The Effects of Emotional Stimuli

on Visuo-spatial Vigilance and Self-Reported State

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Abstract

In the present study we explored the impact of task-irrelevant emotive picture stimuli on visuo-spatial vigilance performance, self-reported state and memory. Ninety-five participants (62 women, 33 men) completed the experiment in which task-irrelevant emotive picture stimuli were embedded in the vigilance task. Four experimental groups were tested by combing two levels of valence, positive versus negative, and two levels of arousal, arousing versus neutral or non-arousing, for the task-irrelevant picture stimuli. The vigil was organised so that baseline performance, the initial impact of the images, and any continual carry-over effects of the images on performance could be measured. In addition to performance on the vigil, subjective state was measured using a self-report questionnaire designed to examine energetic and tense arousal as well as task-related and task-unrelated thoughts. A post-task free-recall test was also employed, asking participants to recall as many of the picture stimuli as they could. Results showed a significant arousal by period linear trend interaction, in which the performance decrement of the groups exposed to the arousing picture stimuli was attenuated in comparison those exposed to the non-arousing stimuli. Further the relationship between self-reported energetic arousal and performance differed for the arousing and non-arousing picture groups. Post-task energetic arousal significantly predicted the performance decrement (linear slope) for the arousing picture group, but not for the non-arousing picture-group. The arousing pictures were also recalled at a higher rate than non-arousing pictures, irrespective of valence. These results provide support for the perspective that the arousal quality of picture stimuli matters more for performance than valence, and that arousing pictures while possibly disruptive when presented concurrently with the vigilance task, may result in improved performance later due to an increase in energetic or cortical

arousal. This finding fits with previous research suggesting that arousing agents are more potent when their possible distracting effects on task performance are no longer competing for cognitive resources.

2.1 General introduction

Vigilance, or sustained attention, describes a state in which attention must be maintained over time, such as monitoring system displays for critical events (Szalma, 2009). For human performance research, this concerns the ability to detect brief, unpredictable signals over time (Davies & Parasuraman, 1982; Matthews, Davies, Westerman, & Stammers, 2000). Recent technological developments in automation, as well as the increased incidence of automated machinery in the workplace, makes vigilance, or monitoring, an important factor in human work performance (Parasuraman & Wickens, 2008; Warm et al., 2008). Although the nature of this monitoring has changed over time, it has been essential to survival throughout history. In the natural context, for basic survival, humans and other animals are required to scan their environment for two key targets; for prey or sources of food, and for predators or other threats. While still relevant for many animals, for humans, the need to detect predators and prey for survival has been replaced with the need to remain vigilant in a work place setting. This has become paramount as workplaces once characterized by manual tasks, such as factory work, have become more reliant on automated machine work, requiring individuals to scan information displays.

In line with these developments, the role of the worker has changed considerably, in that instead of physically completing tasks, one is tasked with monitoring or supervising systems for abnormalities, and stepping in to manually engage in the task if, and when an abnormality occurs. This form of system supervision is not unique to the physical labour workplace, in fact, the ability to sustain ones attention is vital in many settings, including during prolonged driving, when scanning luggage or postal items for potential threats, or during monitoring of medical devices (Hancock & Hart, 2002; Warm, Parasuraman & Matthews, 2008). There are also a number of activities that are not strictly limited to the workplace which require environmental monitoring, including vehicle operation or sport.

Workplace or recreational monitoring activities tend to follow the same basic principles regardless of their specific tasks or objectives. Essentially, individuals are required to engage in extended periods of observation and monitoring while searching for a unique target or set of targets. Once these targets have been identified, a specific response must be performed, often this requires the individual to assume manual control or perform a manual action to bring the system back in line with it's objectives. Although the basic elements of human survival, capturing prey and avoiding predators, are no longer as reliant on sustained attention, the consequences of attention lapses are just as severe, in that failure could result in exposing oneself and others to danger, failing to protect others, or being unable to perform at the level required to maintain employment. This is one key reason why investigating factors with the potential to affect sustained attention is worthy of further research.

2.2 History of vigilance research

The decrease in the ability to maintain focus and detect target stimuli over time was first described during the Second World War; Mackworth (1948) studied this phenomenon and termed it the vigilance decrement. His research focused on the gradual decline in the performance of Royal Air Force cadets working as radar operators during the war. The cadets were required to detect submarines for periods up to two hours, with a decrease in performance becoming apparent after 30 minutes. To investigate the time at which cadets failed to detect targets, or took too long to do so, Mackworth created a simulator in the laboratory using a clock-face. This clock-face task required participants to respond when the clock hand jumped two spaces instead of one, this was the critical event, which occurred at infrequent, random intervals. Like the performance of the Airforce cadets, participants' performance, i.e., their ability to detect targets, decreased over time.

There has been a significant volume of research conducted on the topic of vigilance, and the vigilance decrement since the work of Mackworth. Like the clock-face task, many experiments have been designed to simulate different types of real-world environments. Situations involving luggage scanning, medical monitoring or driving a car, as well as many other monitoring tasks have yielded similar results, in that they display the vigilance decrement (Davies & Parasuraman, 1982; Hancock & Hart, 2002; Ballard, 1996; Damos & Parker, 1994). The key aspect of vigilance tasks is the requirement of the operator to sustain their attention (remain vigilant) for an extended period of time, and respond to critical signals occurring at random, infrequent intervals (Davies & Parasuraman, 1982; Helton & Warm, 2008; Howe, Warm & Dember, 1995). These tasks have been termed vigilance, or sustained attention tasks, as both terms are used throughout the literature, the same will be done throughout this text.

Traditional vigilance tasks required observers to monitor displays for prolonged periods, for example, the clock-face task lasted up to two hours (Mackworth, 1948). Shorter, modern vigilance tasks analogous to the longer duration tasks, but more practical for use in test batteries are now available (Nuechterlein, Parasuraman & Jiang, 1983). For example, the abbreviated task developed by Temple and Colleagues (2000) used in several studies has been shown to display the vigilance decrement typical of longer duration vigilance tasks (Helton, Dember, Warm & Matthews, 2000; Matthews et al., 2001, Ossowski et al., 2011; Helton et al., 2011), however, results between longer and shorter duration vigilance tasks have not always been found to be identical (see Helton, Mathews, et al., 2009). Although the decrement is a consistent feature of all vigilance tasks, several factors have been found to affect it; including manipulation of the perceptual conspicuity or salience of the stimuli used, the event rate of the stimuli presentation, the target probability and the type of responding required (Wilkinson, 1969; Biebuyck, Weinger & Englund, 1990; Ballard, 1996; Hollands & Wickens, 1999).

2.3 Explanation of the vigilance decrement

The cause of the vigilance decrement is a topic that has generated a large amount of interest, and debate amongst vigilance researchers (Helton & Warm, 2008; Brache, Scialfa, & Hudson, 2010; MacLean et al., 2009). Two key competing theories have been put forward to explain the vigilance decrement: the mindlessness, boredom or underload theory (Robertson et al., 1997; Manly et al., 1999) and the resource, mental fatigue, or overload theory (Helton & Warm 2008). While contributing to this debate is not a critical aspect of the current research, it is essential to explore these theories in order to understand and interpret any findings relating to vigilance, and the impact task-irrelevant stimuli may have on the decrement.

The boredom-mindlessness theory suggests that the performance decrement arises as individuals become increasingly bored due to insufficient external stimulation from the stimuli. Rather than being over-stimulated or over-aroused, individuals are said to be under-stimulated or under-aroused. The subjectively boring or repetitive nature of vigilance tasks has been identified as the cause for the decline in performance, as individuals become bored their attention drifts, causing attention lapses (Scerbo, 1998; Manly et al., 1999; Green et al., 2009). This withdrawal of attention from the task is characterized by an increase in task-unrelated thoughts throughout the progression of the vigil (Robertson et al., 1997). Thus the mindlessness theory suggests that the primary cause of attention lapses is the disengagement of conscious awareness from the task and an increase in task-unrelated thoughts, resulting from the monotonous nature of the task.

In contrast to the boredom-mindlessness theory, the resource-depletion model suggests that information-processing is restricted because of the limited availability of cognitive or attention resources (Hirst & Kalmar, 1987; Kahneman, 1973). This means that any competition for processing resources by stimuli other than the vigil may cause performance disruption. During vigilance assignments, participants must make continuous critical versus neutral signal discriminations without the opportunity to rest. Because there is no opportunity for rest, the resources necessary for target detection do not replenish at the rate the resources are depleted, hence, performance declines with time-on-task (Helton & Warm, 2008; Helton & Russell, 2011, 2012, 2013; Hitchcock et al., 2003; Shaw et al., 2009). Individuals are said to have a finite number of cognitive resources, a 'resource reservoir' that must be drawn on to meet task demands. Regardless of the absolute amount of cognitive resources, at some point, sustained attention without rest will lead to a decline in performance. In saying this, there are a number of factors which have been found to influence resource availability, or the absolute amount of resources available to an individual, including sleep, stimulants, environmental conditions and individual abilities. The amount of cognitive resources available to each person can therefore be used to explain individual differences in vigilance performance.

The resource theory of vigilance has been used more widely to explain findings in a number of studies, (Davies & Parasuraman, 1982; Helton et al., 2005; Helton, Shaw, Warm, Matthews, & Hancock, 2008; Temple et al., 2000; Warm, 1993) and is the approach taken in the current research. The resource-depletion theory also fits with research suggesting that sustained-attention tasks, although straightforward, are found to be subjectively stressful (Warm, Matthews & Parasuraman 2009). Although the vigilance task itself may not be deemed particularly difficult, participants report developing a stressed or agitated state throughout the duration of the task.

2.4 Stress

In line with the resource-depletion theory, the demanding nature of vigilance tasks results in heightened levels of participant stress (Hitchcock et al., 2003). There are several aspects of vigilance or sustained attention tasks that induce stress, first, participants must constantly engage their cognitive resources, without time for replenishment, second, they must make target decisions under conditions of uncertainty, and third, they are given little opportunity for situational control, in that they cannot control the environment and must respond to it at random intervals

(Helton et al., 2009). Further evidence for the stressful nature of vigilance tasks has been provided through research using the National Aeronautic and Space Agency Task Load Index (NASA-TLX), a measure of perceived mental workload (Dittmar et al., 1993; Grier et al., 2003; Warm et al., 2008; Temple et al., 2000). This state of stress is more easily explained with a resource-depletion, rather than a boredom-mindlessness theory of vigilance.

The transactional model of stress characterizes stress as a cognitive process, reliant on the relationship between task demands and the individual's ability to cope with these demands (Lazarus & Folkman, 1984). Two appraisal steps help one determine whether a situation is stressful. Primary appraisal processes evaluate demand to determine whether the stimulus is a threat. Secondary appraisal processes then provide assessments about the available coping resources. According to this model, stress arises when task demands exceed the available resources. In vigilance research, the fatigue or task-induced mood shifts reported by participants at the end of an experiment (Warm, 1993), are negative consequences arising from the imbalance between the demands of the task (i.e. responding to the correct stimulus) and the resources available to the participant such as time, attention and control. In a work performance context, stress results when task demands overload a person's ability to cope with their workload (Matthews et al., 2002). Task induced stress is relevant to most, if not all operational settings, such as industrial operations, or medical practice. Research has shown that even during short-duration tasks, stress can harm performance (Matthews et al., 2001). As stress influences ones ability to perform, the relationship between task-induced stress and performance will be investigated in the present study.

2.5 The measurement of stress

Stress can be measured as both a physiological and a psychological construct, both of which have been looked at within vigilance research. During vigilance tasks, physiological measurements of stress have revealed an increase in the levels of adrenaline released in to the bloodstream (Frankenhaeuser, Nordheden, Myrsten & Post, 1971), as well as an increase in muscle tension, headaches, and restlessness (Galinsky, Rosa, Warm & Dember, 1993; Hovanitz, Chin & Warm, 1989). The psychological effects of stress have also been measured using self-report measures, which focus on the subjective aspects of stress. These subjective measures have been found to correlate with physiological indicators of stress (Mathews, 2001). As the current research is interested in measuring differences in subjective ratings of stress, it is appropriate that a self-report measurement tool is used.

2.6 Dundee Stress State Questionnaire

The Dundee Stress State Questionnaire (DSSQ; Matthews et al., 2002) is a global self-report measure of subjective state, which has been developed to reflect the multidimensional nature of stress states, capturing human arousal, mood and fatigue. It is designed to measure affective, motivational and cognitive state changes; accordingly, pre and post-task versions of the DSSQ have been developed to detect state changes resulting from task demands. It has been shown to be sensitive to environmental stress factors, validating its use as a measure of immediate self-reported state (Szalma et al., 2004). Four subscales of the DSSQ will be used in the present experiment, similar to a number of previous vigilance studies (Helton et al., 2000, 2004; Szalma et al., 2004, 2006). The scales of Task-Related Cognitive

Interference (worry about things related to the task), Task-Unrelated Cognitive Interference (worry about things not related to the task), Tense Arousal (nervous-relaxed) and Energetic Arousal (alert-lethargic) were selected for use in the current research. The items for the DSSQ scales were sampled from different sources. Items from the UWIST Mood Adjective Checklist (UMACL; Matthews et al., 1990) were used for the energetic and tense arousal scales. The scales for Task Related Thoughts (TRT) and Task Unrelated Thoughts (TUT) are derived from the task-relevant and task-irrelevant cognitive inference scales developed by Sarason et al. (1986). Several vigilance studies have employed the Dundee Stress State Questionnaire (Grier et al., 2003; Matthews et al, 2001, Smallwood et al., 2004; Helton Dorahy, Russell, 2011; Szalma et al., 2004; Warm, Parasuraman & Matthews, 2008), with results typically displaying a decrease in energetic arousal, accompanied by an increase in tense arousal. This pattern is typical of vigilance tasks and is indicative of task-focus and mental fatigue (Matthews et al., 2002; Szalma et al., 2004; Warm et al., 2008). Accordingly, the Dundee Stress State Questionnaire has been chosen as a suitable instrument to investigate immediate stress responses in the current research.

2.7 Emotional stimuli in vigilance

Despite an extensive history of research on vigilance, there have been relatively few studies examining the potential impact of emotional stimuli on vigilance performance, and in particular, the vigilance decrement. Recently Helton and colleagues (Ossowski, Malinen & Helton, 2011; Helton & Russell, 2011) have explored the impact of task-irrelevant emotional picture stimuli on vigilance performance. In these studies, the authors employed the abbreviated vigilance task (Temple et al. 2000) in which participants are tasked with detecting the appearance of rare O letters occurring in a stream of more common D and backwards-D letters. In their experimental group the vigil was interrupted occasionally by negative arousing picture stimuli, whereas in the control group, the vigil was interrupted by neutral non-arousing stimuli. They found that overall performance in the negative arousing picture conditions was lower than in the neutral picture condition during the periods in which the pictures were presented (Ossowski, Malinen & Helton, 2011; Helton & Russell, 2011). The authors' explanation for the performance disruption in the negative arousing picture condition relative to the neutral picture condition was based on a competitive resource theory account. Findings concerning the ability of emotional stimuli to capture and hold attention provide further support for this perspective. Emotional stimuli have been found to capture attention more than neutral stimuli in a variety of research paradigms, including attentional-blink, choice-reaction time, motor tasks and visual search tasks (Anderson & Phelps, 2001; Green, Draper, & Helton, in press; Keil & Ihssen, 2004; Ohman, Flykt & Esteves, 2001; Zeelenberg, Wagenmakers, & Rotteveel, 2006). In addition, in previous studies task-unrelated emotional stimuli have also been found to disrupt on-task processing when presented just prior to or concurrently with task-related stimuli (Fox, Russo, Bowles, & Dutton, 2001; Ihssen & Keil, 2009). Emotional stimuli appear to capture attention and according to Helton and colleagues, this may explain why the presence of emotional stimuli had a performance cost in their studies. The task-irrelevant stimuli may have either directly (immediate attention capture) or indirectly, by triggering conscious thoughts about the pictures, competed for the resources needed for target detection.

Although Helton and colleagues' findings are intriguing, other findings suggest arousing stimuli and agents (for example, loud noise: Helton, Matthews, &

Warm, 2009, and caffeine: Temple et al. 2000) improve vigilance. Indeed, in previous research a consistently reliable predictor of target detection performance is the participants' self-reported energetic arousal (Helton & Warm, 2008; Matthews, Davies & Lees, 1990). The resource theory explanation is that energetic arousal may be an index of resource availability or allocation. Therefore, it might be expected that arousing picture stimuli would attenuate the vigilance decrement by increasing energetic arousal. Further, arousing agents may be more potent when the possible distracting effects of the arousing stimuli themselves are no longer an issue. Research concerning the effects of exercise on cognitive performance lends support to these ideas. Acute exercise has been found to have stronger effects on cognitive performance after exercise has ceased than during exercise itself (Lambourne & Tomporowski, 2010). Although during periods of exercise the findings are ambiguous, there is a clear improvement in cognitive performance after periods of exercise (Brisswalter, Collardeau, & Rene, 2002; Chang, Labban, Gapin & Etnier, 2012; Lambourne & Tomporowski, 2010). This post-exercise improvement in performance suggests that the heightened level of arousal during exercise could facilitate later cognitive function (Tomporowski, 2003). This may also be true for other arousing stimulation, such as the inclusion of task-irrelevant arousing picture stimuli. While the stimuli themselves may compete for cognitive resources, their arousing quality may generate more resources via elevated cortical arousal, resulting in an improvement in performance after the images have stopped being presented.

2.8 Emotional stimuli in memory

The role of emotive stimuli in memory is a topic that has attracted a significant amount of interest. Past research in to the role of emotive stimuli in memory has tended to focus on one particular type of emotional event or dimension. For example, Kern, Libkuman and Otani (2002) looked at negative arousing versus neutral stimuli. Findings suggest that memory recall of traumatic events is superior to that of neutral events (Kern, Libkuman & Otani, 2002; Christianson & Loftus, 1987). The explanation for such findings given by some researchers being a 'flashbulb memory' mechanism allowing clear and stable memories of traumatic events to develop (Brown & Kulik, 1977; Bohannon, 1988). Others have reported a phenomenon coined the 'Pollyanna' effect, where memory is increased for happy events (Matlin & Stanf, 1978). Several meta-analytic reviews have concluded that although the emotion-memory literature includes many contradictory findings, there is consensus that high emotional arousal leads to enhanced memory for the central details of the stimuli in question (Christianson, 1992; Kern. Libkuman, Otani & Holmes, 2005). Studies that report high levels of arousal can impair memory performance (e.g. Loftus & Burns, 1982; Clifford & Hollin, 1981), focused on peripheral rather than central details of the arousing stimuli. Bradley, Greenwald, Petry and Lang (1992) took a dimensional approach, looking at images that varied along the dimensions of valence and arousal. They found that highly arousing images were remembered better than low arousal stimuli regardless of valence.

2.9 The present study

In the present study the impact of task-irrelevant emotive picture stimuli on visuo-spatial vigilance performance and self-reported state was explored. Task-irrelevant pictures were embedded in the vigilance task as in the case of Helton and colleagues studies (Ossowski, Malinen & Helton, 2011; Helton & Russell, 2011). However several modifications have been added to expand the scope of their work. Both negative and positive valence pictures were included, and we not only assessed vigilance performance during picture presentation, but after as well. Further we employed a visuo-spatial vigil, not an alphanumeric vigil, and lastly, we assessed memory recall of the emotional stimuli post-task.

In the present experiment, the pictures were selected based on their differing levels of valence and arousal. Positive images, as well as negative images, with low to moderate levels of arousal have not yet been looked at in vigilance research. The images were selected from the International Affective Picture System (IAPS) developed by Lang, Bradley, and Cuthbert (2001). The IAPS contains a large set of colour photographs that have been rated according to their emotional content, namely on their valence- how positive or negative the images are, and the level of arousal they elicit. This allows for the systematic selection of images based on these ratings, and has been used extensively to investigate processes in attention and emotion (Lang, Bradley & Cuthbert, (2001). It has also been used in previous studies looking at task-irrelevant visual stimuli in vigilance performance (Ossowski, Malinen & Helton, 2011; Helton & Russell, 2011). In the present study, four experimental groups were tested, each of which was exposed to a different set of task-irrelevant picture stimuli. Two levels of valence, positive versus negative, and two levels of arousal, arousing versus neutral or non-arousing were combined to create four image sets; positive/arousing, positive/non-arousing, negative/arousing and negative/non-arousing picture stimuli.

The vigil was structured so that initially participants were exposed to two pre-picture periods of watch consisting of only the vigilance task, then 5 periods of watch where the vigilance task was interrupted periodically by the task-irrelevant images, and then the vigilance task only for another 4 periods of watch. The vigil was organised this way so that baseline performance, the initial impact of the images, and any continual carry-over effects of the images on performance could be measured. This design allowed us to address how long after a picture had been presented performance was impacted or whether it was impacted at all. As discussed earlier, in some cases, arousing agents are more potent when the possible distracting effects of the arousing stimuli themselves are no longer an issue. Including a post-picture session allowed us to test this theory. The vigilance task employed also differed from that used by Helton and colleagues, who employed an alphanumeric vigilance task requiring the discrimination of letter stimuli. In the present study we have employed a visuo-spatial task. Previous research indicates that emotional stimuli may differentially impact verbal and spatial memory, although the results are not entirely consistent (Brunye, Mahoney, Auustyn & Taylor, 2009**).** Vigilance task performance is interrelated with working memory (Grey, 2001; Shackman et al., 2006) and conceivably emotional stimuli may have differential effects on a verbal (alphanumeric) versus a spatial vigilance task. Therefore, in the present study we employed a visuo-spatial vigilance task to further explore the impact of emotional stimuli on vigilance. Like Helton and Colleagues, in addition to vigilance performance, subjective state was measured. Subjective state was measured by administering a self-report questionnaire designed to examine energetic and tense arousal as well as task-related and task-unrelated thoughts. The questionnaire was administered pre- and post-vigil, to enable us to examine whether participant responses changed after completing the task and being exposed to the picture stimuli.

We also expanded on Helton and colleagues' work by including both valence and arousal dimensions of the emotive stimuli, and then assessed free memory recall for these pictures after the vigil. Participants were asked to recall as many of the picture stimuli as they could, allowing us to see whether any particular set of images was remembered more accurately, which could suggest that those images may have been processed differently. We predict that highly arousing images will be remembered better than low arousal stimuli regardless of valence, in line with findings by Bradley, Greenwald, Petry and Lang (1992).

Our key hypothesis was that the arousal quality of picture stimuli should matter more for performance than valence, and that arousing pictures while possibly disruptive when presented concurrently with the vigilance task, may result in improved performance later due to increased energetic arousal, analogous to the impact of acute exercise often found in the literature (Lambourne & Tomporowski, 2010). We also suggest that the arousing picture stimuli may result in increased levels of energetic arousal post-task, and enhanced memory recall. This research may provide us with information useful for both theory and practice. Results could provide insight in to the role of emotional stimuli in vigilance, memory and attention. They may also have real world applicability, as there are a number of tasks requiring individuals to monitor and detect targets during and after exposure to emotive stimuli.

3. Method

3.1 Participants

The research was conducted with a total of ninety-five (62 women; 33 men) participants. The age of the participants ranged from 18 to 50 years (M = 23.52 years, SD = 5.70). Seventy-three participants were recruited from the University of Canterbury campus via flyers, and online via research groups, which asked for volunteers over the age of 18. For participation $10 NZD vouchers were provided. Twenty-two participants from introductory psychology courses at the University of Canterbury also completed the study for course credit (and did not receive the voucher). All participants had normal or corrected to normal vision according to self-report responses to interview questions given prior to the experimental session.

3.2 Procedure

Participants were seated in individual cubical workstations. As there were a large number of participants for this experiment, it was run with multiple participants at once. Group sizes ranged from one to twelve participants, and due to the seating arrangement, participants were unable to view the computer screens of other participants. Once the participants arrived and were seated, they were asked to turn off any electronic devices. They were then given information about the experiment and given the opportunity to ask questions before being asked to sign the informed consent. The information given to the participants included a warning regarding the nature of the images, as in some of the conditions the images were negative and/or arousing. They were specifically told that some images might show nudity or distressing scenes but it was also explained that the images would be of a similar nature to those that an individual might come across in daily life; for example those shown on the evening news or late night television. A copy of the information sheet given to the participants, the consent form and the debriefing sheet given post experiment can be found in Appendix A. Participants were assigned at random to one of the four vigilance conditions, which were balanced for gender: positive arousing stimuli (24 total participants: 15 female, 9 male), positive non-arousing stimuli (24 participants: 16 female, 8 male), negative arousing stimuli (24 participants: 16 female, 8 male) or negative non-arousing stimuli (23 participants: 15 female, 8 male).

Following Caggiano and Parasuraman (2004) and Helton and Russell (2013) participants completed a target detection task where they monitored the repetitive display of a small black oval shape (1.69 mm x 1.40 mm). Participants were informed that small oval shapes would appear in one of four positions relative to the centre of the screen (indicated with a '+') and that the ovals could be to the left or the right of the centre, and most importantly either near to the centre or further from it. They were instructed to press the spacebar whenever an oval appeared at a target far location 25 mm to the left or the right of the central fixation '+' and to make no response to neutral near ovals positioned 20 mm to the left or the right of the central fixation '+'. Each dot stimuli is displayed for 190 ms and then followed by a response screen (inter-stimulus interval) for 990 ms. Eighty-eight ovals were presented in each block, making each block or period of watch 1.73 minutes long. Responses (the pressing of the spacebar) made within 990 ms of the onset of an oval at a target location were regarded as hits and responses made within 990 ms to ovals at neutral locations were regarded as false alarms. Of the 88 samples per block, 62 ovals were on the near left and near right (neutral stimuli) and 16 were on the far left and the far right (target ovals). All participants were exposed to the same set of positions, but in a random order.

Participants in all groups received vigilance instructions. They were shown displays that indicated the positions of target and neutral ovals in relation to the central fixation cross. These displays also indicated whether participants should press the spacebar or withhold response. After this, but prior to completing the main trials, participants completed practice vigilance trials in which they received feedback when they failed to respond to a far target oval and when they incorrectly responded to a near neutral oval. No accuracy feedback would be provided beyond the practice trial. After the practice period, the participants immediately began the main part of the experiment. The vigilance task lasted 19.22 minutes in total, which included eleven 1.73-minute periods of watch, and 10 seconds of image presentation. The 11 periods of watch were broken up in to the pre-picture baseline period (2 periods of vigilance task) the picture period (5 periods of vigilance task with ten images) and the post-picture period (4 periods of vigilance task). All of these periods were presented in one continuous stream. During the picture period, participants saw ten images, dependent on which condition they were assigned. Each period of watch was interrupted by two images; an image was presented for 1000 ms and then followed by a 52 second block of vigilance task. Thus during the picture period, one period of watch contained two images and two 52-second blocks of vigilance task. During the presentation of the images, the vigilance task was not active. The images were drawn randomly from a list, so each participant saw all ten images assigned to their condition, depending on when it was drawn. Participants were not made aware of the duration of the task.

3.3 Materials

3.31 Images

Four sets of 10 slides each were selected from the International Affective Picture System (IAPS) developed by Lang, Bradley, and Cuthbert (2001). The IAPS contains a large set of colour photographs that have been rated based on their pleasure, arousal and dominance by students using a 9-point scale. The slide sets used in this experiment were chosen based on these normative ratings; the images were organised into four categories based on their level of arousal and valence and from these categories the final images were chosen. To be labeled as arousing the images had to have a mean arousal rating of 6.00 or higher. To be rated as non-arousing, the images had to have a mean arousal rating of 4.00 or lower. To be rated as positive, the images had to have a mean valence rating of 6.00 or higher, and to be rated as negative, they had to have a mean valence rating of 4.00 or lower. Negative and arousing, negative and non-arousing, positive and arousing, positive and non-arousing images were then collated to make the four sets.

The first set was labeled Positive/Arousing (PA) and contained slides that were high in arousal and high in valence, meaning positive. This set contained slides such as a rollercoaster and a naked female. Examples are displayed in Figure 1. The second was labeled Positive-Non-Arousing (PN) and contained slides that were low in arousal and high in valence. This set contained slides such as a sleeping baby and a butterfly. Examples are displayed in Figure 2. The third set was labeled Negative/Arousing (NA) and contained slides that were high in arousal and low in valence, meaning negative. This set contained slides such as a plane on fire and a snake. Examples are displayed in Figure 3. The final set was labeled Negative/Non-Arousing (NN) and contained slides that were low in arousal and low in valence. This set contained slides such as a cemetery and spilled petrol. Examples are displayed in Figure 4. These sets were then narrowed down to ten images each. There were two key criteria for choosing the final images- firstly the images needed to be appropriate for a free recall test. This meant that the slide content needed to be simple in that it was low in complexity, and contained only a small number of objects or persons depicting one key theme. It was also important that the 'positive' groups (PA and PN) had the same level of valence or positivity, that the 'negative' groups (NA and NN) had the same level of valence or negativity, that the 'arousing' groups (NA and PA) had the same level of arousal, and that the 'non-arousing' (NN and PN) groups had the same level of arousal. As there were a limited number of images in the NN group, images from the NA group were chosen to match the mean valence of the NN group. This was tested using independent-samples t-tests. There was no significant difference in the valence of the positive arousing ($M = 6.84$, $SD = 0.34$) and positive non-arousing ($M = 6.87$, $SD = 0.55$) pictures; $t = 0.122$, $p = 0.904$. There was no significant difference in the valence of the negative arousing ($M = 3.30$, $SD = 0.50$) and negative non-arousing ($M = 3.47$, $SD = 0.32$) conditions; $t = 0.921$, $p = 0.369$. There was no significant difference in the arousal of the positive arousing ($M = 6.52$, $SD = 0.49$) and negative arousing ($M = 6.39$, $SD = 0.29$) conditions; $t = 0.696$, $p = 0.496$ and lastly there was no significant difference in the arousal of the positive non-arousing ($M = 3.65$, $SD = 0.35$) and negative non-arousing ($M = 3.79$, $SD = 0.19$) conditions; $t = 1.099$, $p = 0.286$. A copy of the IAPS image numbers with their arousal and valence ratings can be found in Appendix C.

3.32 Dundee Stress State Questionnaire

Participants also responded to a 32-item paper-and-pencil version of the Dundee Stress State Questionnaire (DSSQ; Matthews et al., 2002), which provides a multidimensional assessment of transient states of stress, fatigue and arousal. Out of the 10 scales that are available, Energetic Arousal (EA), Tense Arousal (TA), Task Related Thoughts (TRT) and Task Unrelated Thoughts (TUT) were chosen for this experiment, each of which is measured with eight items, making a total of 32. A five-point Likert scale was employed, where 1 = not at all and 5 = extremely for the EA and TA scales and 1 = never and 5 = very often for TRT and TUT scales, following Ossowski et al. (2011). The questionnaire was administered in two sessions: the pre-task version completed before the start of the vigilance task and a post-task version completed after the task. This format was chosen to detect changes in self-reported state during the different time periods. A Copy of the full questionnaire can be found in Appendix B.

3.33 Free Recall

After completing the DSSQ post-questionnaire all participants were asked to perform a free-recall memory task. Participants were asked to recall as many of the images as they could within a three minute time period. The limit was placed so that the time spent on the task was similar across the different time slots and no participants needed longer than this to finish the task. A Copy of the free-recall exercise can be found in Appendix B. Participants were also asked to describe each image so that a marker would be able to tell which image they were referring to. In terms of marking participant responses, to be considered correct, a response needed to be clear and legible. If a response was unclear, illegible or too vague it was considered incorrect. If a participant included a description that was clearly not in the image set it was considered an intrusion. All participant responses were marked by one individual, and as the number of incorrect responses and intrusions across all of the groups was very low, the number of correctly recalled images was the focus of further analysis. Participants were not made aware of the free-recall task until it was given to them. This was so that participants did not take a different approach to the task knowing they would need to remember the images presented. After completing the free recall, participants were debriefed and given the vouchers or course credit.

4. Results

4.1 Vigilance Performance

To measure vigilance performance, we examined hit rates (correct detections), false alarm rates, and reaction time to target stimuli. In addition, the signal detection theory metric of non-parametric sensitivity, A′, was calculated from the hit and false alarm rates. A′ is a useful measure of performance as it is an indicator of how well the participant could correctly and exclusively discriminate targets from non-targets, irrespective of their own response bias; their tendency to respond or not (Macmillan & Creelman, 2005; Helton & Russell, 2012). Thus A′ was the principal metric of importance for this investigation, although the others are still included to aid interpretation of the results.

We were primarily interested in pre-planned orthogonal polynomial contrasts or trend analysis (see Keppel and Zedeck 2001) and whether these trends were altered by the experimental manipulations. When the research interest is focused on trend analysis, methodologists have encouraged the use of pre-planned polynomial contrasts as they provide the most powerful test of the hypotheses (for example, changes over time; see Ruxton & Beauchamp, 2008). Because the experiment entailed a picture period onset and a picture period offset, we limited our examination to the linear, quadratic, and cubic trends.

4.11 Correct Detections

For correct detections, or hits, there was a significant linear trend, $F(1, 90) = 117.464$, $p < .001$, $\eta_p^2 = .566$, a significant quadratic trend, $F(1, 90) = 40.800$, $p <$

.001, η_p^2 = .312, and a significant cubic trend, $F(1, 90) = 10.936$, $p = .001$, η_p^2 = .108. In addition, there was a significant linear trend for the period by arousal interaction, $F(1, 90) = 4.902$, $p = .029$, η_p^2 = .052. This interaction is displayed in Figure 1. All other results were statistically non-significant, $p > .05$ including any period by valence interaction, and any period by valence by arousal interaction.

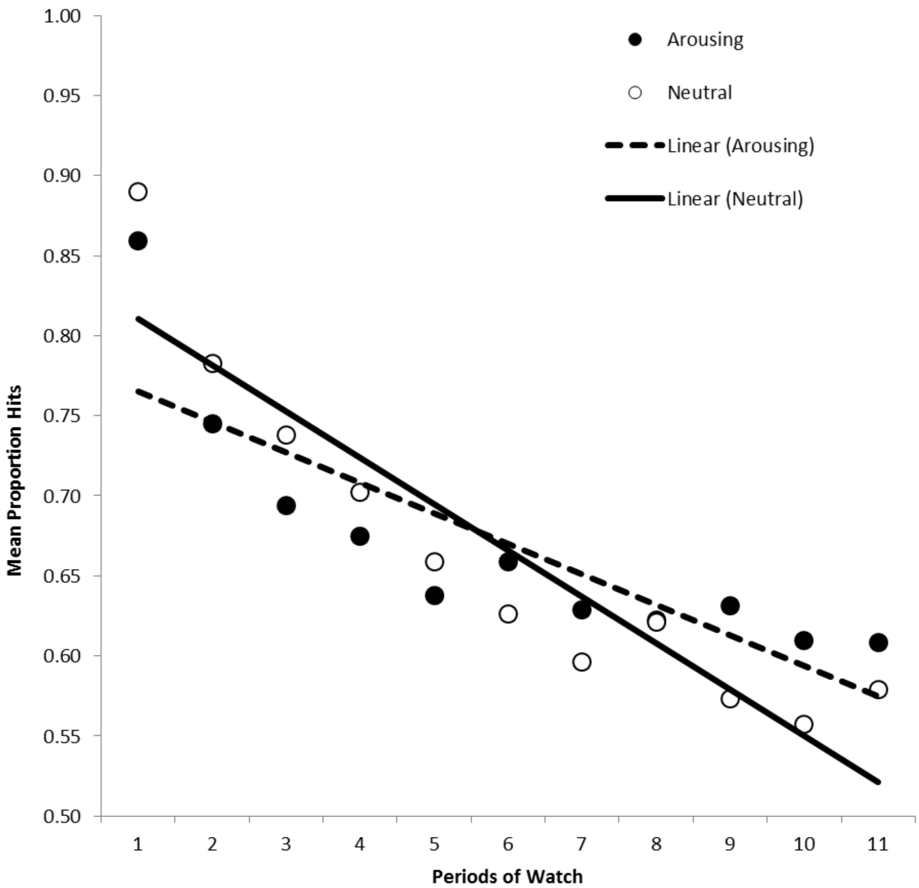

Figure 1. Mean proportion of correct detection (hits) for the arousing and non-arousing picture conditions over the eleven periods of watch. The lines represent the linear trends for the two conditions.

4.12 False Alarms

For false alarms, there was a significant linear trend, $F(1, 90) = 29.271$, $p < .001$, $\eta_p^2 = .245$, a significant quadratic trend, $F(1, 90) = 40.721$, $p < .001$, $\eta_p^2 = .312$, and a significant cubic trend, $F(1, 90) = 5.207$, $p = .025$, $\eta_p^2 = .055$. These trends are displayed in Figure 2. All other results were statistically non-significant, $p > .05$

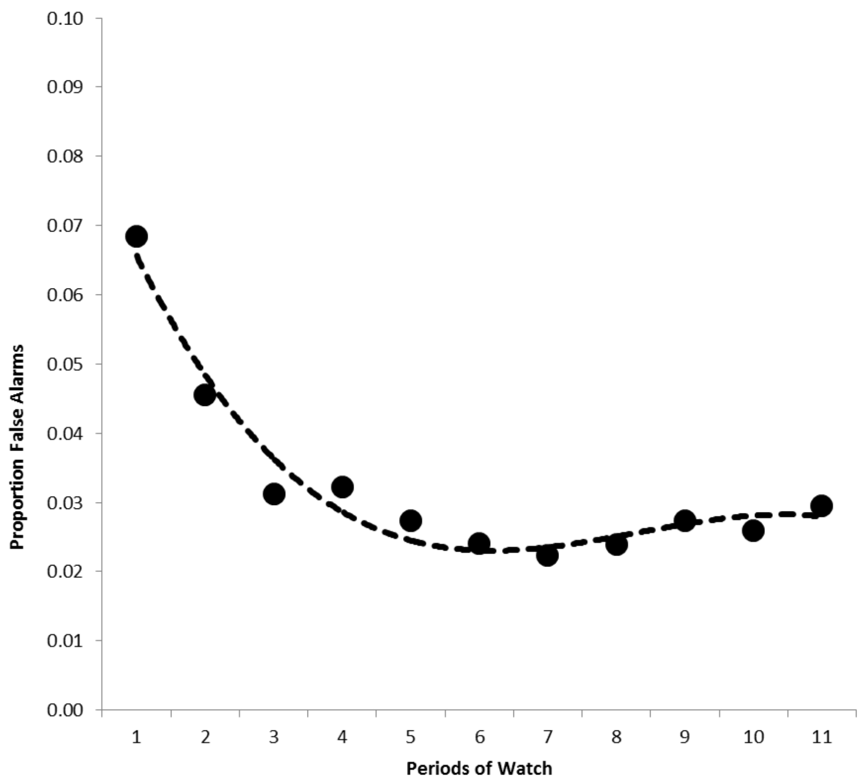

Figure 2. Mean proportion false alarms for all conditions collapsed. The line represents the cubic trend.

4.13 Reaction Time

For reaction time, there was a significant linear trend, $F(1, 88) = 120.995$, $p < .001$, $\eta_p^2 = .579$, quadratic trend, $F(1, 88) = 40.714$, $p < .001$, $\eta_p^2 = .316$, and a significant cubic trend, $F(1, 88) = 16.083$, $p < .001$, $\eta_p^2 = .155$. In addition, there was a significant linear trend for the period by arousal interaction, $F(1, 88) = 4.482$, p =

.037, η_p^2 = .048. This interaction is displayed in Figure 3. All other results were statistically non-significant, $p > .05$ including any period by valence interaction, and any period by valence by arousal interaction.

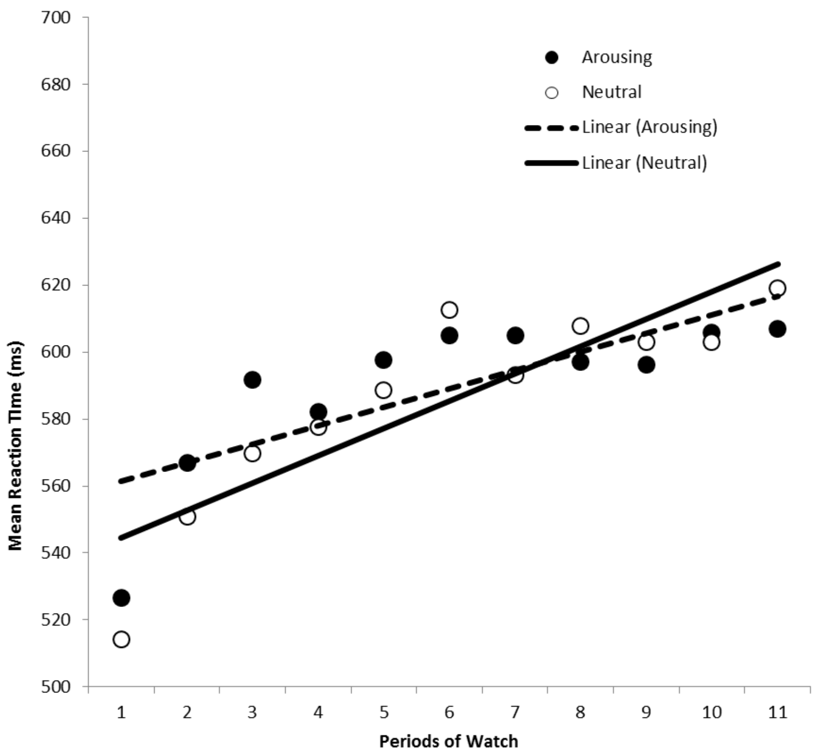

Figure 3. Mean reaction times (ms) for the arousing and non-arousing picture conditions over the eleven periods of watch. The lines represent the linear trends for the two conditions.

4.14 Non-Parametric Sensitivity (A')

For A′ there was a significant linear trend, $F(1, 90) = 87.609$, $p < .001$, η_p^2 = .493, quadratic trend, $F(1, 90) = 35.817$, $p < .001$, η_p^2 = .285, and cubic trend, $F(1, 90) = 8.798$, $p = .004$, η_p^2 = .089. In addition, there was a significant linear trend for the period by arousal interaction, $F(1, 90) = 4.910$, $p = .029$, η_p^2 = .052, which is displayed in Figure 4. All other results were statistically non-significant, $p > .05$

including any period by valence interaction, and any period by valence by arousal interaction. We also examined when the linear period by arousal interaction became statistically significant by iteratively examining the interaction at each period progression. We tested the significance of the interaction for the first two periods of watch and then stepped forward by one period to determine if the interaction became significant. Initially at period 2 the arousal by period interaction was non-significant, $p = .855$, at period 3, $p = .638$, at period 4, $p = .928$, at period 5, $p = .849$, at period 6, $p = .134$, at period 7, $p = .082$, at period 8, $p = .152$, at period 9, $p = .079$, and at period 10 $p = .041$. The change in trend for the decrement due to arousing pictures appears to occur late in the vigil.

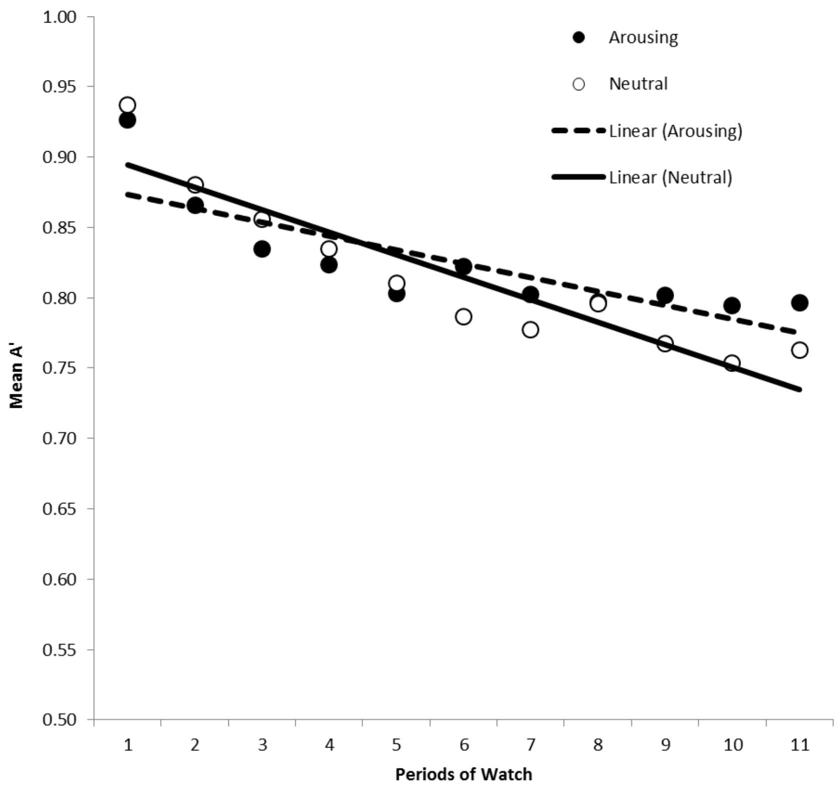

Figure 4. Mean A′ for the arousing and non-arousing picture conditions over the eleven periods of watch. The lines represent the linear trends for the two conditions.

4.2 Subjective Self-Reports

For the DSSQ self-reports, we performed two 2 (scale) by 2 (time) by 2 (valence: positive versus negative) by 2 (arousal: arousing versus non-arousing) mixed analyses of variance. The two measures of arousal (energetic and tense) were run in the same analyses and the two measures of thought content (task-related and task-unrelated) were run in another. This was possible as the scales were comparable in that they used the same response scale and measured similar constructs.

4.21 Arousal

Arousal was significantly higher post-task (M = 2.824, SE = .061) than pre-task (M = 2.621, SE = .042), $F(1, 90) = 9.966$, $p = .002$, $\eta_p^2 = .097$, energetic arousal (M = 2.918, SE = 053) was significantly higher than tense arousal (M = 2.527, SE = .056), $F(1, 90) = 27.815$, $p < .001$, $\eta_p^2 = .230$, and there was a significant scale by time interaction, $F(1, 90) = 94.411$, $p < .001$, $\eta_p^2 = .504$. This interaction is displayed in Figure 5. All other results were statistically non-significant, $p > .05$.

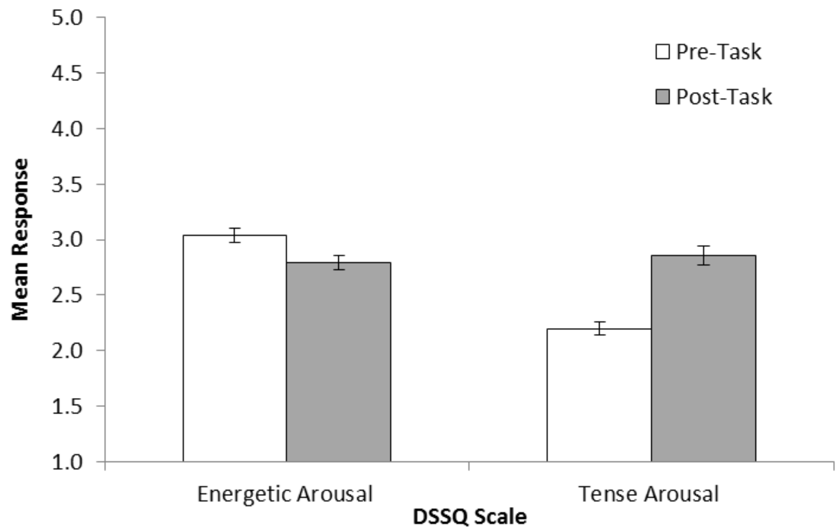

Figure 5. Mean responses for energetic and tense arousal for both pre-task and post-task measures (error bars are standard errors of the mean).

4.22 Thought Content

Thought content was significantly higher post-task (M = 2.521, SE = .065) than pre-task (M = 2.097, SE = .070), $F(1, 90) = 33.997$, $p < .001$, $\eta_p^2 = .268$, task-related thoughts (M = 2.681, SE = 076) was significantly higher than task-unrelated thoughts (M = 1.937, SE = .057), $F(1, 90) = 110.098$, $p < .001$, $\eta_p^2 = .542$, and there was a significant scale by time interaction, $F(1, 90) = 90.174$, $p < .001$, $\eta_p^2 = .492$. This interaction is displayed in Figure 6. All other results were statistically non-significant, $p > .05$.

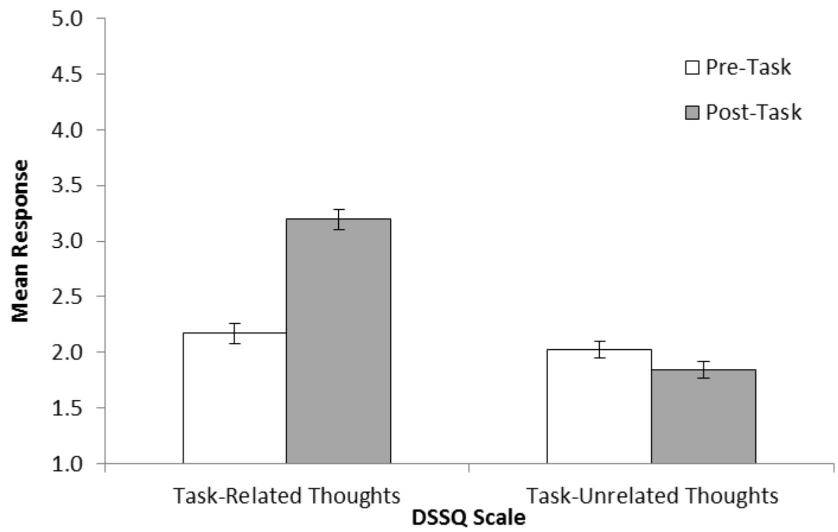

Figure 6. Mean responses for task-related and task unrelated thoughts for both pre-task and post-task measures (error bars are standard errors of the mean).

4.3 Relationship between self-reports and performance

In order to explore the relationship between self-reports, in particular of Energetic Arousal, and performance, two derived indices for A′ for each individual were calculated: the intercept and the slope. For each participant a line of best fit using least squares estimation was calculated for A′. The eleven periods of watch of the vigilance task were centered before calculating the lines of best fit by coding the eleven periods sequentially as -5, -4, -3, -2, -1, 0, 1, 2, 3, 4, and 5. The intercept of the fitted line therefore is the participant's mean A′ and the slope of the line indicates the participant's linear change in A′ over the vigil (Keppel & Zedeck, 2001). This analysis enabled us to examine the relationships between self-reports and average task performance (the intercept) and change in performance over the vigil (the slope) (see Helton et al., 2008; Helton, Dorahy and Russell, 2011; Helton & Warm, 2008; Langer et al., 2010). We were primarily interested in whether self-reported arousal, in particular Energetic Arousal, was related to performance and whether this relationship differed for the arousing and non-arousing picture groups, as previous studies have indicated a relationship between self-reported energy and vigilance performance (Helton & Warm, 2008)

For both A′ intercept and slope we performed a hierarchical regression. In the first step we included arousal picture group (effect coded 1 = arousing pictures, -1 = non-arousing pictures) and Z-scored pre-task DSSQ scores, in the second step we added Z-scored post-task DSSQ scores, and in the third step we added the arousing picture group by post-task Energetic Arousal interaction term. For A′ intercept, none of the steps were statistically significant. For A′ slope, step 1 of the model was non-significant, $F(5, 88) = 2.196$, $p = .062$, $R^2 = .111$ (though the effect of pictures coded as arousing was significant, $p = .219$, $t = 2.148$, $p =.034$), step 2 of the model was non-significant, $F(4,84) = .406$, $p =.804$, $R^2 = .128$, and step 3 of the model was significant, $F(1,83)= 7.108$, $p =.009$, $R^2 = .197$, indicating that there were group differences in the relation between performance and the slope. In the arousing picture group (n = 48) there was a significant correlation between post-task Energetic arousal and A′ slope, r = .373, p = .009, but this correlation was non-significant in the non-arousing picture groups, r = -.165, p = .273.

4.4 Picture Free Recall Performance

For each participant, the number of pictures correctly recalled was calculated. A 2 (valence: positive versus negative) by 2 (arousal: arousing versus non-arousing) between-subjects analysis of variance on the number of pictures correctly recalled was the conducted. Arousing pictures (M = 5.67; SE = .23) were recalled at a higher rate than non-arousing pictures (M = 4.80; SE = .24), $F(1, 90) = 6.879$, p = .010, η_p^2= .071. There was no significant difference between picture valence, $F(1,90)$ = .044, p =.835, nor a significant interaction between arousal and valence, $F(1,90)$= .513, p =.476.

5. Discussion

5.1 Purpose

In the present study the impact of task-irrelevant emotive picture stimuli on visuo-spatial vigilance performance and self-reported state was explored. Ninety-five participants completed the experiment in which task- irrelevant emotive picture stimuli were embedded in the vigilance task. Four experimental groups were tested by combining two levels of picture valence, positive versus negative, and two levels of picture arousal, arousing versus non-arousing, for the picture stimuli. The vigil was organised so that baseline performance, the initial impact of the images, and any continual carry-over effects of the images on performance could be measured. In addition to performance on the vigil, subjective state was measured using a self-report questionnaire designed to examine energetic and tense arousal as well as task-related and task-unrelated thoughts. We also assessed memory recall of the emotional stimuli post-task. Our key hypothesis was that the arousal quality of picture stimuli should matter more for performance than valence, and that arousing pictures while possibly disruptive when presented concurrently with the vigilance task, may result in improved performance later due to increased energetic arousal. We also suggest that the arousing picture stimuli may result in increased levels of energetic arousal post-task, and enhanced memory recall.

5.2 Findings

In the present experiment there was a robust vigilance decrement across all experimental groups, characterized by a general decline in perceptual sensitivity A′, a decrease in the proportion of hits, and an increase in response times to target stimuli. In order to test the impact of task-irrelevant picture valence and arousal on the vigilance decrement, we employed orthogonal preplanned trend analyses. The focus of these analyses was on whether the vigilance decrement was altered by the experimental manipulations of valence and arousal. The performance decrement over time was different for the groups depending on which stimuli they were exposed to, in that the performance decrement of the groups exposed to the arousing picture stimuli (both positive and negative), was attenuated in comparison to those exposed to the non-arousing stimuli, (both positive and negative). This result was consistent across performance metrics. Thus it was arousal, rather than valence that impacted performance. Our further analysis of this performance trend difference indicated the difference emerged late in the vigil, with A′ only becoming statistically significant from the 10th period of watch. This occurred in the post-picture period, well after the pictures were shown in the vigil.

The self-report measures of arousal and thought content were similar those found in other vigilance tasks (Matthews et al., 2002; Warm et al., 2008). Tense arousal was higher post-task than pre-task; where as energetic arousal was lower post-task than pre-task. Task-related thoughts were higher post-task than pre-task and task-unrelated thoughts were lower post-task than pre-task. This pattern is typical of vigilance tasks and is indicative of task-focus and mental fatigue. Picture arousal and valence did not affect the self-report responses across the groups, however we did examine the relationship between self-reports and performance. Previous researchers have found self-reports of energetic arousal to be predictive of performance and in particular, the vigilance decrement (Helton & Warm, 2008; Helton, Matthews, & Warm, 2009).

The relationship between self-reported energetic arousal and performance differed for the arousing and non-arousing picture groups. Post-task energetic arousal significantly predicted the performance decrement (linear slope) for the arousing picture group (PA and NA), but not for the non-arousing picture-group (PN and NN). The post-task energetic arousal reports may have been based on more recent experience with the task; meaning participants may have been more likely to remember how they felt later as opposed to earlier in the vigil. This may provide a partial explanation for why post-task energetic arousal was predictive of performance only for the arousing picture group. The post-task energetic arousal may have been predictive only for the decrement of the arousing group because it is late in the vigil that the arousing slope diverges from the non-arousing slope. Thus the last periods of watch are more influential on the slope for the arousing picture group than the non-arousing picture group. If the post-task reports of energetic arousal are most indicative of late vigil levels of energy, then the relationship may only be significant for those for whom late vigil performance is particularly influential to the overall pattern.

There is also the possibility that the energetic arousal self-report measure we used was not sensitive enough to pick up general differences between participant groups in this study. Future researchers may want to augment self-report measures with physiological measures, which would enable assessment of arousal states during the vigil or alternatively perhaps, use periodic self-report probes. However as this method involves experimenters interacting directly with the participant at specific points throughout the task, it could disrupt ongoing activity. While this method could potentially allow researchers to pinpoint when certain processes begin to occur, the probing itself could adversely impact task performance and subjective state (Giambra, 1995). Furthermore, Smallwood, Baracaia, Lowe and Obonsawin (2003) identified that post-task global measures and thought probing techniques correlate reasonably well. Regardless, the relationship between arousal states and performance change in vigilance tasks requires further research.

The arousing pictures were recalled at a higher rate than non-arousing pictures, irrespective of valence. This finding fits with research by Bradley, Greenwald, Petry and Lang (1992), which demonstrated that in both immediate and delayed free-recall, highly arousing stimuli lead to better memory performance than did stimuli with low levels of arousal. The authors suggested that although several factors affect memory performance, when remembering emotional stimuli it is the arousal dimension that accounts for a significant amount of variability in recall performance. Although other research has indicated that high levels of arousal can impair memory performance (e.g. Loftus & Burns, 1982; Clifford & Hollin, 1981), these studies focused on peripheral rather than central details of the arousing stimuli; therefore they are not inconsistent with the results found here. In fact, several meta-analytic reviews have concluded that although the emotion-memory literature includes many contradictory findings, there is consensus that high emotional arousal leads to enhanced memory for the central details of the stimuli in question (Christianson, 1992; Kern, Libkuman, Otani & Holmes, 2005). It has been argued that the encoding of emotionally arousing events automatically activates attentional and physiological changes, which enhance memory for that event (Libkuman et al., 2004).

In line with an evolutionary perspective, a memory system sensitive to the arousal level of an event acts as a survival tool, as the ability to retain arousing emotional information automatically enables individuals to respond appropriately to similar situations in the future (Kern et al., 2005). This is true for preservative (or appetitive) behaviours such as mating or eating, or protective (or defensive) behaviours such as fleeing from a predator, both of which demand a high mobilization of resources and are therefore good candidates for memory storage.

5.3 Unexpected findings

We did not find evidence of the negative impact of emotional stimuli on vigilance performance found in other studies (Ossowski, Malinen, & Helton, 2011; Helton & Russell, 2011). In these previous studies, the researchers found that overall performance in the negative arousing picture condition was lower than in a neutral picture condition during the periods in which the pictures were presented. The authors' explanation for the performance disruption in the negative arousing picture condition relative to the neutral picture condition was based on a competitive resource theory account. Several other studies also suggest that negative picture stimuli are processed more fully than neutral picture stimuli (Helton, Kern, & Walker, 2009; Kern et al., 2005). Taken together these finding suggest that negative task-irrelevant stimuli have negative consequences on performance by consuming more attention resources. There are several potential reasons that could help to explain why this finding was not established in the present study. Firstly, the vigilance task used in the two studies was qualitatively different. The task employed by Ossowski et al. (2011) and Helton and Russell (2011) was an alphanumeric vigilance task requiring the discrimination of letter stimuli whereas the task employed here was visuo-spatial. While the results are not entirely clear, there is evidence in the literature that emotional stimuli may differentially influence spatial and verbal processing systems (Brunye, Mahoney, Augustyn & Taylor, 2009; Grey, 2001; Shackman et al., 2006).

The nature of the images in the present study also differs from those used by Helton and colleagues. All of the images in the present study could be classed as emotional, thus we were comparing groups with the potential to elicit different emotions, for example happiness (PN images), excitement (PA images) sadness (NN images) or fear (NA images) (Bradley & Lang, 2007). The images in Ossowski were either neutral, or emotional (negative and arousing). Therefore differences between the image sets in the present study were more subtle, especially as the 'arousing' 'non-arousing' 'positive' and 'negative' groups had to be matched, excluding any extreme images from selection. As has been discussed in previous literature, crossing valence and arousal is a difficult task due to the relationship between these two constructs; as hedonic valence ratings become more pleasant or unpleasant, arousal ratings increase as well. Further, pictures that are rated as neutral tend to be rated low in arousal (Bradley & Lang, 2007; Greenwald, Cook & Lang, 1989) found these relationships to be stable and reliable. This is consistent with the perspective that judgments of pleasure and arousal reflect the level of activation in fundamental appetitive and defensive motivational systems, when neither system is active, judgments of both valence and arousal tend to be neutral (Bradley & Lang, 2007). When selecting the picture stimuli for this experiment, the negative non-arousing group was by far the hardest to fill, restricting the number of images that could be presented to participants. As suggested by Tellegen (1985) high negative affect may require a high level of arousal.

5.4 Limitations/Future research

The present study did not include a control group without any images, or a control group with neutral images. Our focus was on the issue of the differential impact of arousal and valence on vigilance performance. Nevertheless, future researchers may want to include additional control conditions to explore how task-irrelevant images in general affect the vigilance decrement. Future studies could also explore how particular groups of images affect performance and self-reported state, by sub-categorizing each image set based on specific stimuli content. For example the positive arousing images could be split in to erotic and adventure sets. This may provide further information on whether content matters as these sets may differently activate the appetitive motivation system. Further, Libkuman, Otani, Kern, Viger and Novak (2007) also suggest that differentiating slide content on the basis of specific emotions, as opposed to the dimensions of valence and arousal could be a topic worthy of further research.

Future research could also be designed to test for gender differences, as women have been found to rate all of the unpleasant content as more unpleasant and more arousing than do men, and men tend to rate erotic stimuli (either couples or opposite sex erotica) as more arousing and more pleasant than do women (Bradley, Codispoti, Sanatinelli & Lang, 2001). In her masters' dissertation, Ossowski (2011) investigated potential sex differences in emotionally stressful tasks. Her results focused on the impact of emotions, in particular negative arousing stimuli, on vigilance task performance, physiological arousal and stress states. Her findings suggest that men and women only significantly differed in their subjective ratings of stress, but not in their physiological arousal patterns or task performance. From these findings, the author concluded that men and women do not differ much in their real objective reaction to stress, meaning that although women report higher levels of stress overall, this does not translate in to physical or physiological differences. Despite this, some evidence suggests that men and women do perform differently in vigilance tasks requiring spatial discrimination (Dittmar et al., 1993) thus future research could be specifically designed to test this.

Another potential limitation of the study relates to the emotional stimuli used. Due to the extensive use of the IAPS in prior research, there is a danger that repeated exposure to the stimuli could lower the impact of the images (Dan-Glauser & Scherer, 2011). Libkuman, Otani, Kern, Viger and Novak (2007) sought to replicate the IAPS norms, one reason being that individuals may be sensitized or habituated to the emotional content, through repeated media exposure. Although they concluded that the arousal and valence norms were roughly similar to the norms reported by Lang et al (1999) and Ito, Cacioppo, and Lang (1998), they did find some evidence for this effect on arousal ratings. Similarly, Bradley, Lang and Cuthbert (1993) found that the acoustic startle reflex habituated with repeated exposure to the same emotional IAPS slides. If this is the case, it could mean that the impact of the images in the present study was limited, as the arousing images may have been less arousing than intended. As the accuracy of the valence and arousal ratings are crucial to the current experiment, a rating study could have been conducted with a similar group of participants prior to the main experiment, to aid the development of valid and reliable image sets for the current research.

5.5 Implications

The results found in this study fit with the perspective that the arousal quality of picture stimuli matters more for performance than valence, and that arousing pictures while possibly disruptive when presented concurrently with the vigilance task, may result in improved performance later due to an increase in energetic or cortical arousal. This finding fits with previous research suggesting that arousing agents are more potent when their possible distracting effects on task performance are no longer potentially competing for cognitive resources. For example, acute exercise has stronger effects on performance after the exercise has ceased, than during exercise itself. During periods of exercise, results concerning cognitive performance are somewhat ambiguous (Brisswalter, Collardeau, & Rene, 2002; Chang, Labban, Gapin & Etnier, 2012). Findings from a meta-analysis by Lambourne and Tomporowski (2010) indicate that while participants' cognitive performance was impaired during exercise, following exercise there was an improvement in performance. Although during exercise the findings are ambiguous, the findings concerning cognitive performance after exercise demonstrate clear improvements. Participants' cognitive performance improved when tested after exercise, suggesting that the heightened levels of arousal during this period could facilitate later cognitive function (Tomporowski, 2003). Conflicting findings concerning performance effects during exercise could be attributed to a resource perspective, in that the competition for attention and cognitive resources between the cognitive task and exercise task (which should impair performance) counteracts the increase in cortical arousal (which should improve performance) depending on resource availability. Interestingly, those with high levels of fitness have been shown to perform better at cognitive tasks during exercise than those who are less fit. This could be as a result of those who are less fit having to allocate more resources to the exercise task than those who are physically fit, leaving more resources for those with a higher level of fitness to engage in the cognitive task (Chang, Labban, Gapin & Etnier, 2012; Tomporowski & Ellis, 1986). Following exercise, an improvement in cognitive performance is evident for participants across both fitness levels. This pattern may also be true for other arousing stimulation, such as the inclusion of task-irrelevant arousing picture stimuli. While the stimuli themselves may compete for cognitive resources, their arousing quality may generate more resources via elevated cortical arousal.

5.6 Concluding remarks

The performance decrement over time was different for the groups depending on which stimuli they were exposed to, in that the performance decrement of the groups exposed to the arousing picture stimuli was attenuated in comparison to those exposed to the non-arousing stimuli. Further the relationship between self-reported energetic arousal and performance differed for the arousing and non-arousing picture groups. Post-task energetic arousal significantly predicted the performance decrement (linear slope) for the arousing picture group, but not for the non-arousing picture-group. The arousing pictures were also recalled at a higher rate than non-arousing pictures, irrespective of valence. These results provide support for the perspective that the arousal quality of picture stimuli matters more for performance than valence, and that arousing pictures while possibly disruptive when presented concurrently with the vigilance task, may result in improved performance later due to an increase in energetic or cortical arousal. This finding fits with previous research suggesting that arousing agents are more potent when their possible distracting effects on task performance are no longer competing for cognitive resources. These findings provide us with information that is useful for both theory and practice; the results provide insight in to the role of emotional stimuli in vigilance, memory and attention. Further understanding the relationship between emotive stimuli, vigilance performance and self-reports of arousal and stress states is extremely important as there are a number of tasks requiring individuals to monitor and detect targets during and after exposure to emotive stimuli, which highlights the potential real world applicability of the findings.

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Appendix A. Information, Consent and Debrief for participants

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The Impact of Picture Stimuli on Spatial Vigilance Performance and Self-Reported State

Information sheet for participants

You are invited to participate as a subject in the research project "The Impact of Picture Stimuli on Spatial Vigilance Performance and Self-Reported State". This project is being carried out as a requirement of the "Masters in Applied Psychology", by Georgia Flood under the supervision of Katharina Naswall and Deak Helton, who can be contacted via email at katharina.naswall@canterbury.ac.nz or via phone +64 3 364 2552. They will be pleased to discuss any concerns you may have about participation in the project.

The aim of this project is to explore the impact of picture stimuli on spatial vigilance performance and self-reported state, specifically looking at the valence and arousal of the stimuli. Although in some conditions the pictures are of a negative and/or arousing nature, they are no more so than pictures an individual would come across in daily life, for example images shown on the evening news or late night television. Specifically, some images may show nudity or distressing scenes.

Your involvement in this project requires the completion of a vigilance task, as well as a pre and post task questionnaire. Performance on the vigilance task will be measured, as will self-reported state prior to, and after performing the vigilance task.

You may withdraw your participation, including withdrawal of any information you have provided, until your questionnaire has been added to the others collected. Because it is anonymous, it cannot be retrieved after that.

All data collected for the study will be kept in locked and secure facilities and/or in password protected electronic form and will be destroyed after five years. Data will only be accessible to the researcher and the research supervisors. The results of the project may be published, but you may be assured of the complete confidentiality of data gathered in this investigation: the identity of participants will not be made public without their consent.

The project has been reviewed ***and approved*** by the University of Canterbury Educational Research Human Ethics Committee; participants should address any complaints to The Chair, Educational Research Human Ethics Committee, University of Canterbury, Private Bag 4800, Christchurch (humanethics@canterbury.ac.nz).

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The Impact of Picture Stimuli on Spatial Vigilance Performance and Self-Reported State

Consent form for participants

I have read and understood the description of the above-named project. I agree to participate as a subject in the project, and I consent to publication of the results of the project with the understanding that anonymity will be preserved.

I understand also that I may withdraw my participation, including withdrawal of any information you provided, until my questionnaire has been added to the others collected. Because it is anonymous, it cannot be retrieved after that.

I note that the project has been reviewed ***and approved*** by the University of Canterbury Human Ethics Committee.

If you would like to receive a report on the findings of the study, please leave your email or postal details in the space below.

NAME (please print): ....

Signature: ....

Date:

Would you like to receive a report of the findings of this study: Yes/No

If yes, email/postal address: ....

Debriefing Sheet for "The Impact of Picture Stimuli on Spatial Vigilance Performance and Self-Reported State"

Aim of the project:

This project is designed to explore the impact of emotive picture stimuli (images) on spatial vigilance performance and self-reported state, specifically looking at the valence (how positive or negative) and the level of arousal associated with the images.

Method:

All participants will complete the same vigilance task, which will be interrupted by picture stimuli; however they will be exposed to different images depending on what condition they are in. Participants will be randomly assorted into each condition. Each group will view images with a different combination of valence and arousal. The four conditions are; negative/arousing images, negative/non-arousing images, positive/arousing images and positive non-arousing images.

Dependent variables:

Firstly, performance on the vigilance task will be measured. Correct detections, false alarms and reaction times will be compared across groups. The duration of the impact of the images will also be measured by looking at performance post-images. In addition to performance on the vigilance task, subjective state will be measured using a self-report questionnaire designed to examine arousal as well as task-related and task-unrelated thoughts. The questionnaire will be administered pre and post vigil, to look at whether participant responses change after completing the task and being exposed to the picture stimuli. A post task free recall test will also be employed, asking participants to recall as many of the picture stimuli as they can. This is to see whether any particular set of images is remembered more easily than the others, meaning that those images may have been processed more fully by the participants*.

Predictions:

In previous studies looking at negative/arousing images and neutral images, it was found that overall performance in the negative picture condition was lower than in the neutral condition, and the negative picture condition had elevated levels of arousal and task-related thoughts. Positive images, as well as negative images with low levels of arousal have not yet been looked at. Results from this study may indicate whether it is the valence or the arousal (or both) of the images that causes these effects. Theory suggests that it may be the images with high levels of arousal, and low levels of valence that are most detrimental to performance, and are associated with an increase in arousal and task related thoughts.

Implications:

This study may provide useful theoretical information concerning the role of emotional stimuli in vigilance performance, attention lapses and memory. It may also have practical implications, as there are a number of tasks requiring a person to detect targets while being exposed to emotional stimuli- for example during medical procedures or during search and rescue.

It is important that you do not tell any other students about the memory test, as knowing that a memory test will be employed may alter the way they approach the task, and affect the results.

Please do not discuss this study with other students, as prior knowledge may affect the results.

Questions?

Thank you for taking part in this study.

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Appendix B. DSSQ Questionnaire & Free Recall

PRE-QUESTIONNAIRE

General Instructions:

This questionnaire is concerned with your feelings and thoughts at the moment. Please answer **every** question, even if you find it difficult. Answer, as honestly as you can, what is true of **you**. Your answers will be kept entirely confidential. You should try and work quite quickly. The first answer you think of is usually the best.

Age............. (years)   Sex. M F (Circle one)

Please indicate how well each word describes how you feel **AT THE MOMENT** (circle the answer from 1 to 5).

Not at all = 1 A little bit = 2 Somewhat = 3 Very much = 4 Extremely = 5

1. Energetic	1	2	3	4	5
2. Relaxed	1	2	3	4	5
3. Alert	1	2	3	4	5
4. Nervous	1	2	3	4	5
5. Passive	1	2	3	4	5
6. Tense	1	2	3	4	5
7. Jittery	1	2	3	4	5
8. Sluggish	1	2	3	4	5
9. Composed	1	2	3	4	5
10. Restful	1	2	3	4	5
11. Vigorous	1	2	3	4	5
12. Anxious	1	2	3	4	5
13. Unenterprising	1	2	3	4	5
14. Calm	1	2	3	4	5
15. Active	1	2	3	4	5
16. Tired	1	2	3	4	5

Please see next page.

Please indicate roughly how often you had each thought **DURING THE LAST TEN MINUTES.**

Never = 1 Once = 2 A few times = 3 Often = 4 Very often = 5

17. I thought about how I should work carefully on the task.	1	2	3	4	5
18. I thought about how much time I would have.	1	2	3	4	5
19. I thought about how others might do on this task.	1	2	3	4	5
20. I thought about the difficulty of the problems.	1	2	3	4	5
21. I thought about my level of ability.	1	2	3	4	5
22. I thought about the purpose of the experiment.	1	2	3	4	5
23. I thought about how I would feel if I were told how I performed.	1	2	3	4	5
24. I thought about how often I get confused.	1	2	3	4	5
25. I thought about members of my family.	1	2	3	4	5
26. I thought about something that made me feel guilty.	1	2	3	4	5
27. I thought about personal worries.	1	2	3	4	5
28. I thought about something that made me feel angry.	1	2	3	4	5
29. I thought about something that happened earlier today.	1	2	3	4	5
30. I thought about something that happened in the recent past (last few days, but not today).	1	2	3	4	5
31. I thought about something that happened in the distant past	1	2	3	4	5
32. I thought about something that might happen in the future.	1	2	3	4	5

POST-QUESTIONNAIRE

General Instructions:

This questionnaire is concerned with your feelings and thoughts during the task. Please answer **every** question, even if you find it difficult. Answer, as honestly as you can, what is true of **you**. Your answers will be kept entirely confidential. You should try and work quite quickly. The first answer you think of is usually the best.

Please indicate how well each word describes how you felt **DURING THE TASK** (circle the answer from 1 to 5).

Not at all = 1 A little bit = 2 Somewhat = 3 Very much = 4 Extremely = 5

1. Energetic	1	2	3	4	5
2. Relaxed	1	2	3	4	5
3. Alert	1	2	3	4	5
4. Nervous	1	2	3	4	5
5. Passive	1	2	3	4	5
6. Tense	1	2	3	4	5
7. Jittery	1	2	3	4	5
8. Sluggish	1	2	3	4	5
9. Composed	1	2	3	4	5
10. Restful	1	2	3	4	5
11. Vigorous	1	2	3	4	5
12. Anxious	1	2	3	4	5
13. Unenterprising	1	2	3	4	5
14. Calm	1	2	3	4	5
15. Active	1	2	3	4	5
16. Tired	1	2	3	4	5

Please see next page.

Please indicate roughly how often you had each thought **DURING THE TASK.**

Never = 1 Once = 2 A few times = 3 Often = 4 Very often = 5

17.	I thought about how I should work more carefully.	1	2	3	4	5
18.	I thought about how much time I had left.	1	2	3	4	5
19.	I thought about how others have done on this task.	1	2	3	4	5
20.	I thought about the difficulty of the problems.	1	2	3	4	5
21.	I thought about my level of ability.	1	2	3	4	5
22.	I thought about the purpose of the experiment.	1	2	3	4	5
23.	I thought about how I would feel if I were told how I performed.	1	2	3	4	5
24.	I thought about how often I get confused.	1	2	3	4	5
25.	I thought about members of my family.	1	2	3	4	5
26.	I thought about something that made me feel guilty.	1	2	3	4	5
27.	I thought about personal worries.	1	2	3	4	5
28.	I thought about something that made me feel angry.	1	2	3	4	5
29.	I thought about something that happened earlier today.	1	2	3	4	5
30.	I thought about something that happened in the recent past (Last few days, but not today).	1	2	3	4	5
31.	I thought about something that happened in the distant past	1	2	3	4	5
32.	I thought about something that might happen in the future.	1	2	3	4	5
33.	I thought about the images I had just seen	1	2	3	4	5

Please see next page.

During the task you were shown a set of images.

Please indicate how well each word describes how you felt about the images **DURING THE TASK** (circle the answer from 1 to 5).

Not at all = 1 A little bit = 2 Somewhat = 3 Very much = 4 Extremely = 5

34. Pleasant	1	2	3	4	5
35. Unpleasant	1	2	3	4	5
35. Interesting	1	2	3	4	5
37. Distracting	1	2	3	4	5
38. Helpful to task performance	1	2	3	4	5
39. Harmful to task performance	1	2	3	4	5

40. Have you completed a vigilance task before? Yes No Unsure

41. Have you completed this particular vigilance task before? Yes No Unsure

POST- FREE RECALL

General Instructions:

Please recall and write down as many of the images you saw during the vigilance task as you can below. You have 3 minutes to do this.

Appendix C. IAPS Ratings

Description	*IAPS number*	*Valence M*	*Valence M SD*	*Arousal M*	*Arousal M SD*	*Group*
Butterfly	1602	6.5	1.64	3.43	1.96	PN
Rabbit	1610	7.82	1.34	3.08	2.19	PN
Balloons	2791	6.64	1.7	3.83	2.09	PN
Sunflower	5001	7.16	1.56	3.79	2.34	PN
Sky	5593	6.47	1.57	3.98	2.31	PN
IceCream	7340	6.68	1.63	3.69	2.58	PN
Cow	1670	6.81	1.76	3.05	1.91	PN
Baby	2060	6.49	1.59	3.8	2.02	PN
Woman	2374	6.29	1.27	3.86	2.18	PN
Couple	2530	7.8	1.55	3.99	2.11	PN
Pilot	8300	7.02	1.6	6.14	2.21	PA
HangGlider	5626	6.71	2.06	6.1	2.19	PA
EroticMale	4490	6.27	1.95	6.06	2.42	PA
EroticCouple	4668	6.67	1.69	7.13	1.62	PA
EroticFemale	4311	6.66	1.76	6.67	2.19	PA
EroticCouple	4689	6.9	1.55	6.21	1.74	PA
Astronaut	5470	7.35	1.62	6.02	2.26	PA
Parachute	8163	7.14	1.61	6.53	2.21	PA
Bungee	8179	6.48	2.18	6.99	2.35	PA
Rollercoaster	8492	7.21	2.26	7.31	1.64	PA
Woman	2039	3.65	1.44	3.46	1.94	NN
Woman	2399	3.69	1.4	3.93	2.01	NN
Man	2490	3.32	1.82	3.95	2	NN
ElderlyWoman	2590	3.26	1.92	3.93	1.94	NN
Jail	2722	3.47	1.65	3.52	2.05	NN
Bucket	7078	3.79	1.45	3.69	1.86	NN
Cemetery	9001	3.1	2.02	3.67	2.3	NN
NativeFem	9045	3.75	1.67	3.89	2.16	NN
Puddle	9110	3.76	1.41	3.98	2.23	NN
HomelessMan	9331	2.87	1.28	3.85	2	NN
Snake	1040	3.99	2.24	6.25	2.13	NA
Spider	1200	3.95	2.22	6.03	2.38	NA
PitBull	1300	3.55	1.78	6.79	1.84	NA
Surgery	3212	2.79	1.67	6.57	1.99	NA
Surgery	3213	2.96	1.94	6.82	2	NA
Tornado	5972	3.85	2.33	6.34	2.2	NA
AimedGun	6250	2.83	1.79	6.54	2.61	NA
Police	6834	2.91	1.73	6.28	1.9	NA
Jet	9622	3.1	1.9	6.26	1.98	NA
Fire	9623	3.04	1.51	6.05	1.88	NA