movie after you have left the lab. However, the experiment will be conducted by a Ph.D. level Clinical Psychology student (James Brazeau) and supervised by clinical psychologist (Dr. Ron Davis). Participants that have any concerns will be encouraged to contact Dr. Davis. Participating in the study also has potential benefits for participants. For example, through participating in the experiment you will have the opportunity to see how psychological research is carried out and have the opportunity to learn about how memories and thoughts work. In addition, results from this research study will be relevant to helping people suffering from mental health problems such as anxiety, depression and posttraumatic stress disorder. Finally, through participating in the study participants may avoid in engaging in certain dangerous behaviours (i.e. texting and driving).

All the data collected in this study will be kept strictly confidential; once you have completed the study no identifying personal information will be connected to the information that you have provided. Furthermore, all data collected in this study will be kept in a secure filing system. If results of this research are presented and/or published any information that could identify participants will not be included. Upon conclusion of the study, any individual may have access the results, which will be available kept on file at the Lakehead University Library in the form of a bound dissertation. Participants are also encouraged to contact Dr. Ron Davis if they have any additional questions about the results of the study. The research project has been approved by the Lakehead University Ethics Board, who can be contacted through the information provided below.

Thank you for taking interest in our study. If you have any additional questions please do not hesitate to contact as through the information provided below.

James Brazeau, M.A. Clinical Psychology,
Ph.D. Candidate, Lakehead University
E-mail: jbrazeau@lakeheadu.ca

Dr. Ron Davis, Ph.D., C. Psych,
Associate Professor, Lakehead University
Phone: (807) 343-8646
E-mail: ron.davis@lakeheadu.ca

Research Ethics Board,
Lakehead University
1294 Balmoral Street
Lower Level 0001
Phone (807) 343-8934

* For online versions participants will be required to check a box indicating that they have read and understood the information contained in this letter.

Appendix B- Consent Form

I understand that I am consenting to participate in the study entitled "Physiological contributions to the development intrusive thoughts and increased arousal". Furthermore the following have been explained to me in a satisfactory manner:

I have read and understood the cover/information letter for the study. I understand that I will view frightening images and films that may involve graphic scenes (i.e., a car accident video) and that I may think about this movie once the study is completed.
I also understand the potential risks and benefits to this study which are contained in the information letter.

I acknowledge that these risks and benefits have been explained to me in sufficient detail.
That I may contact Dr. Ron Davis if I have any questions or concerns about the study.
I understand that participation is voluntary and that I may choose to withdraw at any time and/or not answer any questions that are asked of me.

All information will be kept strictly confidential and at no time will any identifiable personal information be released. All the information collected will be securely stored at Lakehead University for a period of five years. That the results of the research project will be available upon completion at the Lakehead University Library in the form of a bound dissertation. The results may also be published in academic journals and presentations. However, no identifying information will be indicated on any of these forms of publication.

In addition, I understand that I may contact Dr. Ron Davis for information on the results of the study or any concerns that I may have.

__________________________ ____________________
(Please Sign Here)* Date

*For online versions of the consent form participants were asked to check a box indicating that they consent to participate.

Appendix C- State Trait Anxiety Inventory

SELF-EVALUATION QUESTIONNAIRE

STAI Form Y-2

Name______________________________ Date__________

DIRECTIONS

A number of statements which people have used to describe themselves are given below. Read each statement and then circle the appropriate number to the right of the statement to indicate how you *generally* feel. There are no right or wrong answers. Do not spend too much time on any one statement but give the answer which seems to describe how you generally feel.

	ALMOST NEVER	SOMETIMES	OFTEN	ALMOST ALWAYS
21. I feel pleasant	1	2	3	4
22. I feel nervous and restless	1	2	3	4
23. I feel satisfied with myself	1	2	3	4
24. I wish I could be as happy as others seem to be	1	2	3	4
25. I feel like a failure	1	2	3	4
26. I feel rested	1	2	3	4
27. I am "calm, cool, and collected"	1	2	3	4
28. I feel that difficulties are piling up so that I cannot overcome them	1	2	3	4
29. I worry too much over something that really doesn't matter	1	2	3	4
30. I am happy	1	2	3	4
31. I have disturbing thoughts	1	2	3	4
32. I lack self-confidence	1	2	3	4
33. I feel secure	1	2	3	4
34. I make decisions easily	1	2	3	4
35. I feel inadequate	1	2	3	4
36. I am content	1	2	3	4
37. Some unimportant thought runs through my mind and bothers me	1	2	3	4
38. I take disappointments so keenly that I can't put them out of my mind	1	2	3	4
39. I am a steady person	1	2	3	4
40. I get in a state of tension or turmoil as I think over my recent concerns and interests	1	2	3	4

State-Trait Anxiety Inventory

Appendix D- Visual Analog Scales

Please put an 'X' on the lines below to indicate your mood at this very moment.

1. How depressed (e.g. sad or upset) at this very moment?

Extremely ____ Not at all

2. How happy do you feel at this very moment?

Extremely ____ Not at all

3. How angry do you feel at this very moment?

Extremely ____ Not at all

4. How anxious (e.g., worried, or tense)

Extremely ____ Not at all

Appendix E- State Dissociation Questionnaire

Please indicate the extent to which the following statements applied to you AT THIS VERY MOMENT

DURING THE FILM **This applied to me**

		Not at all	**A little**	**Moderately**	**Strongly**	**Very strongly**
1.	I feel dazed, unable to take in what was happening.	0	1	2	3	4
2.	The world around me seems strange or unreal.	0	1	2	3	4
3.	My body feels as if it was not really mine.	0	1	2	3	4
4.	I feel emotionally numb.	0	1	2	3	4
5.	I feel as if I am separate to my body and am watching it from outside.	0	1	2	3	4
6.	I feel as if time is going faster or slower than it really was.	0	1	2	3	4
7.	I feel as if I was living in a dream or a film, rather than in real life.	0	1	2	3	4
8.	Things around me seem too big or too small, or distorted in shape.	0	1	2	3	4
9.	I feel distant from my emotions.	0	1	2	3	4

Appendix F- Tabular diary identical to the one used in Holmes et al. (2009) used with permission of the authors

Thank you for completing the diary. Your participation is very much appreciated. Please do not forget to give back the completed diary.

Thank you!!!

Follow up Session Appointment Card

Date:

Time:

Duration:

If you have any questions or problems, please do not hesitate to contact me at jbrazeau@lakeheadu.ca

PARTICIPANT DIARY

Participant No.:

Date started:

Date completed:

Introduction

❖If over the next week you experience any **intrusions about the film you have just watched**, I would be very grateful if you could note them down in the diary.

❖What goes through our minds can either take the form of words and phrases ("verbal thoughts"), or it can be like mental pictures ("images") in your minds eye. Although mental images often take the form of pictures they can actually include any of the five senses, so you can imagine sounds too.

❖For each intrusion, mark 'I', 'T' or 'IT' on pages 3 and 4 for the corresponding time of day, or **write down that you have had Zero** in that time frame. Then for every single intrusion you have had fill in the details of the content on pages 5, 6 and 7.

❖If you are on occasion unable to record details, please make sure you record that an intrusion has occurred and the date.

PLEASE KEEP THIS DIARY – IT IS VITAL FOR THE EXPERIMENT. THANK YOU!!!!

Date / Day of Intrusion	Was it an Image (I), Thought (T) or both (IT)?	What was the content of the intrusion? (e.g. subject matter)	What, if anything, triggered the intrusion?	How distressed were you at the intrusion? 0 (not at all) - 10 (extremely)?

Date / Day of Intrusion	Was it an Image (I), Thought (T) or both (IT)?	What was the content of the intrusion? (e.g. subject matter)	What, if anything, triggered the intrusion?	How distressed were you at the intrusion? 0 (not at all) - 10 (extremely)?

Mark each intrusion as 'I' for image, 'T' for thought or IT if it is a combination of both. Otherwise write '0' for that timeframe.

Example Day					
Morning	0				
Afternoon	0				
Evening & Night	i				
	i				

Day 1 Date:					
Morning					
Afternoon					
Evening & Night					

Day 2 Date:					
Morning					
Afternoon					
Evening & Night					

Day 3 Date:					
Morning					
Afternoon					
Evening & Night					

Please remember to fill in the content page for each intrusion indicated. Thank you

Day 4 Date:					
Morning					
Afternoon					
Evening & Night					

Day 5 Date:					
Morning					
Afternoon					
Evening & Night					

Day 6 Date:					
Morning					
Afternoon					
Evening & Night					

Day 7 Date:					
Morning					
Afternoon					
Evening & Night					

Please remember to fill in the content page for every intrusion indicated. Thank you

p4

Content Page

Intrusions of the film can include **mental images**, (that is 'see' or 'hear' in your minds eye) and/or **verbal thought**, (thoughts about using verbal language when we talk) or combination of both image plus verbal thoughts.

Date / Day of Intrusion	Was it an Image (I), Thought (T) or both (IT)?	What was the content of the intrusion? (e.g. subject matter)	What, if anything, triggered the intrusion?	How distressed were you at the intrusion? 0 (not at all) - 10 (extremely)?
Day 1 EVE	I	I saw a man diving underwater with a red wetsuit on	Running the bath	2
Day 1 EVE	I	I heard the sound of the water and the diver breathing through his diving mask	Running the bath	6

p5

Appendix G- Impact of Event Scale

INSTRUCTIONS: Below is a list of difficulties people sometimes have after stressful life events. Please read each item, and then indicate how distressing each difficulty has been for you **DURING THE PAST SEVEN DAYS** with respect to Film of the Accident which occurred 7 days ago. How much were you distressed or bothered by these difficulties?

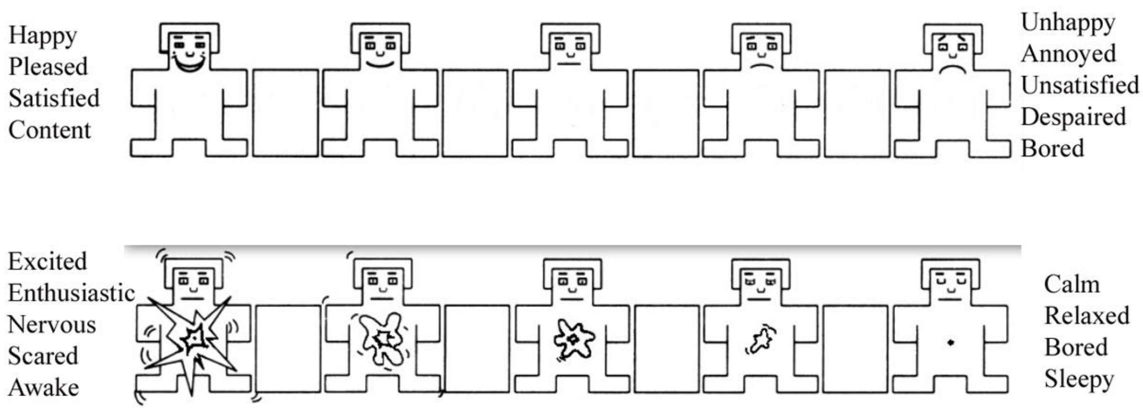
To answer these questions please indicate a rating based on 0 = Not at all; 1 = A little bit; 2 = Moderately; 3 = Quite a bit; 4 = Extremely.

1. Any reminder brought back feelings about it.
2. I had trouble staying asleep.
3. Other things kept making me think about it.
4. I felt irritable and angry.
5. I avoided letting myself get upset when I thought about it or was reminded of it.
6. I thought about it when I didn't mean to.
7. I felt as if it hadn't happened or wasn't real..
8. I stayed away from reminders of it.
9. Pictures about it popped into my mind.
10. I was jumpy and easily startled.
11. I tried not to think about it.
12. I was aware that I still had a lot of feelings about it, but I didn't deal with them.

13. My feelings about it were kind of numb.
14. I found myself acting or feeling like I was back at that time.
15. I had trouble falling asleep.
16. I had waves of strong feelings about it.
17. I tried to remove it from my memory.
18. I had trouble concentrating.
19. Reminders of it caused me to have physical reactions, such as sweating, trouble breathing, nausea, or a pounding heart.
20. I had dreams about it.
21. I felt watchful and on-guard.
22. I tried not to talk about it.

Appendix H- Self-Assessment Manikin

Please indicate how the image makes you feel based on the following diagrams.



Appendix I- Screening Questions and Demographic Information

Please indicate your age:

Please indicate your sex:

Marital status:

Married/common law
Engaged
Long-term relationship
Single
Divorced/separated

How many hours of videogames do you usually play in an average week?

___

Have you ever played Tetris?

Y / N (please circle)

If yes, how many hours would you estimate that you have spent playing this game: ____ (Hours)

Please indicate if any of the following apply to you:

I am currently, or have previously, received treatment for mental health difficulties (e.g., received therapy or taken medication for these difficulties).
I suffer from depression, anxiety, or insomnia.
I am currently taking daily medication to control migraines and/or high blood pressure.
I have hearing or vision problems that would seriously impact my ability to view and listen to a film.
I am currently taking daily medication
Please indicate which medications you are currently taking:

Appendix J- Debriefing letter

Dear Participant,

Thank you for taking part in our study. In this study, you were asked to view a film that depicted some graphic scenes. Hopefully, this was not too troubling for you. However, if you have any questions or concerns please do not hesitate to contact us through the information provided below. In addition, we have provided contact information for the Lakehead Health and Counseling Centre. If you have any mental health concerns, that are unrelated to our study, you may find it helpful to contact the counseling centre.

Thank you for your time and interest,

Sincerely,
James Brazeau

Contact Information:

James Brazeau, M.A. Clinical Psychology,
Ph.D. Candidate, Lakehead University
E-mail: jbrazeau@lakeheadu.ca

Dr. Ron Davis, Ph.D., C. Psych,
Associate Professor, Lakehead University
Phone: (807) 343-8646
E-mail: ron.davis@lakeheadu.ca

Lakehead University Student Health and Counselling Centre
Phone: (807) 343-8361

0.04, *SD* = 0.43). Experimental conditions did not differ on neutral images from the IAPS, $t(102) = 0.385$, $p = .70$. Similarly, differences between conditions on the neutral images from the film were not significant $t(102)= 1.82$, $p = .07$.

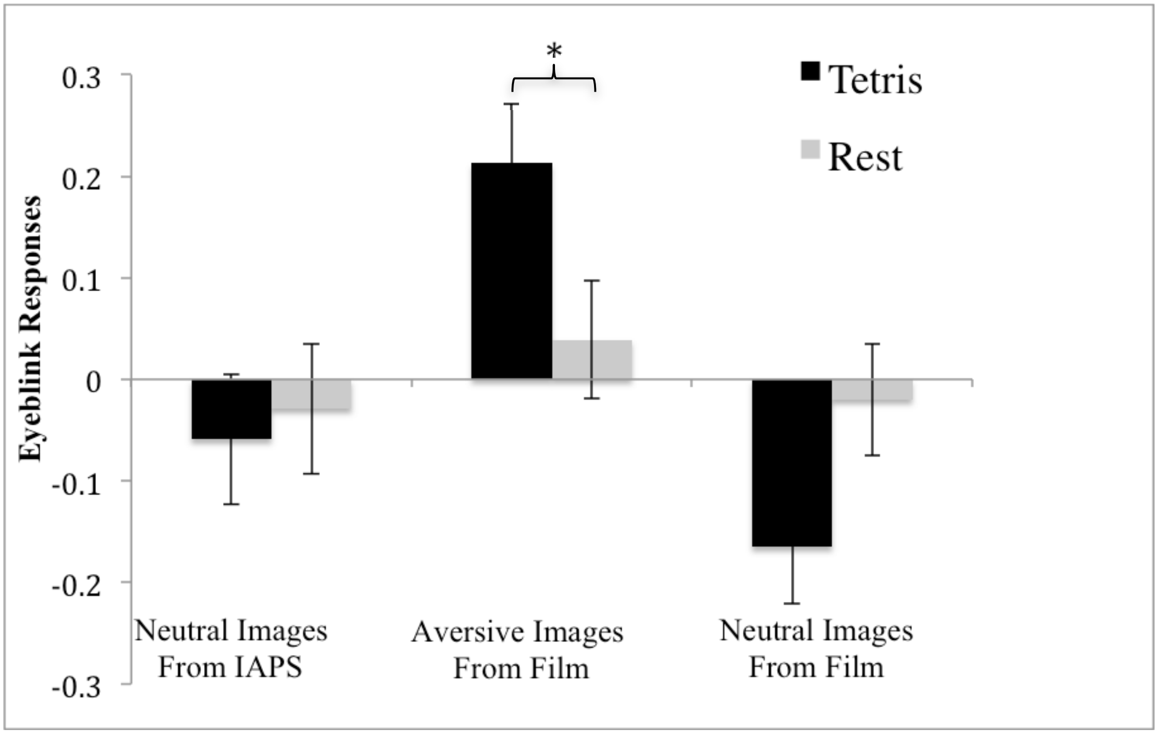


Figure 12. Average *z*-score transformed responses in the eyeblink startle task for each image type. Error bars represent +/- 1 standard error. * $p < .05$.

That Tetris caused increased startle is contrary to expectations. Consequently, exploratory analyses were conducted to examine if the experimental condition moderated the relationship between the measure of the impact of the film (IES) and EMG responses to the aversive-film image. A moderation model was tested using PROCESS macro (Hayes, 2012) with the IES as the predictor X variable, EMG responses to aversive-film images as the Y criterion variable, and experimental condition (i.e., Tetris [coded1]vs. rest [0])

Table 10
Moderated (Experimental Condition) Multiple Regression Results for the Prediction of EMG Responses from IES.

Effect	β	*SE*	*t*	*p*
IES	-0.26	.15	1.68	.10
Condition	0.21	.08	2.45	.02
IES × Condition	0.73	.30	2.41	.02

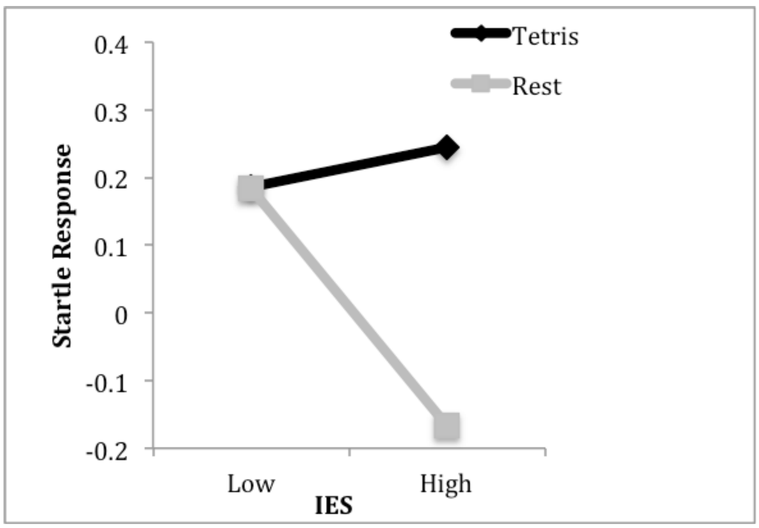


Figure 13. Impact of Events Scale predicting EMG responses to aversive-film Images.

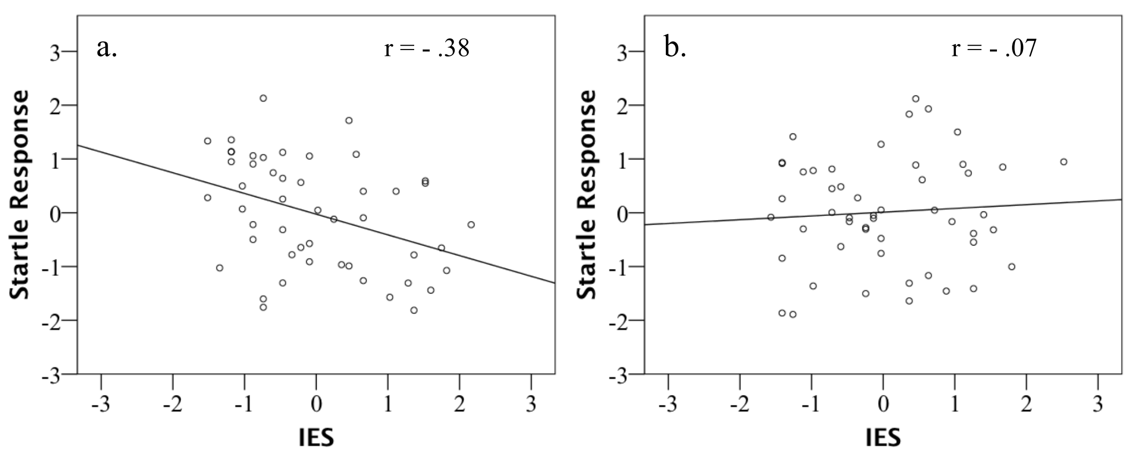


Figure 14 . Scatterplots of the data used in the moderation analysis of the effect of Tetris on the relationship between IES and EMG responses to aversive images. Scatterplots of