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Evaluating Measures of Stress and Post-traumatic Stress Disorder

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Submitted to Swansea University in fulfilment of the requirements for the Degree of Master of Science by Research in Psychology

Declarations

This work has not previously been accepted in substance for any degree and is not being concurrently submitted in candidature for any degree.

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STATEMENT 1

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Abstract

This thesis aimed to identify measures vulnerable to stress and identify whether active inhibition task performance was associated with post-traumatic stress disorder (PTSD) symptoms or personality traits. The discovery of measures of psychological processes affected by PTSD symptoms is particularly useful for situations where self-report measures are less suitable.

Chapter One reviewed several physiological and psychological measures of stress and PTSD.

Chapter Two presented the results of a pilot laboratory study (N = 53) which investigated four different measures purported to be sensitive to stress (heart rate, heart rate variability, latent inhibition, and active inhibition). Due to restrictions imposed by the coronavirus (COVID-19) pandemic, this study was terminated prior to completion of data collection. Despite this, both heart rate and heart rate variability were found to be significantly affected by the two stressors (a number task and video clip). This supported the use of these measures for assessing stress response. Latent inhibition appeared unaffected by stress, although the active inhibition results were unclear, possibly due to the small sample size.

Chapter Three detailed a novel online study (N = 360) that investigated how PTSD symptoms and personality traits affected performance on an active inhibition task. Online research was adopted due to ongoing restrictions. An active inhibition task was completed, followed by the Eysenck Personality Questionnaire and PTSD Checklist for DSM-5. Contrary to expectations, PTSD symptoms were positively correlated with increased active inhibition, with avoidance having the strongest correlation. Individuals who met the criteria for PTSD showed greater active inhibition, than those below criteria threshold. No effect was found for any personality traits.

Chapter Four discussed the finding of this research which suggest PTSD may not always be associated with inhibition deficits and the active inhibition task may have been highlighted as a measurement of inhibitory processing differences associated with PTSD symptoms.

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Abbreviations

ADHD	Attention deficit hyperactivity disorder
ANS	Automatic nervous system
COVID-19	Coronavirus
CBAS	Cognitive-Behavioural Avoidance Scale
DSM-5	Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition
ECG	Electrocardiogram
EPI	Eysenck Personality Inventory
EPQ	Eysenck Personality Questionnaire
EPQ-R	Eysenck Personality Questionnaire – Revised
gradCPT	Gradual-onset continuous performance task
GDNF	Glial cell line-derived neurotrophic factor
HF	High frequencies
HR	Heart rate
HRV	Heart rate variability
LF	Low frequencies
O-LIFE	Oxford-Liverpool Inventory of Feelings and Experiences
PCL-5	PTSD Checklist for DSM-5
PCL-C	PTSD CheckList – Civilian Version
PEN	Psychoticism, Extraversion, and Neuroticism
PTSS	Post-traumatic stress symptoms
PTSD	Post-traumatic stress disorder
RMSSD	Root mean square of successive differences
WKY	Wistar Kyoto

Chapter One: General Introduction

1.1 Overview of Chapter

This thesis aimed to identify measures vulnerable to stress and identify whether performance on an active inhibition task was associated with post-traumatic stress disorder (PTSD) symptoms or personality traits that have been associated with PTSD. The long-term aim of this research originally was to provide evidence for measures that could be used in future research, to evaluate the effectiveness of a yet-to-be-developed resilience intervention for paramedic students. Previous interventions for PTSD, or ones that aim to increase resilience levels against PTSD, have attempted to alter responding under stress (Arnetz, Nevedal, Lumley, Backman, & Lublin, 2009). Therefore, being able to identify valid measures of stress was required, which was one of the aims for this thesis and the rationale behind the laboratory study reported in Chapter Two.

Due to the restrictions imposed by the Covid-19 pandemic, it was necessary to adapt the methods and focus of the research, and instead, the new aim of the research was to investigate the associations of active inhibition with PTSD symptoms and personality traits. This was to see if active inhibition was associated with traits and symptoms related to PTSD, which was the focus of Chapter Three. Therefore, this thesis concerns both measures of stress and PTSD, which are both discussed in this chapter.

This chapter begins by discussing physiological measures of heart rate and heart rate variability as measures of stress and PTSD. As well as physiological measures, since stress and PTSD have altered psychological processes, it was decided to explore psychological tasks used in PTSD and stress research. With a suitable task not identified in current literature, the use of measures from other psychological research, latent and active inhibition, were reviewed as possible markers of stress and PTSD. Since the effect of stress and PTSD have not been investigated with active inhibition before, this was a novel aspect of the research. Therefore, the attempts to assess measures of stress and the association of active inhibition with symptoms of PTSD and personality traits related to PTSD became additional aims and focus of the thesis.

1.2 Physiological Measures

Several physiological markers have been proposed as measures of stress and PTSD. The human stress response is controlled by the autonomic nervous system (ANS), which is split into the

sympathetic nervous system and the parasympathetic nervous system. These two systems are always simultaneously active, with dominance changing depending on an individual's activity. The activation of the stress response is coordinated by the sympathetic nervous system, which initiates changes, including dilated pupils, increased heart rate and restricted digestion (Ulrich-Lai and Herman, 2009). In contrast, the parasympathetic system is responsible for coordinating rest and recovery, such as, by decreasing heart rate and blood pressure (Porges, 1995). The balance of interaction of these two systems can enable an individual to respond effectively to their environment. Abnormalities in bodily responses controlled by these systems could indicate dysregulation of the ANS. Two markers of ANS functioning which have been proposed as physiological markers for stress and PTSD are heart rate and heart rate variability (Pole, 2007; Walker, Pfingst, Carnevali, Sgoifo, & Nalivaiko, 2017).

1.2.1 Heart Rate

Heart rate is typically increased during situations of stress, which has led to it being routinely employed as a physiological measure of stress in laboratory and real-life situations. A recent review conducted by Frazier and Parker (2019) investigated which physiological measures are most commonly used to study acute stress responses (focusing on research using working professionals). They looked at studies that had used outcome measures following a stress-induced task. The researchers found that out of 22 studies, heart rate was the most commonly used measure of stress, closely followed by cortisol. Although the difficulty of collecting cortisol at specific time intervals was discussed, thus heart rate appeared a more feasible measure of stress to be used in research.

Furthermore, reduced heart rate during an acute stressor was used as evidence for the success of a resilience intervention with police officers. Arnetz et al. (2009) conducted a study with 18 police officers, half of these officers received an imagery training intervention, which aimed to reduce stress responses during critical incidents. The training involved ten weekly sessions, where participants were taught relaxation skills to help improve focus and behaviour during critical incidents. As part of these sessions, the officers would hear scripts of critical incidences, which they had to imagine and practise responding to, in an appropriate manner, using the effective coping skills they had been taught. A year post-intervention, participants completed a trauma stressor while physiological measurements were taken, including cortisol and heart rate. The stressor was a realistic critical incident role-play, where the officer had to locate suspects in an armed robbery who, when found, fired shots from a paintball gun. They found, compared

to controls, the individuals who received the intervention showed reduced heart rate change during the stressor, and less cortisol was released. This provides further support that heart rate is increased under stress, therefore can measure stress and suggests that heart rate can be used as a measure to evaluate the effectiveness of interventions designed to prevent PTSD.

Additionally, elevated heart rate reactivity to trauma stimuli has been proposed as an indicator of PTSD, and this finding has been well evidenced in the literature. This makes sense since individuals with PTSD have heightened response to stress and therefore heart rate can be used to compare responses to stress in individuals with PTSD and those without. This would be useful evidence in determining if an intervention is effective to reduce stress responding. Pole (2007) conducted a meta-analysis of studies that had measured bodily reactions in PTSD individuals compared to controls. Seventeen of the studies used standardised trauma cues, and 22 studies used idiographic trauma cues, which were stimuli tailored to the individuals' traumatic experience, e.g., hearing a script of the traumatic event. For both the standardised and idiographic cues, elevated heart rate responses were reliably related to PTSD. There were medium effect sizes for the difference in heart rate response between the PTSD and non-PTSD groups. Additionally, compared to other physiological measures, including skin conductance response and blood pressure, Pole (2007) concluded heart rate elevation was one of the most consistent findings and proposed the possibility of using heart rate measurements to help identify individuals with PTSD. Of the studies used in the meta-analysis, 92.5% used trauma-exposed participants as the control group. Therefore, the increased elevated heart rate in the PTSD conditions, compared to the control participants, appeared to be more than just general anxiety to seeing trauma cues or hearing a trauma script, since the control participants also had experienced a trauma. This suggested there was an increased elevated physiological arousal, specifically in the PTSD participants. A meta-analysis provides good evidence from many studies, to support that the elevated heart rate is found in PTSD in response to trauma stimuli. A limitation of the meta-analysis is that most studies were conducted by the same research teams and used mainly veterans who were predominately male; both factors limit the generalisability of the results. Although subsequent studies have been conducted, that have provided further evidence of elevated heart rate in PTSD from other populations, including, in refugees (Adenauer, Catani, Keil, Aichinger & Neuner, 2010) and traffic accident victims (Ehlers et al., 2010). Overall, it appears that heart rate is a suitable measure of stress and can distinguish between individuals with or without PTSD.

1.2.2 Heart Rate Variability

In addition to heart rate, heart rate variability (HRV) can provide further insight into the function of the ANS and could also act as a measure of stress. HRV is the variations in the time interval between each individual heartbeat (Malik, 1996). HRV was first used as an indicator of cardiac function, but there has been substantial interest in using it as an indirect biomarker of the ANS function (Marques, Silverman, & Sternberg, 2010). Specifically, HRV is believed to be an indicator of parasympathetic functioning or cardiac vagal tone, since the main nerve involved in parasympathetic activity is the vagus nerve (Laborde, Mosley, & Thayer, 2017). Natural fluctuations between heartbeats indicate healthy functioning, therefore, high resting-state HRV is thought to reflect better psychological health and more adaptive emotional processing and responding, particularly in response to stressors (Thayer, Åhs, Fredrikson, Sollers, & Wager, 2012). Whereas low HRV is thought to indicate poorer functioning and reduced capacity to respond appropriately to stress-inducing events or stimuli (Appelhans & Luecken, 2006). This led to research looking at whether HRV is reduced in different mental health conditions, including PTSD, and could therefore be a marker for psychopathology and situations that cause HRV to reduce.

In order to study HRV, the variability in time between each heartbeat must be calculated. Two classes of analyses for calculating HRV have been used, known as time domain and frequency domain (Malik, 1996). Time domain measures are calculations of the time between individual heartbeats whereas frequency domain measures indicate the number of heartbeats that are within a certain frequency range. Reduced or low values of the root mean square of successive differences between heart beats (RMSSD), a time domain measure, have been proposed to imply a reduction in parasympathetic control over the ANS and could be a potential indicator of stress (Laborde et al., 2017). For frequency domain measures, power spectrum is generated from the inter-beat intervals, which separates out the different frequencies of the heart rate analysis. High-frequency HRV (HF) is also thought to measure parasympathetic activity and has been found to be highly correlated with RMSSD (Berntson, Lozano, & Chen, 2005). For the low frequency (LF) component, it is less clear, as it has been proposed to mark just sympathetic function, indicate only parasympathetic activity or be a combination of both (Appelhans & Luecken, 2006). Some researchers use the LF/HF ratio as an index of balance between the sympathetic and parasympathetic systems, however, the use of this index has also been criticised. This criticism is due to the use of the LF component, since it is unclear what physiological activity this value represents, and the fact that the relationship of the

parasympathetic and sympathetic system is not simply reciprocal (Laborde et al., 2017). Thus, the physiological processes contributing to the ratio are unclear, which limits the utility of this index. Since there is a lack of agreement of the gold standard of measurement for HRV (Malik, 1996), different indices of HRV have been used in the literature.

Evidence has suggested that HRV is not only able to indicate the presence of a mental health condition e.g., in PTSD patients, but it can also provide a real-time index of autonomic arousal and therefore evidence, the effect of acute stress. This is because during acute stress, the sympathetic nervous system is activated resulting in changes to HRV (Marques, Silverman, & Sternberg, 2010). This was evidenced by Taelman, Vandeput, Spaepen and Van Huffel (2009) who used a Mensa test as an acute stressor following a condition. HRV was significantly lower in the stressor condition, compared to, at rest, which was said to suggest higher sympathetic nervous system activity during the stress induction. Although this research was only conducted on 28 participants, so more evidence was needed.

A review by Castaldo et al. (2015) investigated the effect of acute laboratory mental stress on heart rate variability, using data from 12 research papers. The type of tasks used in studies varied but usually involved classic stressors, such as arithmetic tasks or public speech task. It was found that in all the studies, RMSSD was decreased during the stress condition, although this finding was not always significant, which may be due to small sample sizes used in some studies. Despite this, the authors concluded that the review showed HRV consistently reduced during mental stress, which therefore suggests HRV could be used as a measure of short-term stress. This was the same conclusion reached by a more recent review conducted by Kim, Cheon, Bai, Lee and Koo (2018) who reviewed a total of 37 studies involving HRV and psychological stress. They supported the use of HRV as an objective measure of stress and mental health conditions and thus HRV appeared suitable to use in order to measure stress response.

Additional evidence that HRV is suitable to show evidence of stress is provided from research using PTSD participants. Kotler, Matar and Kaplan (2000) used 16 PTSD patients who were not on medication and half of these patients were placed on a drug trial. Compared to the PTSD drug treatment group and controls, the non-treated PTSD group had lower HRV (indicated by increased low frequency and reduced high frequency components). Additionally, HRV increased in the treated participants and their scores on the Impact of Event Scale (a measure of PTSD) reduced, as well as their anxiety and depression ratings. This provided initial evidence

that HRV is reduced in individuals with PTSD and that increases in HRV may be associated with a reduction in symptoms, supporting the idea of a dysregulated autonomic nervous system in PTSD. However, these findings were based on a small sample and did not control for potential confounds, such as smoking. Hauschildt et al. (2011) conducted a larger study with 26 individuals with PTSD, 26 trauma-exposed non-PTSD and 18 non-traumatised controls. Heart rate variability recordings were taken at baseline and while watching videos varying in affective nature. One video was neutral (an electrician working), another was positive (child birthday party), then one was trauma related (matched to the individual's trauma e.g., a physical fight) and there were also two negative videos (a motor accident and surveillance themed video). As predicted, HRV was lower at baseline in participants with PTSD than controls and was significantly associated with total PTSD severity, and avoidance and intrusion symptoms. Additionally, HRV decreased in all affective video conditions for PTSD patients. It was not expected for PTSD patients to show decreased HRV on the positive affective videos, as well as the trauma-related video. This was proposed to indicate further evidence of inflexible and altered autonomic nervous system responding in people with PTSD, even in low stress conditions. Taken together, these studies have suggested HRV is reduced in PTSD at baseline and in response to affective stimuli.

Following the publication of several studies looking at PTSD and heart rate variability, Nagpal, Gleichauf and Ginsberg (2013) conducted a meta-analysis to determine if heart rate variability can be used as a psychophysiological marker of PTSD. Nineteen studies were included that used standardised criteria to confirm PTSD diagnosis, and age and gender-matched controls. The different HRV indices were analysed separately. Consistent with the general understanding that PTSD leads to autonomic hyper-arousal, significant effect sizes showed that high frequency HRV and root mean square of successive differences (RMSSD) between heartbeats were lower for PTSD participants than controls at baseline. The authors concluded that the findings should be viewed as tentative, since HRV and its associations to PTSD is quite a recent area of research. Additionally, unpublished data was not included in the analysis, so the large effect sizes may have been partly due to publication bias. These findings have been corroborated with a subsequent more recent meta-analysis by Campbell et al. (2019), who used data from 55 studies and did find smaller effect sizes, potentially due to the inclusion of unpublished data. Additionally, Campbell et al. (2019) identified age as a significant moderator of the association of reduced HRV and PTSD. As age increased, the association was stronger. This is important as it highlights the benefit of using a limited age range in studies looking at associations of

HRV and PTSD as this should lessen variability in results. Overall, it appears that low HRV is a reliable indicator of PTSD and therefore baseline measures may provide indication of presence of PTSD. Additionally, the findings from the review papers showed that HRV is affected by acute stress, warranting its use as an outcome measure, following the induction of stress.

1.3 Psychological Measures

Since heart rate and heart rate variability would be suitable to provide evidence of physiological changes due to stress. It would be advantageous to have stress measures that can indicate change in psychological processes as well as physiological measures. This is because stress alters more than just physiological pathways and common approach in stress research, is to collect multiple types of data, from different modalities, when determining stress status (Beil & Hanes, 2013). Stress is known to affect an individual's cognitive abilities including attentional capacity (Kahneman, 1973) and memory (Olver, Pinney, Maruff and Norman, 2015). Additionally, difficulties in memory, executive functioning and attention are some of the main cognitive difficulties associated with PTSD (Veltmeyer et al., 2005), suggesting physiological measures could also aid diagnosis of people with PTSD, as they may be affected by PTSD symptoms. Since attention deficits have been reported in PTSD and following acute stress, it was decided to identify possible tasks of attention that may be suitable for use as measures of psychological processes affected by stress and PTSD symptoms.

1.3.1 Affective Measures of Attention

In stress literature, tasks involving, looking at attention to threat stimuli have frequently been used. This is largely due to the fact that a key attention deficit in PTSD, is altered attention to threat stimuli (Aupperle, Melrose, Stein, & Paulus, 2012). This means that the majority of paradigms studied, involve the presentation of threat and neutral stimuli. Biases in attention are thought to be shown on these tasks if individuals respond differently to threat stimuli, compared to neutral information. While a number of attentional paradigms have been developed, the emotional Stroop task (Williams et al., 1996) and a dot-probe task (MacLeod, Mathews, & Tata, 1986) are the two main tasks which have been used to look at attention deficits and PTSD.

However, the findings on these paradigms appear to have been mixed. In unpublished literature, 75% of studies using the Emotional Stroop failed to find PTSD specific effects for identifying the colour of trauma-relevant words (Kimble, Frueh, & Marks, 2009). Furthermore, in a meta-

analysis by Cisler et al. (2011), PTSD groups were more impaired on the emotional Stroop task than controls, but so were trauma-exposed control groups. This suggests the emotional Stroop task may be identifying evidence of trauma exposure rather than PTSD and simply indicating general anxiety towards threat words rather than PTSD. Additionally, the effect of laboratory induced stress on Stroop task are contrary to theories of attention and stress, as acute stress has actually been found to reduce interference on standard Stroop tasks and result in better performance (Booth, 2019). Although this was for the standard Stroop task and not the emotional Stroop task, this result suggested using a Stroop task, was not suitable for stress or PTSD, due to varying results found in the literature.

The dot-probe paradigm involved a neutral word and threat word being shown on the screen as a pair. Following this, a probe (the dot) is presented on the screen and participants must respond when the dot appears. This is repeated on many trials with the dot changing location. MacLeod et al. (1986) found that highly anxious individuals were faster to locate the dot when it appeared in the same location as the threat word than the neutral word. This was taken as evidence to show anxious individuals have biased attention to threat. The task was then used in studies of PTSD, with many supporting the idea that the task could detect an attentional bias towards threat in individuals with PTSD (Bryant & Harvey, 1997; Fani et al., 2012).

Additionally, Andreotti, Garrard, Venkatraman and Compas (2015) exposed half of their participants to a 'Noisy Neighbor Task' which is a validated laboratory stressor, where participants have role-play an argument of getting a neighbour (played by a research assistant) to reduce the noise of their music. Following this, a dot-probe detection task was presented and those in the acute stress condition showed a significantly greater bias to threat words than the control participants. This suggests both stress and PTSD can affect performance on the dot-probe task. However, other studies (Pine et al., 2005; Bar-Haim et al., 2010; Sipos, Bar-Haim, Abend, Adler, & Bliese, 2014) contradicted these results and found participants with PTSD were slower to find the dot-probe when it was in the threat word location, potentially showing attentional avoidance of threat stimuli. Furthermore, the effect seemed to differ depending on the main symptoms the PTSD participants presented with. Those with increased hypervigilance symptoms may show greater attention to threat, whereas individuals with high avoidance levels would be more expected to show avoidance to threat (Vyas, Murphy, & Greenberg, 2020). Instead, it may be better to use paradigms without threat stimuli, that can detect more general attention deficits found in PTSD and following stress.

1.3.2. Non-Affective Attentional Measures - Inhibition of Attention

Attention tasks requiring inhibition of attention away from irrelevant stimuli and distinguishing between relevant and irrelevant stimuli, may be better to use to detect individuals under stress and with PTSD. This is because inhibitory processes that have been proposed to be impaired in PTSD and may be partly responsible for the development and continuation of symptoms (Echiverri-Cohen et al., 2016). Also, chronic stress has been shown to disrupt attentional control and acute stress affects executive functioning, including inhibitory processes (Liston, McEwen, & Casey, 2009; Shields. 2020)

Individuals with PTSD have shown difficulty focusing on relevant stimuli in the environment. McFarlane, Weber, and Clark (1993) conducted a study looking at responses to distractor stimuli. During the task, participants had to press a button when a target audio stimulus was presented but ignore other tones. As well as recording false alarm and hit rate, electrophysiological activity was also measured. PTSD performance on the task was slower to target tones than the performance of age and gender-matched control group of healthy individuals. Additionally, the electrophysiological measure results, suggested that PTSD participants struggled to discriminate between the target and distractor tones, causing impairment in both attention and their ability to ignore irrelevant stimuli. The authors suggested difficulties in concentration and attention in PTSD, may be due to an inability to discriminate between relevant and irrelevant stimuli. This indicates attentional tasks requiring attending to target stimuli and ignoring irrelevant stimuli may be suitable to use to identify impairments related to PTSD.

DeGutis et al. (2015) conducted a study to investigate if inhibitory tasks were better predictors of PTSD symptoms than more general executive function tasks. Veterans (N=37) who had experienced a traumatic event, participated and completed the PTSD CheckList-Civilian Version (PCL-C) to assess their level of PTSD symptoms. The cognitive tasks used in the study measured different executive function abilities, including task switching and working memory. Two tasks of inhibitory function were used to measure two different types of inhibitory control. For inhibition of responding, a gradual-onset continuous performance task (gradCPT) was used. On go trials (city images), participants had to respond by pressing a button whereas on no-go trials (mountain scenes) they had to inhibit responding and the dependent variable was percentage of presses on no-go trials (as these indicated difficulty in inhibition). For distractor suppression, they used a version of an attention capture task called an irrelevant singleton visual

search paradigm. The task required the use of visual search to find one unique shape among other shapes. On distractor present trials, one of the other shapes was shown in red whereas on distractor absent trials, all shapes were green. The dependent variable was the mean reaction time on distractor present trials minus distractor absent trials, with a larger mean reaction time indicating difficulty in inhibiting the salient coloured distractor. A hierarchical regression analysis was used to determine if symptoms of PTSD were uniquely associated with performance on inhibitory tasks, more than on the other executive function tasks. The authors found the combination of the two inhibition tasks added to the predictive ability of the regression that was not captured by the other tasks. On their own, performance on these tasks explained a large amount of the variance (25%) in PTSD total score. Furthermore, only the gradCPT and the attention capture task, significantly correlated with PTSD scores, with increased level of PTSD symptoms correlated with poor performance on the tasks. This suggests tasks, that require visual or response inhibition, were best at identifying those with higher levels of PTSD symptoms. It was concluded that individuals with PTSD might have an impairment in their ability to direct attention and are more vulnerable to the influence of distracting stimuli. They proposed this could be due to interference of intrusive thoughts and ruminations, which reduce their ability to engage in effective inhibitory processes.

Additionally, improvement in inhibition of distractors has been shown following exposure therapy of individuals with PTSD. Echiverri-Cohen et al. (2016) conducted a laboratory study using an attentional blink task where individuals had to identify targets (letters) which are shown during a rapid presentation of distractors (numbers). Following receiving either 10 weekly sessions of prolonged exposure therapy or the drug sertraline, participants completed the attentional blink task. They found that participants who showed more reduced PTSD symptoms, following exposure therapy, also had increased inhibition on the task. This pattern of results was not found for the drug treatment group, which was thought to suggest these treatments target different processes to reduce PTSD symptoms. The authors of the paper proposed, that in PTSD, continual activation of irrelevant and relevant stimuli, leads to greater errors in interference and stimuli selection, and that the study highlights underlying mechanisms of PTSD, which could be useful to inform diagnostic methods. This provides further support for the use of an inhibition task as a measure of psychological processing differences in people with PTSD as Echiverri-Cohen et al. (2016) showed that improvement in PTSD symptoms can be detected on attentional inhibition task.

In terms of the effects of stress and attention, it appears that the effects of stress can differ depending on the type of inhibition requirements of the task. Shields et al. (2016) conducted a meta-analysis of the effects of acute stress on executive functions. A section of this analysis reviewed tasks measuring cognitive inhibition (also known as interference control), which they defined as the ability to selectively attend or ignore information, thus is closely related to inhibition of attention. Studies using a multitude of different task types were included for cognitive inhibition such as; sustained attention to response task, visual attention tasks and tasks involving novel interference control. Response inhibition was found to be enhanced following acute stress, whereas cognitive inhibition was found to be impaired. Therefore, this supports that, attentional inhibition is likely to be impaired following stress, similar to the findings with people with PTSD. Although this meta-analysis was criticised by Dang (2017) who believed some of the tasks were incorrectly classified as tasks of cognitive inhibition, although Shields (2017) justifies the classifications used, based on previous stress literature. This debate relates to the fact that current psychological tasks often require more than one type of executive functioning process so people can disagree with what ability the task is measuring. Thus, it may be beneficial to seek alternative tasks from attentional domains that are more specific to inhibitory ability.

In summary, these studies and the ones previously discussed, suggested people with PTSD and under stress have difficulty in responding to threat stimuli, maintaining attention, inhibiting inappropriate responses, and filtering out non-relevant information. However, no task or paradigm reported in either affective or non-affective measures has consistently detected attentional impairment in PTSD or following acute stress across these studies. Therefore, it was decided to consider alternative attentional measures from other domains, which could potentially be used to measure stress and help identify those with or at risk of PTSD.

1.4 Latent Inhibition

Originating from conditioning research, latent inhibition paradigms can also study attention-related processing. In everyday life, humans are exposed to an abundance of stimuli and thus require a system to avoid being overwhelmed. If individuals are repeatedly presented a stimulus (stimulus A) without a consequence, and then subsequently shown stimulus A in conjunction with another stimulus (stimulus B), the learning of the association between stimuli A and B will be slower than if they had not had prior exposure of stimuli A. This is thought to be because the participant screens the irrelevant stimulus from attentional awareness. This is termed latent

inhibition: the fact that it takes longer to form an association with a previously exposed irrelevant stimulus and an outcome than a novel stimulus (Lubow & Moore, 1959). 'Latent' refers to the fact that learning is not visible until a later test is used, and 'inhibition' refers to the decrease in learning, rather than solely an inhibitory process (Lubow, 1989). Latent inhibition studies provide a measure of capacity to ignore irrelevant stimuli, with high latent inhibition shown by difficulty in forming an association with a pre-exposed stimulus, which has been studied using variations of a classic paradigm.

1.4.1 Latent Inhibition Paradigm

In a typical latent inhibition task, there are two participant conditions (pre-exposed and non-pre-exposed) and two stages of the paradigm (pre-exposure stage and test stage). In the pre-exposure stage, the pre-exposed participants are presented with the pre-exposed stimuli during an irrelevant masking task. Whereas the non-pre-exposed condition participants also complete the irrelevant task but are not exposed to the to-be-targeted stimuli. In the test stage, all participants complete the same conditioning task. This usually involves learning a rule that requires forming an association between the pre-exposed stimuli and a target stimulus. The general finding is that pre-exposed participants are slower to learn the association than the non-pre-exposed group, as pre-exposure to the stimulus retards subsequent learning towards this stimulus in the test stage.

One of the main latent inhibition paradigms was developed by Lubow, Ingberg-Sachs, Zalstein-Orda, and Gewirtz (1992), which has been extensively used and adapted in the literature. In the study, 20 psychology students started by completing a masking task that involved three-letter trigrams and participants had to count the number of repetitions of the letters. The trigrams were presented inside a shape (the pre-exposed stimulus) whereas the shape was omitted for the non-pre-exposed group in the pre-exposed stage. In the test phase of 240 trials, on each trial, participants had to predict if they thought a counter on the computer screen would increase. If they were correct, a point was subtracted from their counter and the aim of the task was to have as low a score on the counter as possible. The rule was predicted by the pre-exposed shape, whereas no change to the counter was predicted by a novel target stimulus. The dependent variable was how many trials it took to reach five correct responses (the learning criterion). The study found that those in the pre-exposed condition took over double the number of trials to reach the learning criterion than the non-exposed group; thus, showing latent inhibition. This

was one of the first latent inhibition paradigms using visual stimuli (as previous paradigms used auditory stimuli) and has been used to study latent inhibition in many subsequent studies.

1.4.2. Attentional Theories of Latent Inhibition

The main theoretical argument for latent inhibition uses explanations of attentional processes. An account proposed by Mackintosh (1975) explained the phenomenon using rules of attention and associative strength of a stimulus and an outcome. When a stimulus is an accurate predictor, it is assumed that the probability of attending to this stimulus increases. However, attention is predicted to decrease when a stimulus is not an accurate predictor.

An additional attentional view of latent inhibition is Conditioned Attention Theory which was developed as a model to explain latent inhibition (Lubow, Weiner, & Schur, 1981). This model goes further than Mackintosh's theory by specifying conditions of change in attention and the mechanisms by which these changes may occur. The two additional assumptions made by the theory is that attention declines by a conditioned decrement and reduction in attention to a stimulus is an inevitable outcome of repeated stimulus exposure. Although a criticism of both theories is the inability to explain how latent inhibition is reduced or abolished if the context is changed for the test stage. Despite this issue, the role of attentional processes in latent inhibition is generally accepted. Therefore, the task seems suitable to detect impairment in attention, specifically difficulty in filtering out irrelevant stimuli, which individuals with PTSD have previously shown deficiency in this ability. This suggests latent inhibition could be a suitable objective measure to use.

1.4.3. Latent Inhibition and Psychopathology

1.4.3.1 Schizophrenia and Latent Inhibition

Research studies using individuals with schizophrenia, who are known to have attention deficits (Cornblatt & Keilp, 1994), have provided evidence that latent inhibition paradigms can potentially be used as a measure of psychopathology. Kumari and Ettinger (2010) reviewed the literature of latent inhibition and schizophrenia. They concluded that the most consistent finding is unmedicated acute schizophrenics show attenuated latent inhibition compared to control participants, who were either healthy participants, chronic schizophrenics, medicated acute schizophrenics, or individuals with a different mental health condition. This suggests unmedicated individuals with acute schizophrenia have an attentional deficit that impairs their ability to inhibit irrelevant stimuli. This means that they show better performance on the test

stage than controls, showing faster association learning of the pre-exposed stimulus and outcome. This is a huge advantage of the latent inhibition task as usually patient groups show a deficit in performance, but the fact that they show a better result means the finding cannot be explained due to reduced motivation or fatigue, or effects of medication.

Additionally, personality traits that indicate susceptibility to schizophrenia have been associated with reduced latent inhibition, particularly for traits that relate to positive schizophrenia symptoms. Schizotypy is a personality type that has been proposed to be similar to schizophrenia, including delusions of thinking and feeling paranoid but is a non-clinical presentation. The general finding is that individuals with high schizotypy personality levels show reduced latent inhibition (e.g., Baruch, Hemsley, & Gray, 1988). Gray, Fernandez, Williams, Ruddle, and Snowden (2002) investigated this further, looking at which specific personality traits were associated with impaired latent inhibition. In the study, 80 healthy participants completed the Oxford-Liverpool Inventory of Feelings and Experiences (O-LIFE) questionnaire to measure schizotypal factors of unusual experiences, cognitive disorganisation (aspects of poor attention/concentration), impulsive non-conformity and introvertive anhedonia (lack of enjoyment). A latent inhibition paradigm used was similar to that developed by Lubow et al. (1992). They found that people who had higher scores for unusual experience and impulsive non-conformity showed reduced latent inhibition. This study showed that impairment on latent inhibition paradigms can be associated with certain personality traits, which are associated with risk for psychopathology.

1.4.3.2 PTSD and Latent Inhibition

Surprisingly, despite known attention deficits in PTSD, there has not been any research specifically looking at performance in individuals with PTSD and latent inhibition. Instead, evidence that stress impairs latent inhibition comes from studies focused on trait-anxiety, animal models and acute stressors. Since individuals with schizophrenia and schizotypy are also known to have high levels of anxiety, Braunstein-Bercovitz (2000) proposed that the impairment found for schizophrenia and latent inhibition may be due to increased levels of anxiety. They conducted a latent inhibition study with university students to investigate this. A multiple regression analysis revealed that anxiety accounted for the latent inhibition impairment more than schizophrenia-like symptoms. Although it is important to note this research study was not done with individuals with schizophrenia, so cannot answer if the findings from schizophrenic patients and reduced latent inhibition have been due to anxiety levels. Also,

schizotypy scores still contributed to latent inhibition independently from anxiety. The study indicated a role in anxiety for disrupting latent inhibition and warranted future research of the disruption of latent inhibition due to anxiety or stress.

Further evidence that latent inhibition could be impaired in PTSD has come from animal studies. Ricart et al. (2011) studied if latent inhibition was impaired in a possible animal model of PTSD. They used the Wistar Kyoto (WKY) rat, which expresses animal equivalent behaviours related to symptoms of humans with PTSD. Compared to a control rat model, it would be expected for the WKY rats to show diminished latent inhibition. Indeed, this is what was found, the WKY rats displayed normal conditioning following pre-exposure of a stimulus, thus had impaired latent inhibition. In another animal study, Buhusi, Brown and Buhusi (2017) exposed mice to a range of chronic stressors, including restraint and forced swim, for a three-week duration, prior to a latent inhibition task. Glial cell line-derived neurotrophic factor (GDNF) deficit mice showed no significant difference in freezing duration for pre-exposed or non-pre-exposed stimuli in the high-stress condition, implying that exposure to chronic stress abolished latent inhibition. This supports the idea that individuals with PTSD and those under high levels of stress would show impaired latent inhibition.

A key study looking at latent inhibition and stress was conducted by Braunstein-Bercovitz et al. (2001). They proposed that following a high-stress manipulation, participants would display attenuated latent inhibition. The study had four conditions as there was a pre-exposed and non-pre-exposed condition for both the no stress and high-stress manipulation. In the pre-exposed stage, all participants saw pairs of letters on the screen, e.g., TL or TT, and indicated whether the letters were the same or different using the keyboard. In pre-exposed conditions, the letter pairs were also accompanied by two identical shapes. The test phase was similar to the one described previously for Lubow et al. (1992) where participants had to predict the rule that would indicate when points would be added to a counter shown on the screen. The counter would increase when the pre-exposed stimuli pair was shown on the screen but not when a different stimuli pair was shown. Before the latent inhibition task, participants completed either a low or high-stress arithmetic task depending on their task condition. In the stressful arithmetic condition, individuals had to complete challenging or unsolvable number sequences under time pressure, whereas for the low-stress maths task, easier sequences were presented with no time restriction. They found participants in the low-stress condition showed the typical result; pre-exposed participants required more trials to reach criterion than the non-pre-exposed participants. Whereas in the high-stress condition, latent inhibition was attenuated in pre-

exposed participants, as they required fewer trials to reach criterion than the pre-exposed low-stress condition. From these findings, it appeared a latent inhibition paradigm could be affected by stress. This supported the finding of trait anxiety and animal studies, which suggested that latent inhibition should be vulnerable to stress, therefore potentially a relevant paradigm for people with PTSD. It is therefore unclear whether latent inhibition is abolished by schizophrenia, anxiety, stress, or PTSD, which is why future research was warranted to help clarify this.

1.4.4. Issues of Latent Inhibition as a Measure

The classic paradigm to measure latent inhibition relies on having both a pre-exposed and non-exposed group in a between-subjects design. This has several limitations for its use as a marker of psychopathology. It requires large samples to achieve adequate power and means tests cannot provide an index of an individual's latent inhibition ability, as can only compare performance between the pre-exposed and non-exposed groups. This would be particularly useful for studies of individual differences of latent inhibition. Although there have been attempts to develop a within-subjects measure (Evans, Gray, & Snowden, 2007; Granger, Moran, Buckley, & Haselgrove, 2016), the development of a universally accepted within-subjects paradigm has yet to be achieved. Also, since all the previous studies that support the association of stress and latent inhibition have used between-subject paradigms, it seemed best to continue with this methodology. Additionally, tasks cannot be repeated in the same individuals once the conditioning task rule has been learnt. This eliminates the use of the task in longitudinal studies or for continued monitoring of individuals.

Due to these methodological limitations, it appeared beneficial to identify an alternative task that studies attention to use alongside the physiological measures and the latent inhibition measure to try to overcome the methodological limitations of latent inhibition.

1.5. Active Inhibition

Other paradigms which can be used to look at attention are visual search tasks. Visual search can be a complex task, which varies in difficulty depending on the number of distractors and their similarity to the to-be-found stimuli. These paradigms can study how individuals attend and process irrelevant information to focus on more relevant stimuli. Clinical populations, including people with PTSD, often struggle to deprioritise and inhibit old items to attend to new stimuli, therefore a visual search task appears a suitable psychological task for measuring

deficits related to PTSD symptoms. One task that seems likely to be impaired in those with PTSD is termed “visual marking” or “active inhibition” although this has not yet been studied before and was the aim of this thesis.

1.5.1. Paradigms of Active Inhibition

The original paradigm to measure active inhibition was developed by Watson and Humphreys (1997), who named it visual marking. However, it can also be termed active inhibition as it is believed to involve actively suppressing irrelevant stimuli and thus combines visual search and the inhibition of distractors into one task (Kunar & Humphreys, 2006; Mavritsaki, Heinke, Humphreys & Deco, 2006).

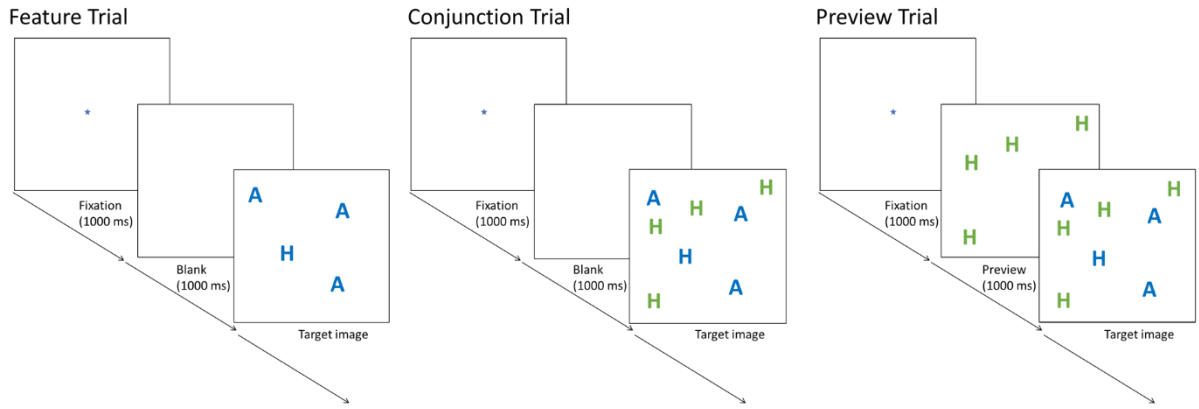

Figure 1. Diagram showing classic Active Inhibition paradigm used by Watson and Humphreys (1997).

The original task paradigm (Figure 1) contained three different trial types, randomly presented, with the aim of each trial to identify if a target letter stimulus (e.g., a blue H) was present among distractor stimuli (e.g., green Hs). In the single-feature trials, only one type of distractor, e.g., blue As, were shown along with the target stimuli. In conjunction trials, individuals were presented with a target stimulus, but this time shown along with two types of distractor stimuli that shared one feature with the target, e.g., green Hs and blue As. In preview trials, one type of distractor stimuli, (e.g., green Hs) were shown 1000ms before the remaining distractor stimuli and the target stimulus. The researchers found that individuals were faster on the feature trial than on the preview trial and faster for the preview trials than on the conjunction trials, which was the key finding. This was believed to show that in the preview trial, the old distractors (e.g., green Hs) were inhibited as a group, making the search task easier as the participant only had to search through the new distractors to find the target blue H. Further studies were conducted to provide evidence of this mechanism.

1.5.2. Mechanism of Active Inhibition

Watson and Humphreys (1997) proposed that the mechanism behind the active inhibition effect, requires attentional processes and inhibition of the old objects. They investigated the role of attention in active inhibition by adding an attention requiring task during the preview stage (presentation of distractors) of the active inhibition paradigm. Participants had to identify if a blue H was present on the screen and the distractors were green Hs and blue As. The attention-demanding task was to read digits aloud during the preview stage when the distractors were shown. This did not completely abolish the preview effect, but reduced the benefit of the distractors, causing participants to have attenuated active inhibition. These findings were also supported by Humphreys, Watson and Jolicœur (2002), who found engaging in either an auditory or visual task, during the onset of the preview distractors, impaired performance on the preview trials. From these findings, it can be concluded that the attentional mechanism must be used to deprioritise the old distractors as when attention was required for a secondary task, the preview benefit was reduced. This also suggests the mechanism requires the use of capacity-limited resources, therefore, cannot be a purely automatic process as it is affected when attentional capacity is limited. Under high levels of stress or anxiety, or in individuals with PTSD, attention capacity is proposed to be limited and therefore these individuals should show performance similar to normal controls undergoing an attention-requiring task. Thus, it would be expected that they would have an impaired preview effect.

Additionally, the preview effect is proposed to require inhibition of old items, which has been supported using evidence from a dot-probe study. Watson and Humphreys (2000) adapted their standard active inhibition paradigm so that on some trials instead of identifying the presence of the blue H, they had to indicate if a probe dot was present on the screen. As expected, if a probe was presented in the same location as an old distractor, then the detection of the probe was worse than if the probe was in a new distractor location. This finding was found for preview trials but not on conjunction trials, and it was also eliminated if participants were told all trials were to detect the probe. This shows that when there was no beneficial advantage to task performance in inhibiting the old distractors, then it appeared participants did not inhibit the distractors. As when the task aim was to find the probe location, detection was not affected by whether the probe was in a location of an old distractor or in a new location. This adds more direct evidence to support that the task requires active inhibition of distractors and is a voluntary action, initiated by the observer when it makes the search more efficient so can be applied by choice (Watson, Humphreys, & Olivers, 2003). Also, this finding suggested the task requires

top-down attentional processes as it involves internal influence such as the observer's goals and intentions.

An alternative argument to this view was proposal by Donk and Theeuwes (2001) that the preview benefit is generated by the attentional onset of the new items, rather than inhibition of the old distractors. This emphasises the role of bottom-up onset of attention, which is activated by external properties of the environment, thus a more automatic process. This view is supported by findings that the preview effect is eliminated when the new stimuli are the same luminance as the background, which cannot be explained by inhibition of old items (Donk & Theeuwes, 2003). However, if improvement in search was purely due to attentional onset of new items, then this rationale cannot fully explain the previous findings using the dot-probe task or how a reduction in preview duration impacts the benefit (Watson & Humphreys, 1997, 2000). Currently, the main accepted view in the literature is that a combination of active inhibition of old items occurs in conjunction with attentional capture of the new stimuli, thus requiring both bottom-up and top-down attentional processes (Barrett, Shimozaki, Jensen, & Zobay, 2016; Yamauchi, Osugi, & Murakami, 2017).

1.5.3 Active Inhibition and Psychopathology

The effect of PTSD and stress on active inhibition has not yet been studied and was the aim of the current thesis. This formed a novel area of investigation and aimed to identify a new measure of psychological processing that is affected by PTSD symptoms; as well as providing further insight into the exact impairments of individuals with PTSD. Research has already been conducted looking at individual differences in performance on an active inhibition paradigm, such as age. Warner & Jackson (2009) compared groups of older and younger adults on an active inhibition task. They found older adults ($\bar{x}$ =73.2 years) required a preview duration of more than 550ms compared to younger participants ($\bar{x}$ =19.7 years) where 414ms was an adequate duration. This finding indicated that active inhibition ability can be affected by an individual difference.

To establish if psychopathology affects ability on an active inhibition task, Mason, Booth, and Olivers (2004) investigated if differences in proneness to psychosis were related to performance on the paradigm. Psychosis can be caused by schizophrenia, and those at more risk of psychosis are thought to have potential attentional difficulties. This has been shown in one of the latent inhibition tasks discussed previously, by Gray et al. (2002) where participants who had higher levels of schizotypy (a marker of increased risk of psychosis) showed reduced latent inhibition.

In the study by Mason, Booth and Olivers (2004), 40 undergraduate students completed a 15-minute visual marking paradigm, the O-LIFE questionnaire, and a measure of social desirability. The task was similar to the one used by Watson and Humphreys (1997), except the stimuli was always present, and participants had to click when the "H" was found and indicate its location. They found that reduced active inhibition was more associated with impulsive non-conformity, and with introvertive anhedonia, although this finding was only found in males. This study provides evidence that certain individuals, who are more likely to have an attention deficit, show poorer levels of active inhibition and suggests that individuals impaired on latent inhibition tasks will also likely show deficits in active inhibition.

Additional evidence that participants with attention issues have increased difficulty on active inhibition tasks has come from studies of children with ADHD. There has been some suggestion that PTSD and ADHD share certain deficits such as impairment in concentration and attention (Szymanski, Sapanski, & Conway, 2011). Mason et al., (2003) used the standard active inhibition paradigm and found that children with ADHD were slower on all trials than controls and made more errors on the preview trials. Although they still showed active inhibition as displayed by faster reaction times on preview trials than conjunction trials. However, a limitation of the study is that to account for errors and outliers, some of the participants' mean reaction times were calculated using reaction times for less than 20 trials, so caution is needed for comparing trial time results. In an additional study, Mason, Humphreys and Kent (2004) also found additional errors for children with ADHD on preview trials, but still found evidence of a preview benefit. The authors concluded that both ADHD and control children were less efficient on preview trials than findings in adult studies. Perhaps suggesting children, in general, are less able to inhibit old items and may explain why a reduced preview benefit was not found in ADHD. Future research with adults with ADHD and additional trials would provide better evidence to determine if ADHD impairs active inhibition. Regardless of these limitations, the studies still provide partial evidence that performance on an active inhibition task was reduced in individuals with ADHD, as shown by an increased error rate.

Support that PTSD symptoms would be associated with impairments in active inhibition comes from previous research that has shown that individuals with PTSD have difficulty inhibiting or suppressing irrelevant distractors. This suggests active inhibition would also be impaired due to PTSD. A number of these studies were discussed previously, which used a range of distractor stimuli including auditory tones (McFarlane et al., 1993), shapes (DeGutis et al., 2015) and letters (Echiverri-Cohen et al., 2016). Limited other research has been conducted using neutral

distractors since most attentional studies in PTSD literature have used affective stimuli. Leskin and White (2007) used the attention network task with neutral arrow stimuli as the target and distractors. The study was conducted with 52 undergraduate students who were categorised either in a PTSD group, high trauma but no PTSD group, or a control group. In the attention network task, participants were required to select the direction a target arrow pointed. The target arrow was shown in the centre of a line of five arrows. Sometimes the arrows would be pointing in the same direction as the target arrow, whereas on other trials they would be in the opposite direction, so participants had to try to inhibit the incongruent arrows. They found that students in the PTSD condition were most impaired on the task and those with high symptom scores for PTSD showed increased distraction of the incongruent stimuli than those without PTSD. The authors concluded executive function impairments in PTSD may be more likely to be shown on tasks for inhibitory processing, compared to other executive functioning tasks. This provides further support that individuals with PTSD struggle with tasks that involve ignoring distractor stimuli, and therefore should be impaired on active inhibition tasks since this requires inhibition of distractors.

Lastly, Kahneman (1973) hypothesised that stress and arousal deplete attentional resources, thus reducing cognitive capacity required to engage in top-down attention processing, whereas automatic processes would be relatively spared. From this, it can be assumed that those under stress or with PTSD would be impaired in displaying preview benefit as active inhibition is reduced when attention capacity is required for another task (Watson & Humphreys, 1997). Evidence for this viewpoint has been found. Sänger, Bechtold, Schoofs, Blaszkewicz and Wascher (2014) used a socially evaluated cold pressor test to induce stress in half the participants, where they had to place their forearm in ice water for three minutes while being videoed and were told their facial expression during the task would be analysed. Following the stress induction, participants completed a visual change detection task that required top-down attention processes. In each trial, participants were shown bars that were sometimes darker or lighter than the background and had to identify changes in the luminance of the bars while disregarding orientation changes (which were a more salient change). The participants in the high-stress condition had greater error rates, particularly in conditions that required top-down processing of less salient changes and ignoring a more obvious orientation change. The authors concluded that stressed participants struggled to maintain intentional attention control during the task leading to increased errors. This study showed that acute stress can impact on inhibition of attention tasks but cannot confirm if this will be shown in relation to PTSD.

1.6. Aims

This thesis aimed to identify objective measures affected by stress and if performance on an active inhibition task would be related to PTSD symptoms or personality traits. The aims of this thesis had to be adapted following a change in method due to restrictions imposed by the coronavirus pandemic.

In Chapter Two, the feasibility of using four different measures were investigated: heart rate, heart rate variability, latent inhibition, and active inhibition. The long-term aim was for this study to provide insight into measures to evaluate an intervention to PTSD for paramedic students. Stress was induced using laboratory manipulations to see if the measures were vulnerable to change. Due to the COVID-19 pandemic, this study had to be curtailed, so data collection was not able to be fully completed.

To adapt to the new restrictions, it was decided to move to online research. Chapter Three details a study conducted using online testing of symptoms of PTSD reported on PTSD Checklist for DSM-5 and investigated if higher levels of symptoms impair performance on an active inhibition task. It was also decided to see if personality variables on the Eysenck Personality Questionnaire that are associated with vulnerability to PTSD would affect performance on the task. The associations of active inhibition with symptoms of PTSD and personality traits became additional aims of the thesis.

Chapter Two: Measures of Stress

2.1. Introduction

This pilot research study aimed to evaluate measures that would be most suitable to use to compare participants' stress responses in no stress and high stress conditions. This was in order to achieve the long-term aim of identifying suitable measures to evaluate a future PTSD intervention for paramedic undergraduate students. Previous interventions for emergency services have involved a trauma paradigm as part of their evaluation (Arnetz et al., 2009; Varker & Devilly, 2012). The rationale for this, is that often the aim of interventions for high-risk occupational groups, who regularly are exposed to traumatic events, is to attenuate their subsequent stress responses in potentially traumatic or high stress inducing situations (McCraty & Atkinson, 2012). Therefore, a useful part of the evaluation of these interventions is to assess stress responding in individuals that have received the intervention, compared to controls who have not received the intervention, following a stressor.

Since this study was designed as an initial pilot, the main aims were just to determine if the four measures chosen were suitable to show the effects of acute laboratory stressors. Future research using paramedic students could then be conducted, once the intervention was developed. The study used two different stressors to induce a stress response. Due to restrictions imposed by the COVID-19 pandemic, this research terminated part-way through data collection, which limited the conclusions that could be made.

2.1.1. Physiological Measures of Stress

It was decided to use two physiological measures since stress is coordinated by a range of physiological responses that are initiated by the autonomic nervous system (Ulrich-Lai & Herman, 2009). Heart rate has consistently been shown to be elevated in situations of high stress and in individuals with PTSD in response to trauma cues (Pole, 2007; Adenauer et al., 2010). Additionally, an intervention study targeting stress response conducted by Arnetz et al. (2009) included heart rate as one of the outcome measures to compare an intervention and a control group. They found both the intervention and control groups showed increased heart rate during a trauma stressor, but that heart rate increased less in the intervention condition. Additionally, Frazier and Parker (2019) found that in studies using physiological measures to measure acute

stress responses, heart rate was the most used measure of stress. Therefore, it was decided that heart rate was deemed an appropriate measure for the pilot study.

Heart rate variability (HRV) has also been suggested as a measure of stress since it is thought to provide a reliable indicator of autonomic nervous system functioning (Marques et al., 2010). The root mean square of successive differences (RMSSD) between heartbeats is an index of HRV that has been used as an indicator of parasympathetic responding. Lower values indicate less influence of the parasympathetic system on the autonomic nervous system, thus potentially increased levels of stress (Laborde et al., 2017). Therefore, high HRV at baseline is thought to indicate good psychological health whereas low HRV suggests poorer functioning and potentially impaired responding to stressful situations (Appelhans & Luecken, 2006; Thayer et al., 2012). Participants with PTSD were found to have lower baseline HRV than non-PTSD controls (Cohen et al., 2000) and reduced HRV in response to affective stimuli (Hauschildt et al., 2011).

Additionally, HRV is able to measure acute stress as it provides an index of autonomic arousal. For example, Taelman et al. (2009) found that individuals following a stressor condition had significantly lower HRV than those at rest. This is due to increased sympathetic nervous system activity as a result of the stress induction. Furthermore, a review Castaldo et al. (2015) assessed the effect of different classic stressors on HRV. In all studies, the consistent finding was that HRV was reduced following mental stress. Thus, supporting the use of HRV as a measure of short-term stress. It was therefore decided to include HRV, using the calculation of RMSSD, as a measure of stress response.

2.1.2. Psychological Measures of Stress

As well as physiological measures, two psychological measures were chosen for use in this study, latent inhibition, and active inhibition. As described in Chapter One, latent inhibition is a term used to describe how learning an association is slower for a previously experienced stimulus compared to a novel stimulus (Lubow & Moore, 1959). Active inhibition is the suppression of irrelevant stimuli and is thought to involve both top-down and bottom-up attentional processes (Watson & Humphreys, 1997; Yamauchi et al., 2017), Psychological measures, such as tests of inhibition and attention, have been shown to evidence effects of stress (Sänger et al., 2014). Latent inhibition paradigms have been used to show how stimuli that seem irrelevant are typically ignored in subsequent tasks. In the classic paradigm, half of participants

were presented with an irrelevant stimulus during a masking task, and this stimulus was then used in the test phase as part of a conditioning task. Individuals who are shown the stimuli during the masking task take longer to learn the conditioning rule compared to individuals that were not shown the stimuli during a masking task (Lubow et al., 1992).

Latent inhibition paradigms were used to study attention deficits in individuals with acute unmedicated schizophrenia (Kumari & Ettinger, 2010) and personality traits associated with schizophrenia (Gray et al., 2002). These studies highlighted how individuals with low latent inhibition showed faster learning during the test phase, which indicated they were impaired in inhibiting the irrelevant stimulus. Braunstein-Bercovitz (2000) proposed that reduced latent inhibition in individuals with schizophrenia may be due to their high levels of anxiety (which is often associated with schizophrenia), rather than their schizophrenic symptoms. This idea has been supported, as reduced latent inhibition has been found in animals exposed to stress (Buhusi et al., 2017) and in individuals with trait anxiety (Braunstein-Bercovitz, 2000). Braunstein-Bercovitz et al. (2001) provided further evidence that stress can attenuate latent inhibition, as following a difficult arithmetic task, which induced stress, these participants had reduced latent inhibition compared to participants in the low stress condition. These findings suggested stress should therefore abolish latent inhibition and therefore latent inhibition was considered a good paradigm to include in this pilot study.

Lastly, it was decided to investigate if an active inhibition paradigm would be affected by stress, something which had not been researched before, so was a novel area of investigation. Active inhibition has been found on a visual search task where individuals show faster search times on trials where they are shown a subset of distractor stimuli prior to the target stimuli, compared to when they are shown all distractors in conjunction (Watson & Humphreys, 1997). As with latent inhibition tasks, reduced active inhibition has been found for individuals with personality traits associated with schizophrenia (Mason, Booth, & Olivers, 2004). Also, children with ADHD were shown to make more errors on an active inhibition task (Mason et al., 2003). In other attentional paradigms, individuals with PTSD showed impairments in inhibiting distractors (McFarlane et al., 1993; Echiverri-Cohen et al., 2016). Additionally, in a high stress condition, healthy participants showed reduced attentional control to inhibit distracting changes to stimuli (Sänger et al., 2014). For these reasons, it was proposed that on an active inhibition task, individuals in high stress conditions would show reduced active inhibition compared to those in the no stress conditions.

2.1.3. Inducing Stress

A challenge for psychological research is being able to induce stress in experimental situations. In past research, a variety of different stress inductions have been utilised. Some studies have chosen to use realistic scenarios to induce stress. For example, as discussed in Chapter One, in the study conducted by Arnetz et al. (2009), police officers completed a realistic role-play involving an actor as an armed robber. A strength of this type of stress induction is because it is highly realistic, it results in a larger change to an individual's stress responses, compared to more artificial laboratory-based inductions. Although the difficulty of using lifelike scenarios is that they are a timely and expensive method to induce stress, and often not practical to use in most studies. This has led to the development of more feasible stress inductions, which can take place in a laboratory setting.

Examples of stressors that can take place in a laboratory environment include electric shocks, the Tier Social Stress Test, film inductions and arithmetic tasks. Electric shocks are often used in a threat of uncertainty type paradigms when the individual does not know when the electric shock will occur (Schmitz & Grillon, 2012). This type of induction has been shown to have psychological, neurological and physiological effects (Robinson, Bond & Roiser, 2015). However, this method of induction has the criticism of causing pain to participants and evokes greater ethical issues than other stressors. Additionally, when using variables such as heart rate variability, it is important participants remain as still as possible, as movement is a factor that can affect recording (Laborde et al., 2017). This may be difficult for participants to do if they are receiving electric shocks, thus, alternative methods may be more appropriate when heart rate variability is being used.

The Trier Social Stress Test (TSST) is a well-known stress procedure that has been used extensively in research and was created by Kirschbaum, Pirke and Hellhammer (1993). The procedure involves participants having to prepare a speech which they then must present to a panel. Following the speech, an arithmetic task is completed which involves counting backwards from 1022 in steps of 13, having to restart if an error is made. This method has been evidenced as a reliable induction of stress, as shown by increasing the presence of different stress hormones e.g., cortisol and increasing heart rate (Linares, Charron, Ouimet, Labelle & Plamondon, 2020). This is a major advantage of using this stress induction, as well as the fact

it is a standardised procedure. Although as with the realistic role-play scenario, this stress induction requires observers to be present to watch the speech, which may not be feasible for studies with small research teams. Additionally, if psychology students are being used as participants, since this is a well-known stress induction, then they may be aware of the procedure which could lead to demand characteristics and affect the effectiveness of the induction.

Other simpler methods have been used to induce stress in individuals, including mental arithmetic challenges (Braunstein-Bercovitz, et al., 2001) and video stimuli (Henckens, Hermans, Pu Joëls, & Fernández, 2009). Since the Trier Social Stress features a mental arithmetic task, it is not surprising that researchers have employed maths tasks as a stressor on their own. These types of tasks have the strength of requiring a relatively short time and limited equipment to administer (Mathias, Corazza, Guaraldi, Barletta, & Cortelli, 2017). The arithmetic task of counting down in increments of 13 has been shown to successfully increase heart rate and reduce HRV (Hanson, Outhred, Brunoni, Malhi, & Kemp, 2013). Other studies have induced stress by using challenging addition and subtractions (Turner, Sims, Carroll, Morgan, & Hewitt, 1987; Benton, Donohoe, Sillance, & Nabb, 2001) or by requiring participants to complete a mixture of difficult and unsolvable number sequences (Keinan, Friedland, Kahneman, & Roth, 1999; Braunstein-Bercovitz et al., 2001). Arithmetic tests have therefore been evidenced as reliable stressors to use in laboratory studies.

Film segments have been considered suitable elicitors of emotion and used extensively in previous research, particularly in studies investigating the psychology of emotion (Rottenberg, Ray, & Gross, 2007). A considerable amount of research has used film clips as stressors to elicit psychophysiological responses. Kirschbaum and Hellhammer (1989) reviewed the use of films to induce acute stress and reported several studies found elevated cortisol levels caused by films with suspense or horror elements, compared to more neutral clips, which indicated activation of the autonomic nervous system. Additionally, other research studies found stressful or fear-classified film clips caused psychophysiological responses associated with increased sympathetic activation, such as increased heart rate, decreased heart rate variability and increased skin conductance response (Fernández et al., 2012; Henckens et al., 2016).

Interestingly some studies have found heart rate deceleration in response to fear or stressful film stimuli. For example, Overbeek, van Boxtel, and Westerink (2012) found heart rate

actually decreased following viewing a fear-inducing film stimulus and this deceleration was greater than for the positive emotion film clips. The finding of heart rate decelerations for this study was explained by Kemp, Koenig, and Thayer (2017) as evidence of a process called orientating. Orientating is a set of neurophysiological reactions to novel stimuli and is considered a key response in emotional perception. Heart rate deceleration, which is coordinated by the autonomic nervous system via the parasympathetic branch, has been used as a measure of orientating and the deceleration in heart rate has been found to be more prolonged for aversive stimuli (Bradley, Keil, & Lang, 2012).

Alternatively, decreased heart rate to fear stimuli may be evidence of a freezing response. Freezing is a type of stress response to threatening stimuli, associated with diminished movement and reduced heart rate (Roelofs, Hagenaars, & Stins, 2010) and is thought to be involved in the perception of stimuli and preparation for action. Reduction in heart rate due to freezing is coordinated by the parasympathetic component of the autonomic nervous system (Roelofs, 2017) and has been shown in response to a horror film clip (Hagenaars, Roelofs, & Stins, 2014), and unpleasant images (Azevedo et al., 2005). Holmes, Brewin and Hennessy (2004) proposed that since when watching a trauma film an individual is unable to actively respond to the stressor, this may explain why a freezing response is displayed, shown by a decreased heart rate, rather than an increased heart rate.

It does not appear that any studies have specifically looked at the heart rate variability during freezing response. Heart rate and heart rate variability are related phenomenon, although heart rate variability is also influenced by other biological processes, such as respiration (Schipke, Arnold, & Pelzer, 1999). Generally, an inverse correlation has been shown between heart rate and heart rate variability (Kazmi et al., 2016), such that when heart rate variability increases, heart rate decreases. This has been found in studies investigating heart rate variability in situations of stress and trauma. For example, Bosch et al. (2001) found that when watching a stressful video that caused heart rate to decrease, heart rate variability was increased. Since parasympathetic dominance occurs during freezing, and heart rate variability is an indicator of parasympathetic responding (Roelofs, 2017), this finding is expected. Also, a study by Chou, La Marca, Steptoe and Brewin (2018) found increased heart rate variability and decreased heart rate when individuals recalled traumatic experiences, which was also concluded to indicate increased parasympathetic activity. Regardless of whether a fear-inducing film clip caused heart rate to increase or decrease, since the main aim in the study was to determine if the

measures were suitable to detect changes in heart rate and heart rate variability, due to responding of the autonomic nervous system, a film clip was deemed appropriate to use as a stressor in the experiment.

2.1.4 Aim and Hypotheses

The aim of the study was to investigate the effects of a number stressor and a video stressor on four different measures purported to be sensitive to stress (heart rate, heart rate variability, latent inhibition, and active inhibition). In the study, participants experienced either a high stress or no stress number task then completed either a latent inhibition or active inhibition paradigm. Following this, participants viewed either a high stress or no stress video, and then were given the inhibition paradigm they had not yet completed. During both the tasks, participants' heart rates were recorded and compared to their baseline heart rate, which was taken prior to both stressors (the number task and the video clip).

For hypothesis one, for the number task, it was predicted that heart rate would increase in the high stress number task condition compared to the no stress number condition (H1a). As discussed previously, since film stimuli have been found to both increase and decrease heart rate, the hypothesis for the video stimuli and heart rate was non-directional. It was expected heart rate would be affected by the high stress video task more than in the no stress condition (H1b).

For hypothesis two, for the number task, it was predicted that heart rate variability would decrease in the high stress number condition compared to the no stress number condition (H2a). For the video stressor it was expected that heart rate variability would be affected by the high stress video task compared to in the no stress video task condition, but the direction of effect was not specified (H2b).

For hypothesis three, it was predicted that latent inhibition would be reduced in high stress conditions indexed by an increased latent inhibition score in the pre-exposed condition, hypothesised to be an index of latent inhibition (H3). This was because a larger learning score would indicate that the individual was faster to learn the conditioned rule, thus showing evidence of reduced latent inhibition.

Lastly, it was hypothesised for hypothesis four, that active inhibition scores would be reduced in high stress conditions indexed by smaller active inhibition scores (H4). The active inhibition score was calculated by subtracting each individual's mean reaction time for the conjunction trials minus their mean reaction time for the preview trials.

2.2. Method

2.2.1 Participants

A power analysis was conducted prior to the study. Based on the expected moderate effect size (*d* = .50), standard power (.80) and alpha (.05 two-tailed), 64 participants were required per group calculated using G*Power 3.1.9.4 software (Faul, Erdfelder, Buchner, & Lang, 2009). Since there were two stress conditions, this required 128 participants in total. It was aimed to test 150 participants, due to expected loss of data due to technical issues.

As previously mentioned, this study had to be stopped partway through data collection because of COVID-19 restrictions, which was why the desired sample size could not be collected. This demonstrated that the current study was underpowered.

In total, 53 individuals took part in the study. They were recruited either using the Swansea University participant pool or via word of mouth. The sample was made up of predominately psychology students (79.2%) and consisted of 35 females and 18 males who were aged between 18-28 years (M = 20.75, SD = 2.17). Psychology students were awarded four credits for participation and non-psychology students were offered a £5 Amazon voucher for their time.

2.2.2 Design

The study had a between-subjects design, as shown in Table 1. Participants were randomised into one of four conditions using a random number generator before starting data collection. Two stressors and two inhibition measures were used in the study. All participants experienced a high stress and a no stress task.

Both stressors in the study were acute laboratory stressors as they had a short duration and were presented in a laboratory setting. As mentioned below, in the procedure section of the method, a mental arithmetic sequencing task was chosen, due to its previous use with a latent inhibition task. Mental arithmetic tasks are active motivated performance tasks, requiring the individual to provide responses that can be judged as correct or incorrect, allowing the individual to be evaluated (Blascovich & Tomaka, 1996). Additionally, in the high stress maths condition, the participants were told the difficult maths task was a subscale of an intelligence test, which added the potential for loss of self-esteem and stress as a result of performing poorly on the task.

A second stressor was required for use in the study, due to having two inhibition tasks that both needed to be preceded by a stressor. It was decided to use a different method of stressor, than an active motivated performance task, so that the effects of a different type of stressor on the

measures could be studied. The passive method of stress induction of watching a film clip, sometimes described as an emotion induction procedure, was chosen (Dickerson & Kemeny, 2004).

The order of the latent inhibition and active inhibition tasks was counterbalanced to eliminate order effects and so that both stressors (number and film tasks) were presented prior to both inhibition tasks. By presenting both stressors to both inhibition tasks, this would identify if both stressors were effective and if one was not effective, then there would still be evidence to show the effects of stress by the successful stressor. Also, by presenting both inhibition tasks at the start and end of the study, this eliminated the potential for order effects compared to if only one of the inhibition tasks had always been presented at the end of the study procedure.

Table 1. Study design and participant conditions for Study One.

		Task 1 →	Number Task →	Task 3 →	Task 4 →	Task 5 →	Video Task →	Task 6
Condition 1	Questionnaires	Baseline HR and HRV measurement	High Stress	Active Inhibition	Recovery period	Baseline HR and HRV measurement	No Stress	Latent Inhibition
Condition 2			High Stress	Latent Inhibition			No Stress	Active Inhibition
Condition 3			No Stress	Active Inhibition			High Stress	Latent Inhibition
Condition 4			No Stress	Latent Inhibition			High Stress	Active Inhibition

2.2.3 Measures

2.2.3.1. Demographic Questionnaire

Participants completed a demographic questionnaire which was based on a supplementary questionnaire created for use in psychophysiological HRV research by Laborde, Mosley and Thayer (2017). At the top of the form, participants had to provide their gender, age and whether they were a psychology student. The questionnaire included 18 questions that mostly required a yes or no response. The questions mainly concerned factors that could affect heart rate and heart rate variability such as caffeinated drinks, exercise, and medication (see Appendix A).

2.2.3.2 Heart Rate and Heart Rate Variability

Participants attached a Firstbeat heart rate monitor belt (developed by Firstbeat Technologies Ltd., Jyväskylä, Finland) to their chest, which was worn until the end of the study. They were shown a printed information sheet of where and how to strap the heart rate monitor and the

experimenter left the room while they attached the belt. The sampling rate of the belt was 1024Hz and two recording segments were taken for each participant. The first segment was recorded from the start of the baseline video until the end of the participant's first inhibition task. The second measurement was recorded from the start of the second baseline video until the end of the participant's second inhibition task. The timings of interest were extracted from the overall recordings. For the baseline section, the extraction was a two-minute segment, taken from 30 seconds after starting baseline recording and ending at two minutes 30 seconds. These timings were the same for the number and video tasks.

Appropriate timing of a heart rate measurement has been debated in literature with the advantage of short-term measurements being easier to perform and control extraneous variables such as body position. However, they could be less stable due to fluctuations in HRV (Li, Rüdiger, & Ziemssen, 2019), although accurate recording of HRV has been found in two-minute-long recordings. For example, in the same individuals, the RMSSD values from short two-minute HRV measurements were found to be highly correlated with RMSSD values from longer recordings of HRV (Munoz, 2015). Thus, it was decided two-minute recording samples would be acceptable in the study.

2.2.3.3. Latent Inhibition

The task was run on DirectRT software and stimuli was created on PowerPoint. The latent inhibition task included a pre-exposure stage where participants were exposed to the target stimuli, and a test stage where participants completed a conditioning task of predicting a rule. In total, the task took approximately 10 minutes to be completed. The task was based on a previously used latent inhibition paradigm (e.g., by Braunstein-Bercovitz, Dimentman-Ashkenazi, & Lubow, 2001; Gray, Fernandez, Williams, Ruddle, & Snowden, 2002). The instructions presented on the PowerPoint screen to participants for the latent inhibition task are included in the appendices (see Appendix B).

Usually, a latent inhibition task involves a separate condition with a non-pre-exposure stage. This was omitted as this study was to evaluate if stress affected performance on the latent inhibition task and due to previous findings, stress was expected to only impact the pre-exposure condition. It was intended to include a non-pre-exposure group in a future research study if the pilot work was effective. This was not possible because of COVID-19 restrictions.

In the pre-exposure stage, there were 128 trials. In each trial, a blue fixation point on a white background was shown for 500ms or 700ms. This was followed by green letter pairs (TT, TL,

LT, LL) on a grey background, which were shown for 150ms and participants were required to indicate if the letters shown were the same or different. Participants responded using the keyboard pressing “A” for letters that were the same and “L” for letters that were different. For the pre-exposed condition, the letter pairs were surrounded by the pre-exposed stimuli that was a green outline of an equilateral triangle pointing either upwards or downwards (see Figure 2). Participants in the non-pre-exposed condition would have completed the same task, but without the green triangle. Participants were told to respond as fast as they could without making many errors.

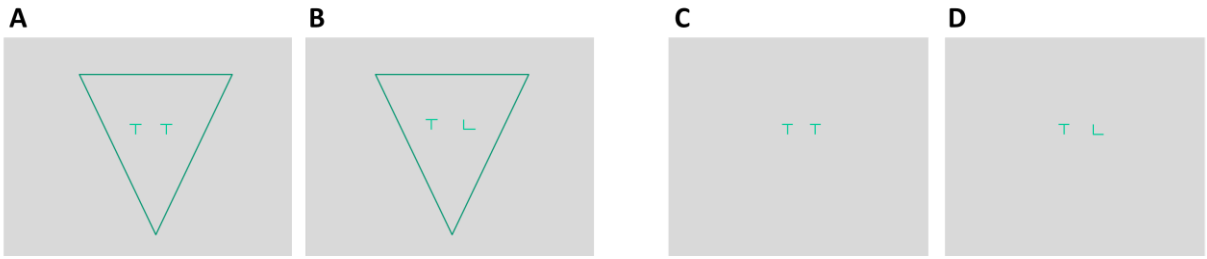

Figure 2. Examples of stimuli used in the pre-exposure stage of the latent inhibition task. Images A and B show examples of the images used in the study in the pre-exposure stage. Images C and D were not used in the study but show what stimuli would have been used if there had been a non-pre-exposure stage in the study. Stimuli not shown to scale.

In the test phase, there were 120 trials and participants were shown the same stimuli as in the pre-exposure stage. Participants were told they were starting a new task and that anything they see on the screen may be relevant. It was explained that some screens would be followed by a gunshot and the task was to try to predict the rule for when the gunshot would occur, which would be 100% true throughout the task. Participants responded by pressing “A” for no gunshot and “L” for a gunshot. The gunshot only occurred on 24 trials and participants were told that most trials would not have a gunshot, so to press the A key if they were unsure. The gun shot occurred 150ms following the presentation of the triangle pointing downwards. The stages of the test phase are shown in Figure 3.

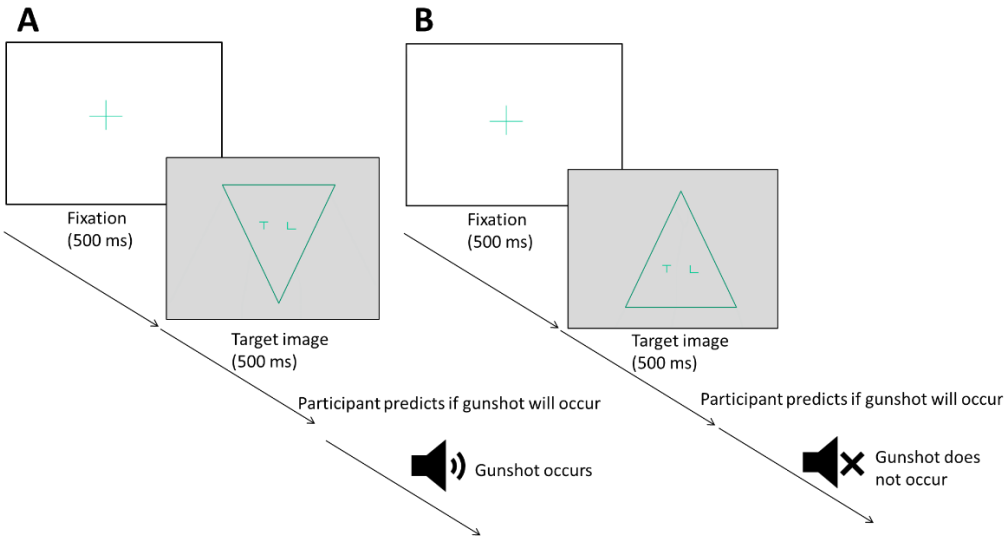

Figure 3. The two different types of trials in the test phase on the latent inhibition task. A shows a trial where a downward triangle is shown so this is followed by a gun shot. B shows a trial where an upright triangle is presented, so the gun shot does not occur. Stimuli not shown to scale.

A latent inhibition score was calculated by subtracting false alarm percentage from hits percentage, with a higher score indicating faster learning of the rule.

2.2.3.4. Active Inhibition

The task consisted of trials involving stimuli images of arrows created on Microsoft PowerPoint contained within a black outline of a square. The task took approximately three to five minutes. The instructions presented on the PowerPoint screen to participants for the active inhibition task are included in the appendices (see Appendix C).

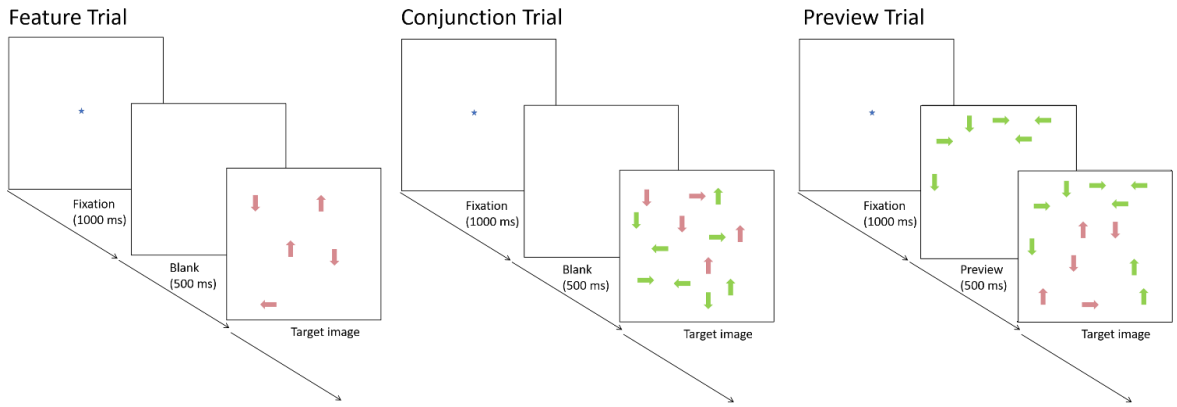

Figure 4. The sequence displays of the three different trial types on the active inhibition task. Stimuli not shown to scale.

There were three different trial types: feature, preview and conjunction which were randomly presented throughout the task (see Figure 4). The practice involved 12 trials containing four presentations of each trial type. The main task involved 72 trials, featuring 24 presentations of

each trial type. In all trials, there was only one red arrow pointing left or right, and participants had to select the direction the arrow was pointing. Participants pressed the "A" key if the arrow was pointing left and the "L" key if the arrow was pointing right.

In the feature trials, a blue fixation point was shown for 1000ms, followed by a blank screen for 500ms. Then four red arrows (pointing up or down) were shown on the screen, along with the red target arrow (pointing left or right). In the conjunction trials, as well as the five red arrows, eight green arrows were also presented in the target image. The green arrows pointed left, right, up, or down. In the preview trials, the trial was the same as the conjunction trial, but instead of the 500ms blank screen, the eight green arrows were presented before the red arrow appeared (i.e., were previewed).

In a bespoke excel scoring template, a formula was used to add a correction to reaction times. Reaction times below 300ms or greater than 300ms were omitted. Also, for incorrect responses, an error penalty of 600ms was added. For every participant, an active inhibition score was calculated as their average reaction time on conjunction trials minus their average reaction times for preview trials.

2.2.3.5. Visual Analogue Scales

Four visual analogue scales were created in Microsoft Word and printed for use in the study (see Appendix D). The first two sets of lines were used for participants to evaluate the amount of stress and amount of relaxation felt by the participant during the number task (stressor one) and the second set of lines were to evaluate stress and relaxation felt during the video task (stressor two). The lines were 10 inches long and numbers were shown below each line to indicate each inch. On the left side of the scale was the words "Not Stressed" and the right side of the scale were the words "Extremely Stressed". For the relaxation rating scale, on the left side were the words "Not Relaxed" and on the right side "Extremely Relaxed". Participants could mark anywhere on the line to indicate how they felt during the number and video tasks.

2.2.4 Procedure

The study was given ethical approval by the Department of Psychology Ethics Committee which is a sub-committee of the Research Ethics Committee at Swansea University, Ref: 2020-2730-1712 (see Appendix E). Additionally, an amendment was approved on 23rd March 2020 to increase the age range of the study from 18-30 to individuals up to the age of 40. An adapted version of an experimental protocol document recommended by Laborde et al. (2017) for

research using HRV was used for each participant (see Appendix F). This document was mainly used as a checklist during the study.

At least one day before the experiment, individuals who had signed up to participate in the study were emailed to remind them about the study and asking them to avoid caffeine and food at least two hours prior to participating. On arrival to the study, individuals read an information form (see Appendix G) and then signed a consent form before taking part (Appendix H). After they completed the demographic questionnaire, participants then attached the heart rate belt to themselves and the experimenter checked it was recording correctly. A viscous gel was used on the belt to help ensure accurate recording of heart rate.

Once participants had attached the heart rate belt, participants viewed a neutral video of an ocean scene for three minutes to record a baseline heart rate measurement (video taken from https://www.youtube.com/watch?v=vpdcMZnYCko&t). Participants completed the number task which was either high or no stress. This was the first stressor for the study. This stressor was based on the maths challenge used by Braunstein-Bercovitz et al. (2001). This was one of the main reasons for choosing the sequencing maths task as one of the stressors since it had already been used previously with a latent inhibition task and been shown to be suitable to affect latent inhibition task performance. Therefore, it seemed suitable to use it as one of the stressors in the study. Additionally, although stressors like The Trier Social Stress Test (TSST) (Kirschbaum et al., 1993) have been shown as reliable stress inducers, due to requiring additional researchers to act as observers and having a lengthy speech section to prepare and perform, it was decided just having the arithmetic task element would be suitable for this study to show whether the measure could detect stress.

In the high stress version of the number task, participants were shown, by PowerPoint, sets of five numbers, which were also read out loud by the experimenter. The participants were told the sequences of five numbers varied according to a mathematical rule. They had to verbally answer what they thought the next number in the sequence was, from four possible options. They were also informed the number task formed part of a subscale of an intelligence test. The first five sequences were difficult, and the remaining sequences were unsolvable. There was a time limit of 30 seconds per sequence, which was shown on the screen by an animated countdown timer. To ensure that the task duration lasted for three minutes, fifteen sequences were created with participants shown as many sequences as required until three minutes passed (see Appendix I).

For the first 12 participants, the no stress number condition was an easy arithmetic task. This task was similar to the high stress condition but with easier sequences to complete e.g., 5, 10, 15, 20, 25, and there was no time limit per question (see Appendix J).

Since the heart rate technology was unfamiliar to the researcher, it was planned to monitor results at an early stage after approximately 20 participants to confirm the heart rate belts were working correctly. Following this review of the results, it was realised that the easy maths tasks appeared to be acting as a stressor due to the increase in heart rate during this task. It was observed that heart rate increased in the no stress number task ($\bar{x}$ = 8.66 SD = 6.29, n =12) and this increase was similar to the heart rate change observed in the high stress number task ($\bar{x}$ = 8.39 SD = 4.42, n = 20). This also fits with qualitative verbal reports from participants which had been made to the experimenter following the experiment. Additionally, participants' visual analogue scale ratings of stress were high for the task (see Figure 5, page 54).

It was therefore thought the task was acting as a stressor. It was decided to change the task, during the pilot study, to a more neutral task, which is described below. This is because the study was to look at how stress affects responses on the different measures, therefore it was important for the no stress conditions to act as controls, for comparison to the stressor conditions and not induce stress to participants. It was felt that terming the task 'a maths task' was causing the stress to participants, despite the easy nature of the questions. Thus, it seemed best to change the task to an alternative that did not involve any mathematical component but to keep the stimuli as similar as possible to the difficult maths task.

Attention conditions have been used in heart rate research and are sometimes termed vanilla baselines and can be used as a control condition. An example of this type of condition could be counting the number of times a particular colour appears on the screen (Jennings, Kamarck, Stewart, Eddy & Johnson, 1992). The revised no stress condition used in the study was a font number task. This task was developed specifically for this study to ensure the stimuli used in both number task conditions was the same. This is because it is very important in heart rate research to keep comparison conditions as similar as possible. Thus, by using the font condition, participants were shown the exact same stimuli but in a non-stressful context. Participants viewed the same sets of five numbers as in the high stress conditions, but instead, in these sets, one of the numbers in each set had been changed to a different font. Participants had to say which number in the sequence was in a different font. They were told they did not need to rush and to go at their own pace. Since this task was easier than the difficult maths task and thus

quicker to complete, forty sequences were created to ensure there were enough sequences for the three-minute duration of the task (see Appendix K).

Immediately after the task, participants completed the visual analogue scale. Then the participants either completed the active or latent inhibition task depending on the counterbalancing of their condition.

After the inhibition task, there was a three-minute recovery period and then a second baseline heart rate measurement was taken while watching a different ocean video to the first baseline for three minutes (video taken from https://www.youtube.com/watch?v=vpdcMZnYCko&t). Participants then viewed the video task, which was either high or no stress. The decision for using a video task was that the task was relatively easy and quick to perform. This was required for the current study as the design had a number of different elements and needed a stressor that didn't take a long time to implement. Although both the arithmetic task and video task can be criticised as being relatively simplistic stress inductions, this was a pilot study to find initial evidence of whether the measures of heart rate, heart rate variability, latent inhibition or active inhibition were affected by stress, and it was required to use stress inductions that were suitable to fit into a laboratory study. Also, since participants were having to use a laptop for the inhibition tasks and baseline measurements, it was practical to use film clips that could be shown on the same equipment.

In the high stress video task condition, participants were shown a three-minute clip from the horror film "Darkness Falls" (the clip was the final three minute of this video but the DVD footage clip was used as it had better quality https://www.youtube.com/watch?v=ABcGHReGK5E&). This clip was previously used by Overbeek, van Boxtel and Westerink (2012) and was shown to affect heart rate. For the no stress video, a three-minute clip of video footage of the ocean was included. This video had been validated as a relaxing video as was found to be a suitable video to use for baseline cardiovascular responding (Piferi, Kline, Younger, & Lawler, 2000). They rated the video immediately after on the visual analogue scale. It was decided to be appropriate to use alongside a horror clips as this video had been evidence as not causing stress.

Following this, participants completed the inhibition task that they had not completed in the previous section of the experiment. Once the inhibition task was finished, a brief mood restoring video was presented (https://www.youtube.com/watch?v=69UlVQpYwUE&t=9s) and

participants removed the heart rate belt. They were then debriefed about the study and given debrief form (see Appendix L).

2.2.5 Statistical Analysis Plan

A one-way analysis of variance (ANOVA) was used to compare the visual analogue ratings for the number tasks and the video tasks.

One-way ANOVAs were used to test all experimental hypotheses. The independent variable was stress condition, and the dependent variables were heart rate difference, heart rate variability difference, latent inhibition learning score, and active inhibition score. The calculations used to compute each dependent variable are explained below. Separate ANOVAs were conducted to compare the low and high stressor for the number task and the low and high stressor for the film task.

2.2.5.1 Heart Rate and Heart Rate Variability

Prior to analysis, the artefact corrected inter-beat intervals (time between two consecutive heartbeats) were exported from FirstBeat software into an excel database. The artefact detection on the FirstBeat software had been evidenced as reliable and accurate (Sami, Seppänen, & Kuusela, 2004). The time segments of interest were extracted and formulae within the excel spreadsheet were used to calculate heart rate and heart rate variability (RMSSD: square root of the mean squared differences between normal heartbeats).

Mean heart rate change was calculated by subtracting each participant's heart rate during the baseline condition from their average heart rate during the task and calculating a mean. Thus, a positive number indicates on average heart rate increased during the task whereas a negative number indicates on average heart rate decreased during the task.

Heart rate variability difference score was calculated as each participant's average RMSSD value during baseline minus their average RMSSD during the number or video task. Therefore, a greater positive change score indicates a greater reduction in HRV during the task, which is thought to indicate stress.

2.2.5.2 Latent Inhibition

Latent inhibition learning scores were calculated by subtracting false alarm percentages from hits percentages with a higher score indicating faster learning of the rule. Since latent inhibition data is known to have a bimodal distribution as participants tend to learn the task relatively

quickly or never learn the rule, with absence of mid-range learning scores. It was decided to employ statistical methods usually used in latent inhibition studies (Gray, Fernandez, Williams, Ruddle, & Snowden, 2002) which follow a technique proposed by Conover and Iman (1981). This involves calculating rank transformations of the latent inhibition learning scores followed by conducting a parametric ANOVA.

2.2.5.3. Active Inhibition

Active inhibition scores were calculated as the conjunction trial reaction time minus the preview trial.

2.3. Results

2.3.1. Data Distribution and Outliers

For the number tasks, eight participants had a value that was two standard deviations above the mean for either their heart rate or heart rate variability recording on the baseline or number task. These participants were removed from the number task heart rate and heart rate variability analysis. For the video tasks, 12 participants had a value that was two standard deviations above or below the mean for either their heart rate or heart rate variability recording, on the baseline or video task, so were excluded.

Some of the raw heart rate and heart rate variability data distributions showed a non-normal distribution but because the difference scores, which were required for the analysis, were normally distributed, parametric analysis was used for the data (see Appendix M for data distributions).

The active inhibition score was also normally distributed so was suitable for parametric analysis. Three participants were excluded from this data as had a trial reaction time or active inhibition score two standard deviations above the mean.

As expected for the latent inhibition data, there was a bimodal distribution and it was decided to employ statistical methods usually used in latent inhibition studies (Gray, Fernandez, Williams, Ruddle, & Snowden, 2002) which follows a technique proposed by Conover and Iman (1981). This involves calculating rank transformations of the latent inhibition learning scores followed by conducting a parametric ANOVA. It has been evidenced that this approach is suitable, although it violates some ANOVA assumptions. There were no outliers for the latent inhibition data. Boxplots and histograms are included in Appendix M.

In total 17 participants had at least one measurement (either heart rate, heart rate variability or active inhibition) that was deemed to be an outlier and was removed. The participant's scores on the other measures were still included. The final sample sizes for each low and high stress condition for the different measures are shown in Table 2. See Appendix N for the original sample size for all tasks and measures and outlier removal for each task and measure.

2.3.2 Descriptive Statistics

Results for the descriptive statistics are given in Table 2**.** All groups were well matched on age and gender. Due to the removal of outliers and counterbalancing, participant numbers vary in the different groups for the different measures and conditions.

Table 2. Group demographics for Study One.

		Font task	**Difficult Maths Task**	**Ocean Video**	**Darkness Falls Video**
Heart rate and Heart rate variability	n	13	20	22	19
	Age	20.77 (1.92)	20.75 (2.69)	20.77 (2.58)	20.89 (2.23)
	Gender (female %)	69.23%	60%	59.09%	68.42%
Latent Inhibition	n	7	13	14	13
	Age	20.29 (1.50)	21.08 (2.36)	20.64 (2.41)	21.08 (2.50)
	Gender (female %)	57.14%	53.85%	64.29%	84.62%
Active Inhibition	n	7	12	13	13
	Age	21.29 (2.14)	20.83 (2.55)	21.08 (2.36)	20.23 (1.36)
	Gender (female %)	71.43%	66.67%	53.85%	61.54%

Note. The values shown for age on the table are mean values and in the brackets are the standard deviations.

2.3.3. Stress Manipulation Check

Participants rated two visual analogue scales from a scale of one to ten for the number task and the maths task, one for stress and one for relaxation. A Spearman's rank-order correlation revealed the stress and relaxation ratings were highly correlated for both the number task (r_s = -0.68, p = 0.001, N = 53) and the video task (r_s = -0.84, p = 0.001, N = 53). Therefore, since the ratings were highly correlated, only the stress ratings are presented (see Figure 5). It was decided to include the stress ratings for all 53 participants since no participant had outliers on all measures.

A one-way between subjects' ANOVA was conducted to compare the effect of number task condition on participants' stress ratings. Normality checks and Levene's test were carried out and the assumptions were met. There was a significant effect of task condition on stress ratings,

$F(2, 50) = 26.60$, $p < 0.01$, $\eta^2 = 0.52$. Due to having different sample sizes, the Hochberg's GT2 was used for post hoc analysis. The analysis revealed that the increase in stress rating from font ($\bar{x} = 2.18$, SD = 2.23) to easy maths task ($\bar{x} = 4.86$, SD = 2.09) was statistically significant ($p = .002$). As well as the increase from font task to difficult maths task ($\bar{x} = 6.59$, SD = 1.47, $p < 0.01$). Lastly, the increase from easy maths to difficult maths task was also significant ($p = .027$).

Despite the easy maths task being rated as significantly less stressful than the difficult maths task, the task had a mean stress rating of 4.86, suggesting it was potentially not an appropriate no stress task. These findings were expected from observations of participants during this task and this was why the font task was introduced. From the manipulation check, the font task seemed suitable for a comparison no stress task. Based on these results, the data for the easy maths task was excluded from subsequent analyses meaning twelve participants data was removed for the heart rate and heart rate variability analysis for the number task and six participants data for the latent inhibition and six participants data from the active inhibition data.

The ocean video was rated as significantly less stressful than the Darkness Falls video as confirmed by a one way ANOVA; $F(1, 51) = 51.37$, $p < 0.01$, $\eta^2 = 0.502$. Although the average stress rating given to the Darkness Falls video was only 5.13 out of a maximum rating of 10. This raised concern as to whether the video was a suitable stressor, as it was just over halfway on the scale, between "Not Stressed" and "Extremely Stressed".

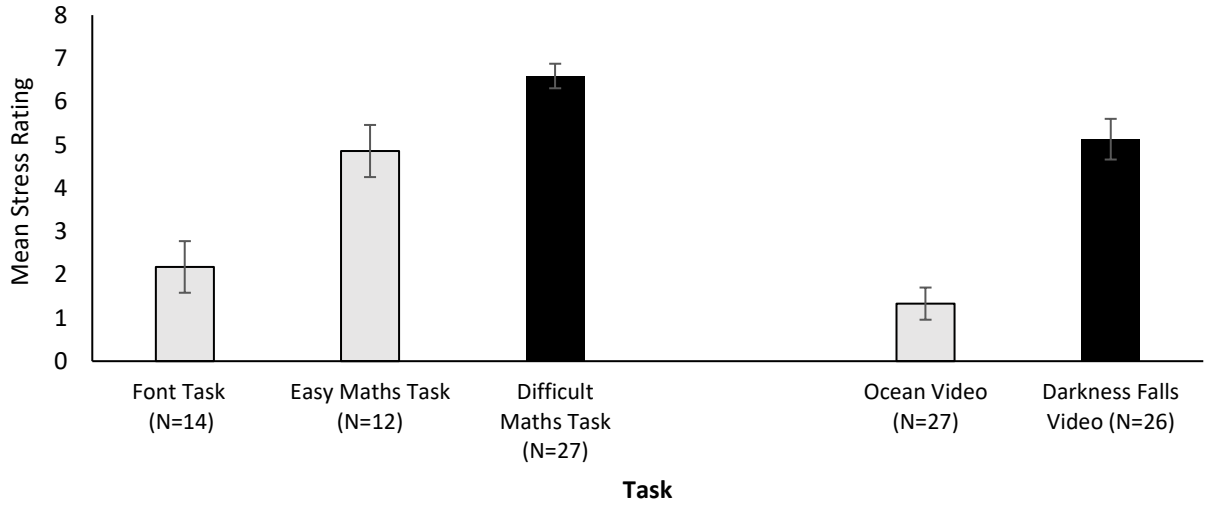

Figure 5. Group differences in stress ratings to the stress tasks. Scale from 0-10, Not Stressed = 0 and Extremely Stressed = 10. Error bars represent ± 1 standard error of the mean. The easy maths task was removed from the data due to the high stress ratings obtained.

2.3.4. Heart Rate

Mean heart rate change was calculated by subtracting each participant's heart rate during the baseline condition from their average heart rate during the number task, then calculating a mean. Thus, a positive number indicates on average heart rate increased during the number/video task whereas a negative number indicates on average heart rate decreased during the number/video task. The mean heart rate changes for all conditions are shown in Figure 6.

A one-way ANOVA was conducted to determine the effect of number task condition on change in heart rate. There was a significant effect of task condition on mean change in heart rate and heart rate increased more in the difficult maths task condition, $F(1, 31) = 8.98$, $p = 0.005$, $\eta^2 = 0.23$. This was the result predicted, suggesting the difficult maths task was more stressful than the font task, as participants in this condition had a greater mean change in heart rate.

A one-way ANOVA was conducted to determine the effect of video condition on change in heart rate. On average, heart rate reduced from baseline to Darkness Falls condition and it reduced significantly more than when watching the ocean video, $F(1,39) = 9.92$, $p= 0.003$, $\eta^2 = 0.203$. This met the hypothesis that heart rate would be affected by watching the Darkness Falls video.

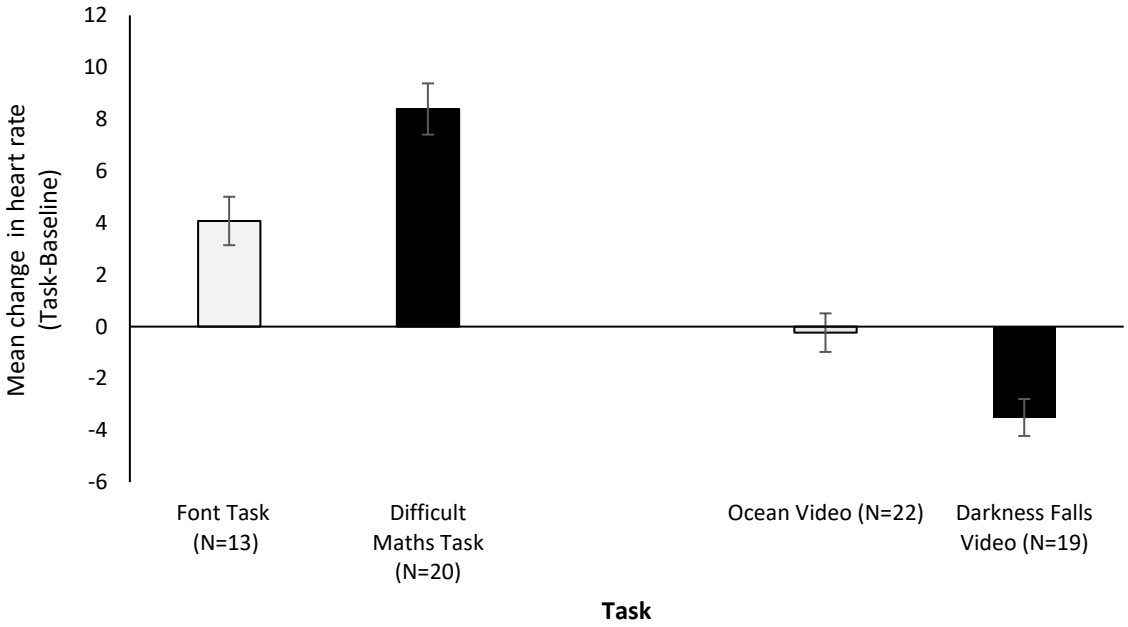

Figure 6. Mean change in heart rate depending on task condition. Change in heart rate was calculated as Task HR-Baseline HR. Error bars represent ± 1 standard error of the mean.

2.3.5. Heart Rate Variability

Heart rate variability difference score was calculated as each participant's average RMSSD value during baseline minus their average RMSSD during the number or video task. Therefore, a greater positive change score indicates a greater reduction in HRV during the task, which is thought to indicate stress. The mean heart rate variability changes for all conditions are shown in Figure 7.

A one-way ANOVA was conducted to determine the effect of number task condition on change in heart rate variability. The ANOVA revealed the difference between the font and difficult maths task on change in heart rate variability approached significance [$F(1,31) = 3.63$, $p = 0.066$, $\eta^2 = 0.105$]. Potentially this lack of significance was due to the study being underpowered, which is supported by the medium effect size. The difference was in the expected direction as it was predicted that heart rate variability change would be greater in the difficult maths condition indicating HRV decreased more in the difficult maths task than the font task.

A one-way ANOVA was conducted to determine the effect of video condition on change in heart rate variability. The effect of video condition on mean change in heart rate variability also approached statistical significance, $F(1,39) = 4.03$, $p = 0.052$, $\eta^2 = 0.094$. As with the hypothesis for the effect of the video condition and heart rate, no direction of effect had been hypothesised.

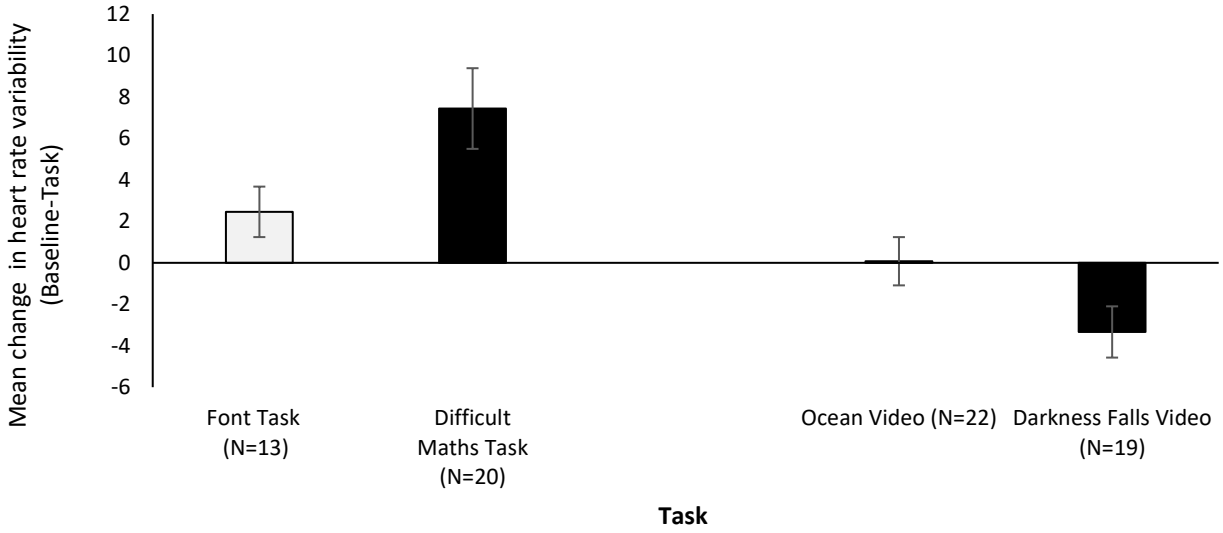

Figure 7. Mean change in heart rate variability depending on task condition. Change is heart rate variability was calculated as baseline-task, so a greater positive score shows a greater decrease in heart rate variability. Error bars represent ± 1 standard error of mean.

2.3.6. Latent Inhibition

For each participant, a latent inhibition learning score was calculated by subtracting false alarm percentage from hits percentage with a higher score indicating faster learning of the rule. The mean latent inhibition learning scores for all conditions are shown in Figure 8.

A one-way ANOVA was conducted to determine the effect of number task condition on latent inhibition scores using the ranked latent inhibition scores. There was no significant effect of number task condition on latent inhibition score, $F(1, 18) = 0.16$, $p = 0.70$, $\eta^2 = 0.009$.

A one-way ANOVA using the ranked learning inhibition scores was conducted to determine the effect of video condition on latent inhibition learning score, which was not significant $F(1,25) = 0.193$, $p = 0.67$, $\eta^2 = 0.008$.

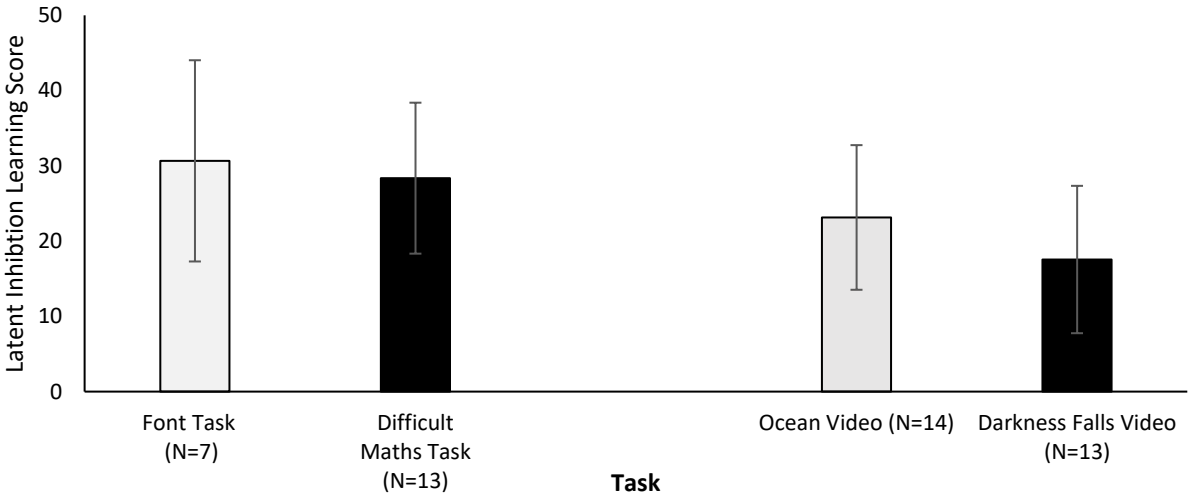

Figure 8. Mean Latent Inhibition Learning Score depending on task condition. Error bars represent ± 1 standard error of the mean.

2.3.7. Active Inhibition

2.3.7.1 Reaction Times on Active Inhibition Trials

Reaction times were as expected for all conditions. The feature condition had the fastest reaction time, followed by the preview condition and the conjunction condition had the slowest reaction times (as shown in Table 3).

Table 3. Reaction times for the three different trial types on the active inhibition task.

	Font task (n =7)	**Difficult Maths Task (n = 12)**	**Ocean Video (n = 13)**	**Darkness Falls Video (n = 13)**
Conjunction reaction time	957.74 (185.42)	916.09 (167.10)	947.35 (214.04)	949.13 (161.41)
Preview reaction times	946.55 (180.91)	851.35 (116.20)	902.08 (181.16)	891.06 (171.09)
Feature reaction times	874.86 (136.84)	801.45 (157.66)	804.36 (194.25)	797.17 (119.61)

Note. The values shown in the table are mean values on reaction time in milliseconds and in the brackets are the standard deviations.

Three one-way ANOVAs were conducted to determine the effect of number task condition on active inhibition trial reaction times. There was no significant effect of number task condition on active inhibition reaction times for either of the three trials: conjunction [$F(1, 17) = 0.25$, $p = 0.62$, $\eta^2 = 0.015$], preview [$F(1, 17) = 1.98$, $p = 0.18$, $\eta^2 = 0.104$], or feature [$F(1, 17) = 1.05$, $p = 0.32$, $\eta^2 = 0.058$]. Although small effect sizes are shown for the conjunction and feature trials, and medium effect size for the preview condition.

Additionally, three one-way ANOVAs were conducted to determine the effect of video task condition on active inhibition trial reaction times. There was no significant effect of video task condition on active inhibition reaction times for either of the three trials and the effect sizes were all close to zero: conjunction [$F(1, 24) = 0.001$, $p = 0.981$, $\eta^2 = 0.000$], preview [$F(1, 24) = 0.025$, $p = 0.875$, $\eta^2 = 0.001$], or feature [$F(1, 24) = 0.013$, $p = 0.911$, $\eta^2 = 0.001$].

2.3.7.2. Active Inhibition Scores

Active inhibition scores were calculated as the conjunction trial reaction time minus the preview trial. The mean active inhibition scores for each condition are shown in Figure 9.

A one-way ANOVA was conducted to determine the effect of number task condition on active inhibition score. There was no significant effect of task condition on active inhibition score [$F(1, 17) = 1.64$, $p = 0.22$, $\eta^2 = 0.09$].

Additionally, a one-way ANOVA was conducted to determine the effect of video condition on active inhibition score, which was not significant $F(1,24) = 0.15$, $p = 0.70$, $\eta^2 = 0.006$.

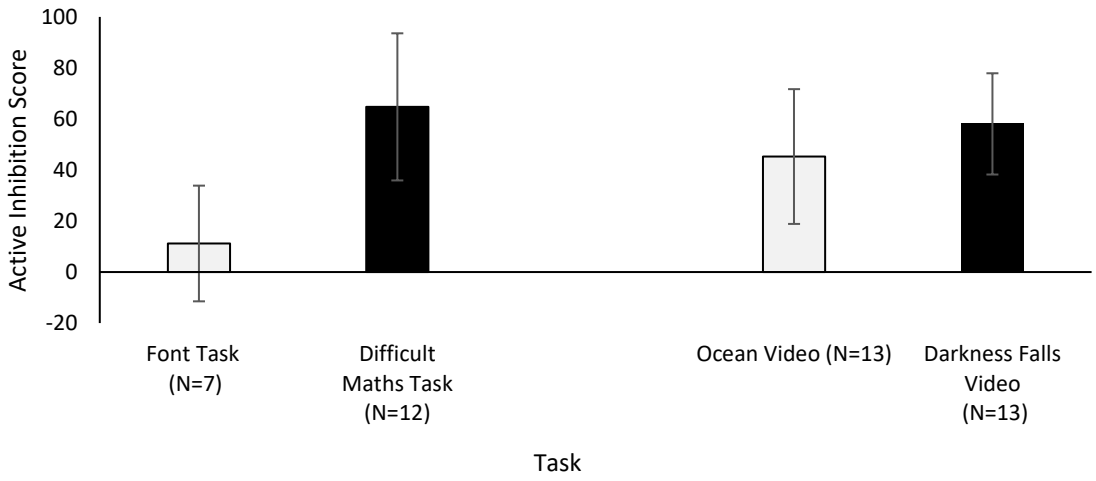

Figure 9. Mean Active Inhibition Score depending on task condition. Error bars represent ± 1 standard error of the mean.

2.4. Discussion

The pilot research study was conducted to investigate which measures would be most suitable to measure a change in participants' stress responses in low and high stress conditions. In the study, participants had to solve sequences from a number task that was either manipulated to be high stress or no stress. Participants then completed either a latent inhibition or active inhibition paradigm. Following this, a high or no stress video was shown. The remaining inhibition paradigm that they had not yet completed was then administered. Heart rate was recorded at baseline and in both the number and video tasks. Due to the restrictions imposed because of COVID-19, this research was terminated partway through data collection, which limits the conclusions that can be made, due to the small sample size. Therefore, as well as the significance of the results, the effect sizes will be discussed using eta squared which is one of the most used statistic of effect size for ANOVA (Lakens, 2013).

Hypothesis 1a and 1b were supported as heart rate significantly increased in the high stress number task stress compared to the no stress number task. Also, heart rate was significantly reduced in the high stress video compared to the no stress video. For hypothesis 2a and 2b, heart rate variability showed a greater reduction in the high stress number task condition (as compared to the no stress number task) but showed a greater increase in the high stress video condition (compared to the no stress video). Both these findings approached significance (p = 0.066 for number task, p = 0.052 for video task) and medium effect sizes were found. There was no significant effect of stress condition on latent inhibition (H3) and effect sizes were close to zero. No significant difference was found for active inhibition scores (H4) for either of the two stressors (number task or film clip), although a medium effect size was found for the number task.

2.4.1. Heart Rate

Heart rate increased in the high stress number condition compared to the no stress number condition and showed a large effect size ($\eta 2$ = .23) according to Cohen (1988)'s benchmarks of effect size for eta squared. This fits with previous findings, that heart rate increases during a difficult maths test (Turner et al., 1987; Hanson et al., 2013). Additionally, the difficult maths condition was rated on visual analogue scales as significantly more stressful than the font task. This provides further support that the maths test induced stress and this induction of stress was evidenced by the heart rate measure. Despite the supporting result, the font task was only

conducted with 14 participants, therefore it may be necessary to replicate using this control condition with a larger sample size to confirm the findings are reliable, especially since a large effect size was found.

For the video task, the opposite result was found. Heart rate reduced significantly more in the high stress video condition compared to the no stress video condition and had a large effect size ($\eta 2 = 0.203$). This supported hypothesis 2a, as due to previous studies reporting that stressful videos appeared to either increase or decrease heart rate, a directional effect was not specified for this research. This matched the finding by Overbeek et al. (2012) who used the same video as this study and found that heart rate decreased. This was explained by Kemp et al. (2017) as evidence of orientating, which is a response given to novel stimuli and often involved in emotional perception. Alternatively, it may have evidenced freezing, which has been used to explain heart rate deceleration to distressing films and images (Azevedo et al., 2005; Hagenaars et al., 2014). Since the purpose of this study was to test if the measure could detect change in individuals, due to responses associated with stress, this was achieved through use of the video. In order to determine if the heart rate deceleration during the video was due to orientating or freezing, additional measures could be used such as a stabilometric platform which can measure movement during stimuli viewing. This could provide support for freezing if movement was found to be reduced during the viewing of the video.

The difference in heart rate was lower for the video stressor ($\Delta\bar{x}$ =3.50, SD = 3.10) compared to the number task ($\Delta\bar{x}$ = 8.4, SD = 4.42), which suggested the difficult maths task induced a greater stress response in the study. Therefore, in the future, the use of an arithmetic task may be best to use to induce change in heart rate compared to video stimuli. Overall, heart rate appears a good measure to use to detect change due to stress induction.

2.4.2. Heart Rate Variability

Heart rate variability was not significantly different for either the number task or video task although the *p* values were close to significance for both tasks. This may have been due to the study having low power as it was stopped before the target participant size could be collected. Especially as medium effect sizes were found for both ANOVAs ($\eta 2 = 0.11$ and $\eta 2 = 0.094$ respectfully). The difference was in the expected direction as it was predicted that heart rate

variability change would be greater in the difficult maths condition indicating HRV, decreased more in the difficult maths task than the font task.

The pattern of the results supported the hypotheses, as there was a greater reduction of heart rate variability in the difficult maths condition, compared to the font task condition. This supported Hanson et al., (2013) findings, who also found decreased heart rate variability in a maths task. Although since the results from this study were not significant, it cannot be concluded if heart rate variability is a suitable measure. Although the fact that medium effect sizes were found for both stressors suggests that heart rate variability can act as a measure of change due to stress. The reason the difference between no stress and high stress conditions was not significant was probably due to the small sample size. This could be confirmed by conducting a replication of the study with a larger sample size.

2.4.3. Latent Inhibition

There was no significant difference in the latent inhibition learning scores, between the high stress and no stress conditions for either the number or video task. Also, the effect size for both the number and video task were near zero ($\eta^2 = 0.009$ and $\eta^2 = 0.008$ respectively) suggesting the latent inhibition task was not sensitive to the stressors used.

This finding is contrary to Braunstein-Bercovitz et al. (2001)'s study where individuals who completed a difficult maths task showed reduced latent inhibition. In this study, the format of the difficult maths stressor used by Braunstein-Bercovitz et al. (2001) was replicated closely, so it is unlikely the difference in results is due to features of the stressor used. Braunstein-Bercovitz et al. (2001) only had nine participants per condition reducing the reliability of their results. Potentially the participants in the Braunstein-Bercovitz study may have found the maths task more stressful than the participants in this study. One of the only differences was, in their task, they asked participants at the end of the questions, whether they wished to know their score compared to the performance of other participants and were told that they had a lower score than others. This may have caused additional stress to participants, which was then sufficient to attenuate latent inhibition. Although this task still appeared to be reasonably stressful as had a mean stress rating of 6.6 out of 10, suggesting it was perceived as stressful. Due to counterbalancing and having to terminate data collection early, the sample size was particularly small for some of the conditions, with one condition only having seven participants, therefore more research is needed looking at the effects of stress on latent inhibition, potentially using other types of stressful tasks.

2.4.4. Active Inhibition

There was also no significant difference in active inhibition scores for the high or no stress conditions. Even though the active inhibition task did not show evidence of changes due to stress, the paradigm was successful in showing an active inhibition effect. This provided support that the paradigm created for use in the study was appropriate to measure active inhibition. Also, the effect of stress on active inhibition was a novel area of investigation, as no study had already been conducted looking at the effects of induced stress prior to an active inhibition task. It had been hypothesised that active inhibition would decrease under high stress conditions, due to findings of individuals with PTSD on other inhibition tasks (McFarlane et al., 1993; Echiverri-Cohen et al., 2016) and the impact of stress on attentional control (Sänger et al., 2014). As with the other tasks, the sample size was small for active inhibition, which may be why a significant effect of stress on active inhibition was not found. Although for the number task, the effect size was medium ($\eta^2 = 0.09$), but the effect size was lower for the video task ($\eta 2 = 0.006$).

Surprisingly, the results for the number task were in the opposite direction than what was hypothesised as individuals in the font task had lower active inhibition scores compared to participants in the difficult maths task condition. It was unclear why the mean active inhibition score was less for the font task condition. When looking at the individual trial data, two participants in the font condition had negative active inhibition scores (meaning they were faster on the conjunction than the preview trials) which reduced the overall mean. Since the font task result was found with a very low participant number (n = 7), it may not have been a reliable result and replication is needed.

Interestingly as shown in Table 3, page 58, the raw reaction times on the active inhibition trial were lower in the difficult maths task compared to the font task. Although the difference in reaction times were non-significant, small to medium effect sizes were found ($\eta 2 = 0.015$, 0.058, 0.104). Potentially stress induced by the difficult maths task caused participants to be faster on each trial type. It has been reported that stress could affect cognitive abilities in an inverted-U function, with mild levels of stress causing faster reaction times than in more relaxed or more intense stress states, as mild stressor could induce an optimal level of arousal improving attention (Arnsten, 2009; Harris, Ross, & Hancock, 2008). Although other researchers have argued against an inverted-U function of stress in improving attention but instead proposed that

stress can increase motor ability. For example, Shields, Rivers, Ramey, Trainor and Yonelinas (2019) found that individuals who experienced a mild cold pressor stress induction, showed faster reaction times on two inhibitory flanker tasks compared to participants who did not have the stressor. They argued that this finding was not due to mild stress improving selective attention but that the mild stressor, accelerated motor actions, evidenced by decreased reaction times, but no difference in accuracy or inhibitory control. Thus, impaired motor ability could be a possible explanation for the faster response times on the active inhibition task, following the difficult maths test. Since the study was unpowered (due to COVID-19), this increase in reaction time could not be explored further but may be an area of interest for future studies.

2.4.5. Strengths, Limitations and Conclusion

The major limitation of the study was the small sample size, which was out of the experimenter's control due to the COVID-19 pandemic and the need to stop face-to-face data collection. It was hoped to continue this study when restrictions changed, however this was not possible. Also, it is noted that ocean video can be argued in literature to be relaxing and therefore the video chosen for the no stress video condition may not have acted as a control, which was the intention, but could be argued to be relaxing instead (Anderson et al., 2017). The ocean video was chosen as the no stress version to the horror clip, due to the fact it has been evidenced as a suitable baseline (Piferi et al., 2000). Although an improvement may be to use more neutral and potentially less relaxing video, such as a video of a train journey, which was used in a neutral condition by Vianna and Tranel (2006).

Despite being terminated early, the study still allowed the feasibility of using different measures to index stress to be explored. The practicality of using the heart rate belts was good, with all participants in the study successfully able to attach the belts themselves and there was no occurrence of the belts failing to record. Although the latent inhibition and active inhibition tasks failed to show a difference due to stress, these tasks were easy to administer and complete.

In terms of the long-term aim of being able to determine suitable measures, reasonable conclusions could be made about the effectiveness of the measures. Both heart rate and heart rate variability appeared to be affected by stress, based on the significance levels and effect sizes found. This supports their use in future research that is also focused on using physiological measures to evidence stress responding. In terms of using heart and heart rate variability to evaluate an intervention by comparing responses to stressors, the results from the arithmetic

task showed a reasonable change in heart rate, although less in heart rate variability. Whereas for the video stressor, the difference in heart rate and heart rate variability change in the stressor condition were even smaller than from the arithmetic stressor. It is known that laboratory stressors are less effective at inducing arousal than more realistic stressors (Kirschbaum et al. 1993). Since this was just a pilot research study, stressors were chosen that could practically be used in a laboratory setting and could indicate if the measures were affected by stress. If the pandemic and restrictions had not been introduced, potentially a simplified replication of the study would have been conducted, using a more realistic stressor in order to alter psychological and physiological processing to a greater level.

The effect sizes found for differences in performance on the latent inhibition paradigm were near zero. This possibly indicated that a latent inhibition paradigm may not be a suitable measure to use to compare responding following stress and is likely too complex to be used in the evaluation of an intervention design.

In summary, this pilot study still provided useful findings especially in terms of the feasibility of using the heart rate belts and preliminary evaluation of different physiological and psychological measures of stress. Due to the lack of significant findings, more research is needed using heart rate variability and latent and active inhibition with larger sample sizes to determine if they could act as a suitable measure of stress.

Chapter Three: Online Study

3.1. Introduction

Following the suspension of in-person data collection due to COVID-19, it was necessary to move to online data collection. This research study aimed to investigate if personality traits thought to increase risk for PTSD, and PTSD symptoms in a non-clinical sample would be associated with impairments on an online inhibitory attention task requiring active inhibition.

3.1.1. Inhibition and PTSD

Since impairments in inhibitory processes have been thought to be involved in the development and maintenance of PTSD, attention tasks that involve inhibition could indicate individuals with PTSD (Echiverri-Cohen et al., 2016). This idea has been supported by evidence of impairment in individuals with PTSD on tasks requiring inhibition of distractor stimuli which were covered in Chapter One (DeGutis et al., 2015; Leskin & White, 2007; McFarlane et al., 1993). Also, individuals with PTSD have shown improvements on an attentional blink paradigm (which requires inhibition of distractors) following exposure therapy (Echiverri-Cohen et al., 2016). Therefore, a task requiring the use of inhibition should detect impairment of performance in individuals with PTSD or with higher levels of PTSD symptoms.

3.1.2. Active Inhibition and Latent Inhibition

Active inhibition was first investigated by Watson and Humphreys (1997) using a paradigm that required inhibition of distractor stimuli, to make visual search more efficient. As explained in Chapter One, an active inhibition paradigm involves three different trial types; conjunction, preview and feature. In the typical paradigm, the aim of the task is to identify a target stimuli (e.g., a blue H) from a selection of distractors (e.g., green Hs and blue As). In the feature trials, the participant only viewed one distractor type (e.g., blue As) and the target stimuli. Whereas in the conjunction trials, two types of distractor stimuli are shown that both share a feature with the target (e.g., green Hs and blue As). The main trial of interest is the preview trial, which is when one type of distractor is shown prior to the target stimuli and the rest of the distractor stimuli. The key finding on the task was that individuals were faster on preview trials, compared to the conjunction trials. Additionally, evidence discussed in Chapter One from studies that

used a dot-probe style task (Watson & Humphreys, 2000) and the addition of a secondary task (Humphreys Watson, & Jolicœur, 2002), provided evidence that active inhibition requires top-down attentional control and is an attention demanding ability. Therefore, it would be expected for active inhibition to be impaired in individuals with difficulties with attention and inhibition.

In Chapter Two, another inhibition task was used to study latent inhibition which has previously been found to be abolished by stress and therefore seemed a possibility as a potential measure of stress. It was decided not to include this measure in the online study alongside active inhibition. There were a number of reasons for this; firstly, no evidence was found in the previous study that latent inhibition was vulnerable to stress, suggesting issues of being able to replicate previous findings from Braunstein-Bercovitz et al. (2001). Also, although a non-pre-exposed condition was not included in the pilot study in Chapter Two, it was discussed in the method section that this condition would have been added in a future study, but this study was not able to be conducted due to the pandemic restrictions. For the online study, it would have been necessary to include the non-pre-exposed condition as well as a pre-exposed condition, to show whether latent inhibition occurred and if PTSD symptoms affected latent inhibition. This would have increased the number of participants required for the online study. Furthermore, latent inhibition is not replicable, therefore as a measure of stress, active inhibition would be a more useful measure as it would have the potential for longitudinal research. Lastly, the latent inhibition task required audio stimuli, which could have more potential issues when moving to online research, as participants would have been using their own electronic equipment. So, it seemed most suitable to choose active inhibition, out of the two inhibition measures to be included in the online study.

3.1.2.1 Individual Differences in Active Inhibition

Individual differences in performance on active inhibition paradigms have been identified. Warner and Jackson (2009) conducted a study comparing younger and older adults using active inhibition tasks with differing lengths of preview duration. They found older adults required the preview length to be at least 586ms, as they did not show a benefit in the preview condition when it was reduced to a shorter time. Additionally, Watson and Maylor (2002) found that older adults were impaired in showing a preview benefit, if moving stimuli were used as the distractor stimuli, whereas younger adults were able to suppress these distractors. This has led to conclusions that active inhibition is not as robust in older adults and proposed to be owing to

reduced attention capacity, and deficits in inhibition or suppression, due to ageing (Allen & Payne, 2012).

Impairments have also been found in attention-related disorders. Mason et al. (2003) showed that children with ADHD, had an increased reaction time for all the trial types and made more errors on the preview trials, than the feature trials and compared to children without ADHD. They suggested the increase in errors was possibly due to increased impulsivity symptoms in the ADHD participants, and the reaction time difference may have been indicating a delay in starting the search of the target stimuli, or overall slower responding. For the greater numbers of errors in preview trials to the controls, the authors proposed this may be due to an inability on some preview trials to ignore the old distractors presented during the preview phase. Therefore, it appears that the task can highlight individuals who have difficulties with attention. Since PTSD is known to be associated with inhibitory deficits, it was hypothesised people with PTSD will show a reduced ability to inhibit stimuli in the preview conditions.

3.1.2.2. Active Inhibition and PTSD

An active inhibition task had never previously been used to compare inhibitory processing in individuals with PTSD (compared to those without PTSD) or to look at the association of performance on the task with PTSD symptoms. This was the aim of the current study. This type of research is important, as if individuals with PTSD show differential performing on the task, compared to people without PTSD, then the task may be suitable for use as an objective measure of PTSD. The identification of new objective tasks for clinical disorders is particularly useful for population groups where self-report measures as less useful. For example, some paramedics have been suggested to be hesitant to report symptoms of PTSD, due to fear of possible stigma or the possibility of losing their job (Clohessy & Ehlers, 1999; McFarlane, Williamson, & Barton, 2009). Although performance on a behavioural task is unlikely to perfectly predict the presence of a mental health condition, it could be used in combination with other measures to aid diagnosis. Additionally, an inhibition paradigm could be used to show evidence of improvement following treatment. As discussed in Chapter One, Echiverri-Cohen et al. (2016) used the inhibitory attentional blink paradigm as an outcome measure to show improvements in participants with PTSD following exposure therapy. This is an easier method of showing support for a treatment approach compared to time-consuming interview methods. As well as being novel, this research study is interesting, since individual differences in active inhibition

is a relatively understudied area, and the task involves temporal segmentation on distractor stimuli, which is absent from most other tests of inhibition e.g., the singleton capture task (Theeuwes & Burger, 1998). Using a new task of inhibition to look at inhibitory deficits in PTSD, can provide greater understanding of the extent of inhibitory impairments in individuals with PTSD, as well as potentially identifying a new outcome measurement of processing affected by PTSD symptoms.

There has not been a substantial amount of research conducted looking at the effects of the different symptom clusters of PTSD and inhibition deficits. Since it has been proposed that intrusive thoughts could be an indicator of impaired inhibitory processes (Brewin, 2001), it would be expected for increased levels of intrusive symptoms to be related to increased deficit in inhibitory processes. This has been supported by Kertzman, Avital, Weizman and Segal (2014), who gave a standard Stroop task to 100 participants, 50 were outpatients with a chronic diagnosis of PTSD and 50 healthy controls. In the task, participants read out the ink colour of different words e.g., the word "red" and on some trials, the stimuli were congruent (colour name is same as ink colour) or incongruent (colour name is not the same as the ink colour). They found the frequency of experiencing intrusive memories of the traumatic event was significantly associated with impaired interference inhibition. Therefore, it would be expected that intrusive symptoms in PTSD would negatively correlate with active inhibition performance. They also found hyperarousal and avoidance symptoms were not related to level of interference on the task.

It is surprising that hyperarousal was not associated with inhibitory control, since the symptom cluster encompasses difficulties in concentration and an amplified startle response, which likely arise from inhibitory deficits (Aupperle et al., 2012). It appears more research is needed to investigate the effects of alterations in arousal and reactivity on inhibitory processes, since very limited research has looked at this. Additionally, more research is also needed for alternations in cognitions and mood, which appear not to have been studied in relation to inhibitory deficits. It would possibly be expected for this cluster to be associated with poorer inhibition since they comprise symptoms of rumination and increased negative emotions. The current online study will provide some initial evidence of the effects of these symptom clusters on a specific inhibitory process.

For the symptom cluster of avoidance, it is more complex than other symptom clusters to predict the effects on inhibition. In the study by Kertzman, et al. (2014) described above, avoidance was shown to be unrelated to inhibitory performance. It is possible increased avoidance may be associated with better inhibition, because of increased use of emotional suppression. For example, Amir et al. (1997) investigated the association between coping styles and PTSD symptoms. A sample of 46 patients with PTSD completed the Impact of Event Scale (Horowitz, Wilner, & Alvarez, 1979) to measure PTSD symptoms and completed a coping style questionnaire, which assessed the use of eight different coping styles. They found that use of a suppression coping style was strongly correlated with avoidance symptoms ($r = 0.55$), whereas none of the other coping styles (e.g., help-seeking or blame) were significantly correlated with avoidance. This suggests, potentially, individuals scoring highly on avoidance symptoms would have practice of suppressing and inhibiting stimuli from their awareness. Although in contrast, a suppression coping style was also moderately correlated with intrusive symptoms ($r = 0.31$). The authors proposed that the intrusive symptom finding highlighted how suppression was an ineffective coping style, as despite efforts to suppress these emotions, patients still suffered intrusions. Perhaps for neutral stimuli or in participants with lower levels of PTSD, intrusion symptoms would be lower in those that use an avoidance coping style.

In contrast, there is some evidence avoidance may relate to worse inhibition. Wu et al. (2015) conducted a study using a classic go/no-go task where in the paradigm, one stimulus requires a response whereas participants must inhibit their response to other stimuli shown. By recording electrical potentials in the brain, they found that avoidance was the only symptom cluster which was associated with reduced speed of the final part of the response inhibition process. These results suggested that increased levels of avoidance result in the increased time needed to inhibit responses. Although this task was measuring response inhibition rather than inhibition of visual stimuli, so may not equate to how avoidance symptoms affect performance on the active inhibition task.

3.1.3. Personality and PTSD

Personality is an important factor to consider in stress research as an individual's personality traits can affect their biological reactivity of stress responses and influence coping styles used in response to a stressor, as stated by Vollrath (2001). It would be beneficial if individual performance on the active inhibition task is affected by risk factors for developing PTSD, such

as personality traits, as then the task could potentially be used to indicate risk for the development of PTSD. In a recent review by Sareen (2014), personality factors were highlighted as a risk factor for PTSD, including Neuroticism and avoidant-coping. Furthermore, Neuroticism is seen as the personality trait with the clearest and strongest associations with psychopathology compared to other traits and many psychological disorders involve increased presence of this trait (Watson, 2001). One model of personality, particularly relevant for the study of stress, which includes the trait Neuroticism, was developed by Hans Eysenck (Eysenck, 1991). His model suggested that there are three main factors of personality, which are Psychoticism, Extraversion and Neuroticism and each dimension has a strong biological basis (Eysenck, 1963).

Considerable research has been conducted looking at the impact of Psychoticism, Extraversion, and Neuroticism on the development of PTSD. For example, McFarlane (1992) conducted a longitudinal research study using the Eysenck Personality Inventory (EPI) which was given to male firefighters and 13 months later, a subgroup of firefighters (that were thought to be at high risk for PTSD) were assessed using the Diagnosis Interview Schedule. They found that levels of Neuroticism at time-point one, along with family history of a psychiatric disorder, predicted those who had developed PTSD, 13 months later, with correct prediction 67% of the time.

In a research study conducted by Holeva and Tarrier (2001), scores on personality traits on the Eysenck Personality Questionnaire (EPQ-R) were measured in individuals, who had very recently been involved in a traffic accident. Both Neuroticism and Psychoticism scores taken shortly after the accident were associated with the severity of PTSD symptoms four to six months later. This was even with high control of variables, such as the severity of the accident, and if they had been involved in an accident previously. These results have been further supported by a systematic review by Jakšić, Brajković, Ivezić, Topić and Jakovljević (2012), that conducted a literature review on the personality traits and their association with PTSD. Neuroticism was particularly highlighted as a risk factor for PTSD, which was consistently found in many studies, whereas Extraversion was frequently reported to be negatively associated with PTSD, thus appeared to act as a protective factor.

Finally, in a very recent paper, Mason, Roodenburg and Williams (2020) reviewed a selection of studies looking at personality risk for PTSD in paramedics and nurses and emphasised that low levels of Extraversion and high scores on Neuroticism appeared to pose an increased risk for developing burnout, which could lead to PTSD. The authors concluded the importance of

researching personality risk factors, particularly for individuals routinely exposed to trauma and how knowledge of risk factors could benefit recruitment and intervention design. Thus, higher levels of Psychoticism and Neuroticism have been associated with a vulnerability to developing PTSD, whereas Extraversion appears to act as a protective factor for PTSD, particularly in professions that involve frequent experiences of traumatic events.

3.1.4. Personality and Behavioural Tasks

Personality traits have been proposed to affect performance on attention requiring tasks, including focusing on a target stimulus while ignoring distractors. There are individual differences in capacity of concentration and being able to maintain attention to tasks e.g., anxious people are often more distractable (Matthews, 2009).

In terms of visual search, investigating individual differences in performance due to personality traits is a relatively understudied area. Newton, Slade, Butler and Murphy (1992) used a visual search task involving letter stimuli and found individuals with high Extroversion and low Neuroticism displayed faster reaction times on the task, whereas Psychoticism was associated which decreased accuracy. This may be because extraverts are less affected by background noise or distractions. Also, higher levels of Neuroticism have been found to be associated with increased feelings of worry and mind-wandering, which have been proposed to interfere with performance on tasks. This was what Robinson and Tamir (2005) concluded when Neuroticism positively predicted variability in response time task identifying words into categories. They proposed that this indicated distractibility, due to possible mind-wandering or "mental noise" as they described it. Therefore, it appears that individuals with increased Neuroticism or Psychoticism show worse performance on attentional tasks, but those with heightened Extraversion may display better performance.

With regards to personality and inhibitory ability, some studies using the Eysenck Personality Questionnaire (EPQ) have found difference in performance on inhibitory tasks. Crow (2019) used a continuous performance task where individuals had to respond to a certain stimulus and inhibit a response if the stimulus was not present. They found that Neuroticism was associated with poorer accuracy, suggesting Neuroticism is associated with deficits in inhibition, although Extraversion did not appear to affect task performance. The author suggested that since Neuroticism is known to be strongly associated with feelings of anxiety, it made sense that higher Neuroticism resulted in poorer performance as anxiety has been proposed to result in a more error-prone response style in tasks. Additionally, MacLean and Arnell (2010) looked at

the effect of personality type on the magnitude of attentional blink, where a greater magnitude indicates poorer inhibitory ability, and increased difficulty in disengaging from an initial stimulus. They found that Extraversion was associated with a smaller magnitude of attentional blink, whereas Neuroticism was related to a larger attentional blink and poorer target accuracy. This suggested extraverts may show better performance on an attentional task, whereas, as discussed previously, those with higher levels of Neuroticism were more likely to be impaired.

For the active inhibition task, there is limited research on the effects on personality. The only study that appeared to have researched this, provided initial evidence that an active inhibition task is affected by differences in personality. Mason, Booth and Olivers, (2004) found reduced active inhibition was associated with the personality trait of impulsive non-conformity, as well as the trait introvertive anhedonia in males. While a recent meta-analysis by Knežević et al. (2019) reported that EPQ-R personality traits did not appear be closely related to measures of psychosis proneness, the trait of impulsive non-conformity did significantly relate with Psychoticism. This provides evidence to suggest that individuals with increased levels of Psychoticism will show a poorer ability on the active inhibition paradigm. Although the effects of Extraversion and Neuroticism on an active inhibition style task have not been studied, it was decided to investigate these traits, along with Psychoticism, since it appeared this may identify those at increased risk of developing PTSD and these traits have been shown to affect performance on other attentional tasks.

3.1.5 Aim and Hypotheses

The first aim was to see if differences in personality would affect performance on the active inhibition task. Based on the findings reviewed above for visual search and inhibition tasks, it was hypothesised for hypothesis one that individuals with either low Extraversion (H1a), high Neuroticism (H1b) or high Psychoticism (H1c) would be particularly prone to disrupted active inhibition. Neuroticism and Psychoticism were predicted to be negatively correlated with active inhibition, while Extraversion was hypothesised to be positively correlated.

The second aim was to determine if increased symptoms of PTSD lead to impaired performance on an active inhibition paradigm, indicated by reduced scores on the active inhibition task, and to examine which symptoms were associated with altered performance. This would indicate that symptoms associated with PTSD affect the cognitive inhibitory processes necessary to actively inhibit stimuli. Hypothesis two (H2) was that increased ratings of PTSD symptoms (intrusions, avoidance, alterations in cognition and mood, alterations in arousal and reactivity)

would be negatively correlated with active inhibition scores. This would indicate that increased PTSD symptoms were associated with poorer active inhibition. As discussed, there has been limited research looking at the influence of different symptom clusters on inhibitory processes. Based on the studies mentioned above, intrusive symptoms appeared likely to be more strongly associated with poorer inhibition, than the other symptom clusters.

Lastly the third aim was to see if individuals who met the criteria for PTSD would show a different performance on the active inhibition paradigm, than individuals who did not meet the criteria. It was hypothesised for hypothesis three (H3), that participants who met the criteria for PTSD would show lower active inhibition scores, compared to those that did not meet the criteria for PTSD. An active inhibition score was calculated for each participant as the conjunction trial reaction time minus their reaction time for the preview trial. Therefore, a lower active inhibition score indicated a reduced ability to inhibit distractors in the preview condition, compared to in the conjunction condition.

3.2. Method

3.2.1. Participants

Using an expected moderate correlation, based on the findings by Mason, Booth and Olivers, (2004), (ρ = 0.3), standard power (.80) and alpha (.05 two-tailed) on a power analysis (G*Power 3.1.9.4 software; Faul et al., 2009) for a correlation bivariate normal model, 84 participants were required. The aim was to test at least 200 participants, due to expected incomplete or poor data from some participants on the active inhibition task, or insufficient questionnaire data, and to ensure a significant number of participants met the criteria to be in the potential PTSD condition for the ANOVA.

Participants were recruited from social media, SurveyCircle (SurveyCircle, 2021) and by word of mouth. The study was advertised as looking at personality and resilience. In total, 360 members of the general public participated in the online study from July to November 2020.

Forty-eight participants were excluded for the following reasons: 12 participants were excluded for either being under 18 or aged 60 or above. Twenty participants were excluded for failing one or both of the attention check questions (described in the measures section). Additionally, 16 participants were excluded for having a lie scale score of above 15. The value of 15 was used as this value was two standard deviations above the mean in a large sample study by Eysenck, Eysenck and Barrett (1985) so participants were excluded that responded with high levels of social desirability. It was also decided to exclude participants with more than 10% of blank responses on either questionnaire, but no participants fitted this criterion once the other exclusion criteria were applied.

Due to their performance on the active inhibition task, nineteen participants were excluded. Of these, three participants were excluded who had more than 30% incorrect responses on the active inhibition task. Using histograms and boxplots, a further 16 participants were excluded due to having reaction time two or more standard deviations above the mean on either the conjunction, feature, preview trials or on their overall active inhibition score.

The final participant sample size was 293. The final sample consisted of 193 females, 98 males and two did not specify. The average age of participants was 31 years ranging from 18 to 59. Information on ethnicity and employment of the current sample is shown in Table 4.

Table 4. Ethnicity and employment information of participants for Study Two.

		Number
Ethnicity	White	230
	Asian	36
	Black	1
	Mixed	10
	Other	8
	Prefer not to say	8
Employment	Employed	157
	Full-time student	97
	Furloughed	9
	Retired	1
	Unemployed	10
	Other	18
	Prefer not to say	1

3.2.2. Measures

3.2.2.1. Demographics

A short demographic questionnaire was included with four questions that covered age, gender, ethnicity, and employment status (see Appendix O).

3.2.2.2. Eysenck Personality Questionnaire Revised (EPQ-R)

The Eysenck Personality Questionnaire Revised (Eysenck et al., 1985) is a questionnaire designed to assess personality traits using 100 yes or no statements (See Appendix P). The three personality traits assessed by the EPQ-R are Extraversion (23 items), Neuroticism (24 items) and Psychoticism (32 items). It also includes a lie scale (21 items) as a measure of social desirability. Higher scores indicate increased presence of the personality trait. An attention check question was added, halfway through the questionnaire, to identify participants who did not read the questions. The attention check question was "*For this question, please select "No" to show your attention*" which used similar phrasing as the attention check questions used by

Kung, Kwok, and Brown (2018). A bespoke excel template was used to score the EPQ-R after raw data was formatted.

The EPQ-R was chosen as it has been reported to have good test-retest reliability (Center & Callaway,1999) and high internal reliability (Psychoticism = 0.77, Extraversion = 0.88, Neuroticism = 0.87, lie scale = 0.81; Eysenck et al., 1985). In this study, the internal consistency of the EPQ-R was high for Extraversion (Cronbach's $\alpha = 0.86$) and Neuroticism ($\alpha = 0.90$) but slightly lower for Psychoticism ($\alpha = 0.71$). Social desirability also had a lower internal consistency ($\alpha = 0.66$), although it was still at an acceptable level. The average scores on the personality variables in this study are shown in Table 5, alongside the norms from the EPQ-R manual (Eysenck & Eysenck, 1992 as cited in Smillie et al., 2009).

Since Neuroticism and Extraversion were the main personality traits desired to be studied, the NEO-Personality Inventory (NEO-PI-R: Costa & McCrae, 1992) was considered as an alternative questionnaire to be used the study. This questionnaire also includes Neuroticism and Extraversion, alongside the traits of Openness, Agreeableness and Conscientiousness. However due to issues of using a commercially available questionnaire within the Gorilla software of the online study, and the fact the EPQ-R is freely available, this led to the decision of using the EPQ-R.

The Neuroticism scale of the EPQ-R, which was the trait of main interest due to its links to stress and development of PTSD, has been shown to have large similarities in the content of the items in the NEO-PI-R and was found to have a strong correlation (.85) to the neuroticism scale of the NEO-PI-R. (Gow et al., 2005; Van Den Berg et al., 2014). Thus, it was felt this justified the use of the EPQ-R questionnaire in the present study.

Table 5. Mean scores on the personality variables (with standard deviations in parentheses underneath).

	Online Study Sample			**EPQ-R norms**	
	All	**Male**	**Female**	**Male**	**Female**
Psychoticism	5.96	6.95	5.45	4.91	3.04
	(3.76)	(3.83)	(3.61)	(3.15)	(3.01)
Extraversion	12.37	13.13	12.03	14.29	13.47
	(5.48)	(5.42)	(5.49)	(4.85)	(5.07)
Neuroticism	13.56	11.82	14.44	10.06	10.72
	(6.23)	(6.19)	(6.08)	(5.07)	(5.13)

Note: The norms from the EPQ-R manual (Eysenck and Eysenck, 1992 as cited in Smillie et al., 2009)

3.2.2.3. PTSD Checklist-5 (PCL-5)

The PTSD Checklist-5 (PCL-5; Weathers et al., 2013) is a 20-item measure that assesses the symptoms of PTSD used in the DSM-5 (See Appendix Q). The four symptom clusters measured are intrusion symptoms (five items), avoidance symptoms (two items), negative alterations in cognitions and mood (seven items), and alterations in arousal and reactivity (six items). Items were scored on a 5-point Likert scale from "Not at all" to "Extremely". A total score was also calculated as a measure of total severity which can range from 0 - 80. Higher scores indicate higher symptom severity. An attention check question was also added halfway to this questionnaire, which was "*please select "Quite a bit*" to show your attention". The PCL-5 responses were formatted and then scored using an excel template, which was made for the analysis of the PCL-5 data collected in this study.

The PCL-5 has been shown to have excellent overall internal reliability (α = 0.95) and test-retest reliability (r = 0.82) (Blevins, Weathers, Davis, Witte, & Domino, 2015). Additionally. Ashbaugh, Houle-Johnson, Herbert, El-Hage and Brunet (2016) confirmed in a large sample (N = 838) high internal reliability of each of the subscales and overall PTSD severity: intrusion (α = 0.88), avoidance (α = 0.81), negative alterations in cognitions and mood (α = 0.90), alterations in arousal and reactivity (α = 0.85) and total score (α = 0.95).

In the present study, there were similarly high levels of internal reliability; intrusion (α = 0.85), avoidance (α = 0.79), negative alterations in cognitions and mood (α = 0.86), alterations in arousal and reactivity (α = 0.80), and total score (α = 0.93).

Table 6 shows the mean scores for the PTSD variables for the participants in this study. Since norms have not been reported in the PCL-5 manual, they are shown compared to scores from a large non-clinical undergraduate sample, in a study conducted by Ashbaugh, Houle-Johnson, Herbert, El-Hage and Brunet (2016).

The measure is one of the most commonly used questionnaires to assess symptoms of PTSD in clinical settings and for use research purposes (Cernovsky, Fattahi, Litman & Diamond, 2021) as well as being used in National Healthcare Service (NHS) settings. The questionnaire consists of 20 statements, which are easy to understand and requires a short time to complete, thus is appropriate for a general population sample.

In terms of the use of this questionnaire with a non-clinical sample, the PCL-5 was updated in 2013 to reflect changes made to PTSD diagnosis in the DSM-5 and limited research appears to

have been done using this questionnaire with non-clinical samples. Although, since the questionnaire follows the same symptom clusters as the DSM-5 subscales, which is one of the main diagnostic manuals for mental health conditions. This was a major factor for selecting this measure for the study, instead of using questionnaires which have been rendered outdated, due to the updated DSM-5 assessment criteria e.g., the Impact of Event Scale Revised (IES-R) (Weiss, 2007). Also, other researchers have used the questionnaire in this manner, as mentioned above, that Ashbaugh et al. (2016) investigated the psychometric properties of the questionnaire with a non-clinical sample of undergraduate students. They found high convergent and divergent validity, and high internal consistency for the subscales as shown in the Table 6. This provides some initial evidence to suggest the questionnaire is appropriate to use with non-clinical individuals.

Table 6. Mean scores on the PTSD variables (with standard deviations in parentheses underneath)

	Online study sample	**Comparison sample**
Intrusion	5.21 (4.44)	5.6 (4.90)
Avoidance	2.41 (2.09)	2.7 (2.40)
Negative alterations in cognition & mood	8.30 (6.01)	7.1 (6.90)
Alterations in arousal & reactivity	6.33 (4.56)	5.5 (5.30)
Total severity	22.25 (15.02)	20.9 (17.70)

Note: The comparison sample used was reported in Ashbaugh et al.(2016) using a large non-clinical undergraduate sample (N = 838)

3.2.2.3.1. PTSD Status

Participants were categorised as meeting the criteria for PTSD using instruction from the PCL-5 manual, which is based on the diagnostic criteria from the DSM-5 (Weathers et al., 2013) and has been summarised below:

- To fit the criteria for a provisional diagnosis of PTSD, this requires a certain number of items to be endorsed from each symptom category; where endorsed means an item must be scored as “moderately” or higher by the participant (equating to a score of two or more)
- Then following the DSM rule that:

- For the intrusion and avoidance subscales, at least one item from each had to be endorsed.

  AND

- For the alternations in cognition and mood, and alterations in arousal and reactivity subscales, at least two items, from each subscale, needed to be endorsed.

- Participants who met these criteria were classified as PTSD.
- Participants who did not fit these criteria were classified as no PTSD.

It is stated in the manual for the PCL-5 that the questionnaire only provides a provisional diagnosis of PTSD. Also, since the experience of a traumatic event was not assessed in the online study (referred to as criterion A event in the DSM-5), it is acknowledged that the groups used in the study are not indicatory of a firm diagnosis of PTSD. Nevertheless, for clarity and the purposes of this study, it was decided to use the terms "no PTSD" and "PTSD" when describing these groups. The PCL-5 is a well-validated measure of PTSD (Blevins, Weathers, Davis, Witte, & Domino, 2015) and self-report measures to establish PTSD status have been used in previous research (e.g., Leskin & White, 2007). Therefore, it was deemed appropriate to use for this study.

This does mean that a non-clinical non-traumatised sample was chosen to be used in the study. This sample was seen as suitable for the research study, as the presence of symptoms in these populations can be regarded as having equivalences to the same clinical symptoms present in people diagnosed with a mental health condition. Also, there is the benefit of the absence of potential confounding factors such as possible effects of medications and comorbidities. This is often the reasoning behind the use of non-clinical samples in this type of research, such as by Mason et al. (2004) who used a non-clinical sample when investigating proneness to psychosis and active inhibition.

Other advantages of choosing a non-clinical non-traumatised sample are practical, as non-clinical participants are easier to recruit than those with mental health conditions. Additionally, because of the coronavirus pandemic, the decision was made to move to online research. Due to limited time constraints for data collection, it would not have been feasible to gain NHS ethics, without which, it would have proved difficult to recruit individuals with PTSD. Although it is acknowledged that using participants with PTSD would have been provided stronger evidence of the effect of PTSD on active inhibition, using a non-clinical non-

traumatised sample can still provide initial evidence of possible effects of psychiatric symptoms on visual paradigms and possible avenues of future research to then be conducted with clinical populations.

3.2.2.4. Active Inhibition Task

This was the same task as described in Chapter Two, with some minor changes, which are described below, to make it suitable for use in the online study. As before, there were three different trial types: conjunction, preview, and feature, which were randomly presented during the task (see Figure 10). For all trials, the aim was to identify the direction the target red arrow was pointing, either left or right.

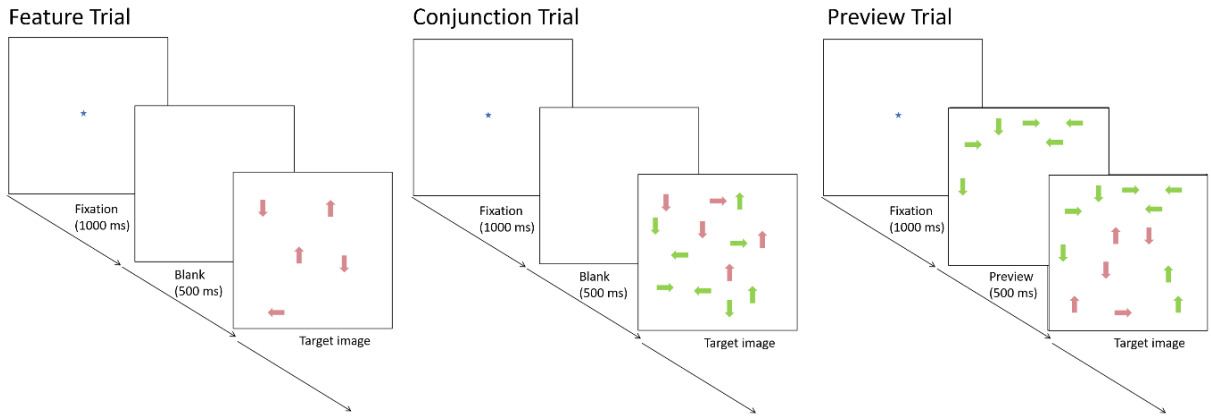

Figure 10. Figure 4 as presented in Chapter Two. The sequence displays of the three different trial types on the active inhibition task. Stimuli not shown to scale.

In every trial, a blue fixation point was displayed for 1000ms. In the feature and conjunction trials, a blank screen was shown after the fixation point for 500ms. Then for just the feature trials, four red arrows that were pointing either up or down, were shown along with a target red arrow that was pointing left or right. Whereas in the conjunction trials, along with the five red arrows, the target image included eight green arrows (pointing up, down, left, or right). Lastly, the preview trials were identical to the conjunction trials, however rather than having a blank screen presented for 500ms, the same eight green arrows (that were also shown in the target image of that trial) were displayed. Therefore, these green arrows were shown before the red arrows appeared and thus were previewed. This was the same arrow presentation as used in Chapter Two, although due to the requirements of the different software used for the online study, they were no longer presented in a black square outline.

The instructions were reworded slightly from the first study (see Appendix C) and the revised instructions are included in Appendix R. In the online study instructions, participants were told

that the task was about to start and to sit about arm's length from their screen. They were also asked to ensure they were in a quiet room, which was added to the online study instructions, since participants were no longer taking the study in a controlled laboratory environment. As with the previous instructions, participants were told they had to find the red arrow pointing left or right and were instructed to press the "A" key if the arrow was pointing left and the "L" key if the arrow was pointing right.

The practice contained 12 trials and during the practise trials, participants received instant feedback for their responses (shown by either a tick or a cross at the bottom of the screen). This was a feature added to the online study and participants were informed it would occur in the instructions. The practice took approximately one minute. At the end of the practice trial, participants were given their percentage of correct responses (which was another addition to the online version of this task).

The main task involved 144 trials, split into three blocks of 48 trials with no instant feedback. This was double the number of trials compared to the task used in Chapter Two, which was made up of just one block. In the online study, the main trials took approximately six minutes and following each block, participants were told their number of correct responses. Since the online study task was longer than the previous version, participants were told they could take a short break between blocks if necessary.

Prior to statistical analysis, for the active inhibition task, a formula was used to apply a correction to reaction times. Any reaction time less than 300ms or above 3000ms for a trial was omitted. Additionally, an error penalty of 600ms was added to incorrect responses. For each participant, a mean reaction time was calculated for each trial type (feature, conjunction, and preview). An active inhibition score was also calculated as the conjunction trial reaction time minus the preview trial for every participant.

3.2.3. Procedure

Ethical approval for the study was provided by the Department of Psychology Ethics Committee, Ref: 2020-2730-3905 (See Appendix S).The study was created and hosted on Gorilla Experiment Builder (www.gorilla.sc; Anwyl-Irvine, Massonnié, Flitton, Kirkham, & Evershed, 2020). The study could only be completed on a computer due to the active inhibition task requirements. This was mainly because of the requirement of a keyboard, so a restriction was added that prevented people from completing the study on a device that was not a desktop or laptop (i.e., smart phones could not be used). Participants began by reading the online

information sheet (see Appendix T) and the consent form (see Appendix U). On the consent form, they electronically selected "*I agree to participate*" to provide consent. Following this, demographic information was collected. A practice of the main task was completed by all participants, which was 12 trials long, taking approximately one minute. During the practice phase, if a participant scored equal to or less than 80%, they were required to repeat the practice trial. Participants then proceeded to the main trial stage which took approximately six minutes and was made up of three blocks with each block containing 48 trials, so was 144 trials in total.

The questionnaire stage of the online study began with the EPQ-R followed by the PCL-5. Both these questionnaires had software scripting added, so participants would receive a prompt message if they had left any answers blank, but they were not forced to complete them.

Participants were then given the opportunity if they wished, to submit their email to enter an Amazon raffle with three prizes of: £20, £10 or £5 Amazon vouchers. Towards the end of the data collection period, due to additional Amazon vouchers remaining from a prior study, a £5 payment was offered to participants, instead of entry into the raffle. A debrief form was then shown before participants completed the study (see Appendix V).

3.2.4. Statistical Analysis Plan

Spearman's rank-order correlations were used for personality variables (Extraversion, Neuroticism, and Psychoticism) and active inhibition scores. They were also chosen to be used to examine the relationship between PTSD variables (intrusion symptoms, avoidance symptoms, negative alterations in cognitions and mood, alterations in arousal and reactivity and PTSD total severity) and active inhibition.

Spearman's rank-order correlations were chosen as it was expected that PTSD subscales on the PCL-5 would have a skewed distribution since a non-clinical sample was used. Therefore, non-parametric analysis was required, as an assumption for conducting a parametric test, such as a Pearson's correlation, is that the data is normally distributed. Spearman's rank order correlations can be used when the assumptions of the Pearson correlation are markedly violated, therefore they were appropriate for use with data with a skewed distribution.

Additionally, the use of correlations was suitable to assess whether active inhibition was associated with personality traits or symptom clusters of PTSD, two of the aims of this research study. Correlations were chosen to provide evidence to indicate if active inhibition is related to symptoms of PTSD or personality traits. Furthermore, correlation analysis was used in previous

research to look at the associations of traits and active inhibition (Mason, Booth & Olivers, 2004). Although correlations cannot provide causal inferences, this analysis is appropriate in order to look at the relationships of the identified variables of interest with active inhibition. Additionally, since the variables of personality traits, level of PTSD symptoms and active inhibition scores are continuous variables, using correlation analysis is most suited to this type of variable.

A one-way analysis of variance (ANOVA) was used to compare active inhibition scores in the no PTSD group compared to the PTSD group. The reasoning behind using a one-way ANOVA was to see whether PTSD status affected active inhibition score. Specifically, to see if average active inhibition scores in the PTSD group were significantly different from those in the non-PTSD group. The final aim of the study was to investigate the effect of PTSD on active inhibition, so this analysis could provide initial indication to see if there is any difference in performance due to PTSD status.

3.3. Results

3.3.1. Data Distribution and Outliers

Prior to conducting any statistical analysis, histograms and boxplots were created to identify outliers (see Appendix W). Using histograms and boxplots 16 participants were excluded. This was due to having a reaction time on either the conjunction, feature, preview trials, or on their overall active inhibition score that was two or more standard deviations above or below the mean. The final sample consisted of 293 participants.

It was decided not to exclude participants with scores two standard deviations above the mean on the personality or PTSD variables, as this would remove high scores on these variables from the analysis, who were of interest to the aim of the study.

The active inhibition scores were normally distributed as were the distributions on Extraversion, Neuroticism, and Psychoticism. However, as expected, the histograms showed the distribution of scores on the subscales of the PCL-5 were negatively skewed. Non-parametric analysis of Spearman's rank-order correlations were used for the analysis of the EPQ-R and PCL subscales, and active inhibition scores.

3.3.2. Descriptive Statistics

Figure 11 shows the results on the reaction times on the active inhibition task. As expected, paired t-test showed that reaction times were fastest in the feature condition compared to the conjunction condition, $t(292) = -37.40$, $p < .001$, $d = 2.19$, and the preview task, $t(292) = -19.84$, $p < .001$, $d = 1.16$. Reaction times in the preview task were also faster than in the conjunction task, $t(292) = -23.07$, $p < .001$, $d = 1.35$.

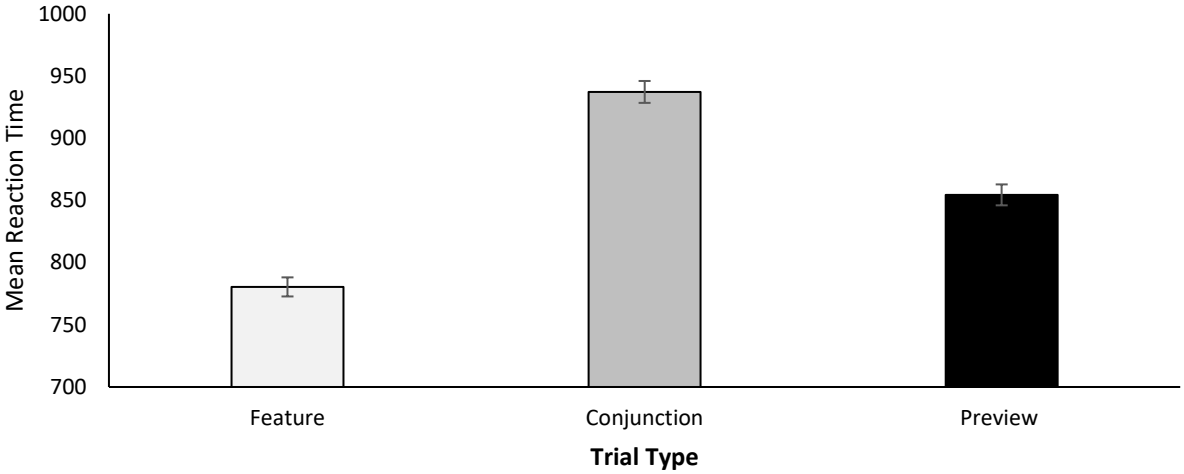

Figure 11. Mean reaction times on active inhibition task for all participants.

3.3.3. Personality Variables and Active Inhibition Score

Spearman's rank-order correlations were conducted to investigate the relationship between the personality variables and active inhibition score (see Table 7). There were no statistically significant correlations between any of the three personality variables (Extraversion, Neuroticism and Psychoticism) and the active inhibition score. This did not support hypothesis one, as it was hypothesised that Extraversion would be positively correlated to active inhibition scores (H1a) and Neuroticism (H1b) and Psychoticism (H1c) would be negatively correlated with active inhibition scores.

Table 7. Correlations between active inhibition score and personality variables (N = 293)

	Extraversion	Neuroticism	Psychoticism
Active Inhibition Score (N = 293)	.004	.050	.100

3.3.4. PTSD Variables and Active Inhibition Score

A Spearman's rank-order correlation was used to assess the relationship between PTSD variables and active inhibition score. Table 8 shows the result of the correlations. Four of the PTSD variables showed significant weak positive correlations (intrusion. avoidance, alterations in cognition and mood and total severity). The correlation was strongest for avoidance and active inhibition score r_s (293) = .20, p = .001. These results were contrary to hypothesis two as it was hypothesised that active inhibition scores would be negatively correlated with PTSD symptoms.

Table 8. Correlations between active inhibition score and PTSD variables (N = 293).

	Intrusion	Avoidance	Alteration in Cognitions/Mood	Alterations in Arousal/Reactivity	Total Severity
Active Inhibition Score (N = 293)	.15**	.20**	.12*	.11	0.14*

Note. ** *significance at 0.01 level, *significant at 0.05 level*

3.3.5. PTSD Status and Active Inhibition Score

Table 9 shows the scores on the subscales of the PCL-5 and the reaction times on the active inhibition task for the PTSD condition and No PTSD condition.

Table 9. Mean scores on subscales of the PCL-5 and mean reaction times on active inhibition task (with standard deviations in parentheses).

	No PTSD (n= 215)	**PTSD (n =78)**
Intrusion	3.66 (3.49)	9.49 (3.98)
Avoidance	1.61 (1.63)	4.60 (1.60)
Negative Alterations in Cognition and Mood	5.97 (4.62)	14.72 (4.56)
Alterations in Arousal and Reactivity	4.55 (3.26)	11.24 (4.03)
PTSD Total Severity Score	15.79 (10.31)	40.05 (11.07)
Feature reaction time	776.32 (127.66)	791.77 (141.32)
Conjunction reaction time	931.10 (154.87)	953.92 (137.65)
Preview reaction time	852.96 (146.47)	858.42 (137.97)
Active Inhibition Score	78.14 (60.71)	95.50 (61.92)

A one-way ANOVA was conducted to determine the effect of PTSD condition on active inhibition score (see Figure 12). There were 78 participants in the potential PTSD group and 215 participants in the no PTSD condition. There was a significant effect of task condition on active inhibition score $F(1, 292) = 4.63$, $p = 0.03$, $\eta^2 = 0.016$. This finding was contrary to hypothesis three (H3), as individuals in the potential PTSD condition had a higher mean active inhibition score compared to participants in the no PTSD condition. This suggests individuals with potential PTSD showed better active inhibition than non-PTSD participants.

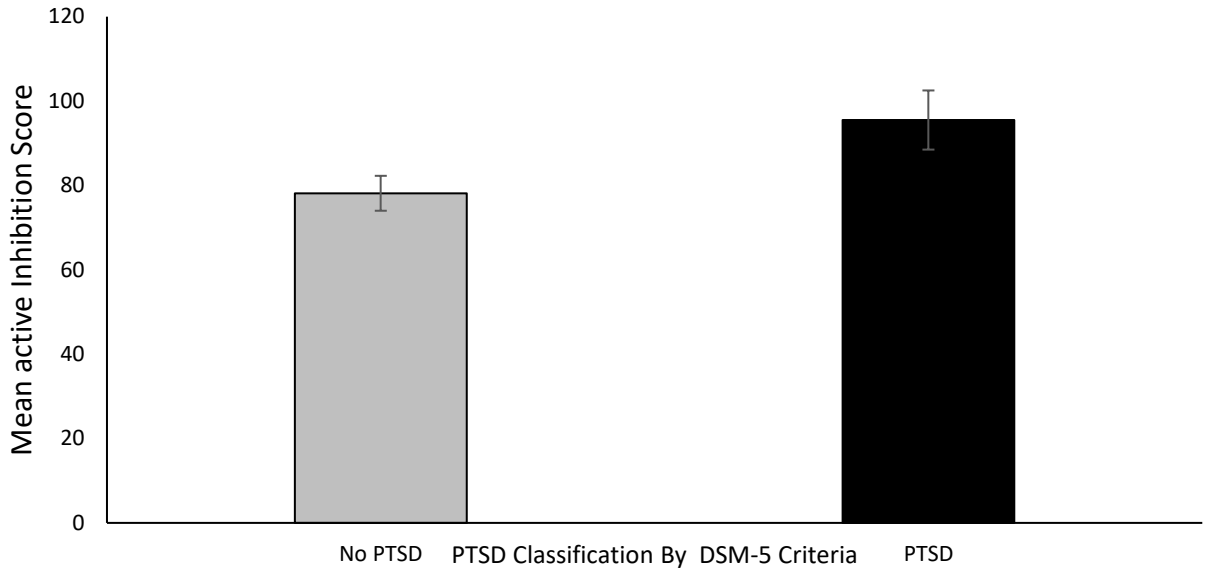

Figure 12. Mean Active Inhibition Score depending on PTSD classification. Error bars represent ± 1 standard error of the mean.

3.4. Discussion

The main purpose of this research study was to examine if impairments due to PTSD or differences in personality traits would affect performance on the active inhibition task. An online study was conducted where individuals completed an active inhibition task and two questionnaires, one measuring PTSD, and the other measuring personality traits.

Contrary to hypothesis one, it was found there were no significant correlations for any of the three personality variables (Extraversion, Neuroticism and Psychoticism) and active inhibition score. Additionally, opposite to what was predicted in hypothesis two, three PTSD symptoms (intrusions, avoidance, and alterations in cognition and mood) were significantly positively associated with greater active inhibition scores. Lastly, for hypothesis three, the results showed individuals who met the criteria for PTSD showed increased active inhibition (indicated by higher active inhibition scores) compared to no PTSD participants.

3.4.1. Personality and Active Inhibition

For hypothesis one, it was found that none of the three personality variables (Extraversion, Neuroticism and Psychoticism) were significantly correlated with active inhibition score. It was hypothesised that individuals with either low Extraversion (H1a), high Neuroticism (H1b) or high Psychoticism (H1c) would be particularly prone to disrupted active inhibition, due to their association with PTSD and findings from other visual search and inhibitory tasks.

As discussed in the introduction, this was a novel area of investigation since no previous research has looked at the effects of these personality variables on active inhibition. Studies from other visual search and inhibitory tasks suggested that low Extraversion and higher levels of Neuroticism would result in poorer performance on active inhibition (MacLean & Arnell 2010; Newton, Slade, Butler, & Murphy,1992; Robinson & Tamir, 2005). Additionally, a schizotypy personality trait, related to Psychoticism, was found to be associated with poorer active inhibition by Mason et al. (2003). Although, in the continuous performance task by Crow (2019), Extraversion did not affect task performance. Thus, it appears that factors may moderate whether personality traits affect performance, such as the type of task or the population used. Matthews (2009) highlighted several contextual factors that could affect whether personality traits facilitate or impair performance, including participant's motivation levels, the time of day and features of the testing environment. Future research using more controlled environments

and timing, as well as accounting for differences in motivation, may find evidence of personality differences on an active inhibition task.

3.4.2. PTSD Symptoms and Active Inhibition

For hypothesis two, it was found that three PTSD symptoms (intrusions. avoidance and alterations in cognition and mood) were significantly positively associated with greater active inhibition scores, with avoidance showing the greatest correlation ($r = 0.20$).

As with personality traits, there had also not been many research studies conducted looking at the effects of the different symptom clusters of PTSD and relation to inhibition deficits. Contrary to expectations, intrusion symptoms, which had previously been found by Kertzman et al. (2014) to correlate with decreased inhibition using a Stroop task, were positively associated with participants' active inhibition scores. It has also been proposed that intrusive thoughts could be an indicator of impaired inhibitory processes (Brewin, 2001), therefore it is surprising that intrusion symptoms correlated with better active inhibition. It was also contrary to hypothesis two, that alterations in cognition and mood, which includes increased negative emotions and ruminations, had not appeared to have been investigated previously but were hypothesised to lead to reduced active inhibition. It could be that since a non-clinical sample was used, perhaps these symptoms need to be present at higher levels to result in deficits in inhibition.

Avoidance showed the greatest correlation with active inhibition scores. As discussed in the introduction, it was unclear if levels of avoidance symptoms would affect active inhibition. Although since most studies using individuals with PTSD have found deficits in inhibition, it was still hypothesised for avoidance to correlate to poorer inhibition. Additionally, avoidance symptoms had been found by Wu et al. (2015) to result in greater impairment on an inhibitory task (a go/no-go task). This task measured associations to response inhibition rather than inhibition of stimuli, so this may be why the same results were not found on an active inhibition paradigm. Also, avoidance had no effect on the Stroop task performance in the study conducted by Kertzman et al. (2014). A possible explanation for why avoidance was associated with better active inhibition is that individuals with increased levels of avoidance have more practice in inhibiting intrusive thoughts. This potentially supports the previously mentioned study by Amir et al. (1997), who found avoidance symptoms were strongly related to the use of suppression coping style, which suggests they would have practice of suppressing and inhibiting stimuli

from their awareness. This study provided some support for this explanation since an avoidance coping style was associated with increased suppression, which could potentially explain the finding that higher scores for avoidance were associated with greater active inhibition. Although Amir et al. (1997) did report that a suppression coping style was also associated with increased intrusive symptoms, perhaps this may be more evident for emotional stimuli or only in individuals with more severe levels of PTSD (as the study sample used PTSD patients at a hospital receiving treatment). This could explain the significant positive correlation between active inhibition score and avoidance symptoms.

Further support for the explanation that the practice of avoidance of thoughts and inner cognitions accounted for the improvement in active inhibition could be found by using a more specific measure of cognitive avoidance, such as the Cognitive-Behavioural Avoidance Scale (CBAS) (Ottenbreit & Dobson, 2004). This is a 31-item questionnaire that covers four subscales of avoidance, two of which are forms of cognitive avoidance which includes items on thought/memory suppression and dissociating from the emotions caused by the traumatic event. Allen (2018) used this self-report measure with an undergraduate sample to determine what type of avoidance symptoms were associated with performance on a computer-based behavioural inhibition task. The task involved reading two scenarios (attending a party and volunteering on a project) and the participant had to pick from three options what they would decide to do in response to different events that occurred during the scenarios. The response options were either to select an inhibited response (which was reflective of avoidance behaviour), a non-inhibited response (where they did not show avoidance), or an intermediate response, which was a neutral response. As expected, scores on a task measuring behavioural inhibition were associated with behavioural avoidance but not cognitive avoidance. Therefore, it would be useful to conduct a replication of this online active inhibition study, with the addition of this measure, as it would be expected for cognitive avoidance to correlate more with active inhibition performance than behavioural avoidance. Use of this questionnaire in a study replication could add additional support to the explanation that increased use of thought suppression related to avoidance symptoms aided performance on the active inhibition task.

3.4.3. PTSD Status and Active Inhibition

The finding that potential PTSD participants showed increased active inhibition, was opposite to hypothesis three, since it was hypothesised for individuals with PTSD, to show reduced active inhibition. This was based on findings from previous studies, discussed in Chapter One, that have suggested PTSD is associated with deficits of inhibiting distractor stimuli (DeGutis et al., 2015; Leskin & White, 2007; McFarlane et al., 1993). Instead, the findings from the online study suggested that individuals with PTSD were better at screening the preview items from awareness and, in fact, showed better temporal inhibition. This was not expected due to active inhibition being an inhibitory mechanism and the fact that PTSD is associated with deficits in inhibition (Echiverri-Cohen et al., 2016).

3.4.3.1. Relation to Previous Literature

A critical consideration was that there were differences between the inhibition task used in the present study, compared to the previous literature. For example, McFarlane et al. (1993) found poor inhibition of an auditory stimulus, whereas this study looked at inhibition of responding in a visual search task. Also, in the attention capture task, used by DeGutis et al. (2015), the main distractor stimulus that individuals had to inhibit, was also the most salient object on the screen, as it was the only item in a different colour. This probably made the distractor difficult to inhibit as it would have been attention-grabbing, due to its uniqueness, whereas in the active inhibition task, there was no uniquely coloured distractor. Thus, it may be that the distractors in the active inhibition task were easier to inhibit, compared to the stimuli used in other inhibitory tasks and were within the attentional capabilities of individuals with PTSD.

Features of the active inhibition task may also explain why population groups known to have attentional deficits with inhibition, have still shown intact active inhibition. Although children with ADHD exhibited more errors, their active inhibition ability was robust, evidenced by decreased preview reaction time, compared to the reaction time for conjunction trials (Mason et al., 2003). Additionally, older adults also displayed active inhibition, despite known inhibitory ability impairments developing due to age (Warner & Jackson, 2009). Thus, the inhibitory demands required on an active inhibition task may be less than in other inhibition tasks used in literature e.g., Stroop task or singleton attention capture task, where those with PTSD symptoms have been shown to have reduced inhibition (DeGutis et al., 2015; Esterman et al., 2013, Polak et al., 2012). The fact that other population groups with known inhibitory difficulties have also shown unaffected active inhibition may suggest this task requires reduced

inhibitory capacities. Additionally, as with PTSD, individuals with ADHD and older adults have exhibited increased impairment on Stroop tasks and singleton attention capture tasks (King, Colla, Brass, Heuser, & von Cramon, 2007; Kramer, Hahn, Irwin, & Theeuwes, 2000; Mason, Humphreys, & Kent, 2005: Van der Elst, Van Boxtel, Van Breukelen, & Jolles, 2006). This provides further support that these tasks require increased inhibitory abilities than the active inhibition paradigm. Perhaps better inhibition in individuals with PTSD may only be shown when tasks have relatively low attentional and inhibitory demands.

Additionally, the temporal segmentation of the preview trials between the old and the new distractors may have simplified the task and given the potential PTSD participants time to deploy their suppression abilities. Other inhibition tasks do not have this time delay, so this may explain why better inhibition has not been observed in PTSD participants before. Evidence from Warner and Jackson (2009) showed that the temporal time delay appears a crucial feature for successfully inhibiting distractors on the preview trial, especially for populations with reduced attentional capacity. In the study, older adults displayed successful active inhibition, when the duration was 586ms, however when the preview length was less, they showed an impairment of active inhibition and appeared unable to suppress the distractors. The authors suggested this was possibly due to older adults requiring increased time to implement attentional strategies, due to their reduced attentional ability. A replication of this online study, using a range of preview durations, could provide further evidence to support the explanation that the temporal segmentation was why individuals with potential PTSD showed better inhibition on the active inhibition task.

An alternative possibility was that the differing findings were due to features of the population group. The current study used an online non-clinical sample whereas the majority of other studies reported used veterans or patient groups (e.g., DeGutis et al., 2015; McFarlane et al., 1993). Perhaps only individuals with acute PTSD, or relatively low levels of symptoms, show better inhibition. When PTSD becomes more chronic, increased levels of symptoms such as intrusions and hyperarousal, may result in better levels of suppression not being observed. This could provide an additional reason why differing results were found in the current study, since most previous inhibition studies have used veterans or participants who have been diagnosed with PTSD, therefore likely had higher symptomology of PTSD, and/or more chronic levels of PTSD, than in the current sample. Catarino et al. (2015) found the ability of thought suppression negatively correlated with PTSD symptoms, suggesting inhibition ability worsens as deficits with PTSD increase, adding partial support to this explanation. Also, in some studies, such as

DeGutis et al. (2015), participants had high comorbidity with depression which could explain the reduced levels of inhibition found in the study rather than their increased levels of PTSD symptoms.

3.4.4. Why May Individuals With PTSD Appear to Show Better Active Inhibition?

A possible explanation for the results could be that PTSD individuals may have better cognitive control due to increased practice of inhibiting negative thoughts and memories related to their trauma. This could also explain why avoidance had the strongest correlation with active inhibition, due to practice avoiding thoughts or memories related to their trauma. Suppression was highlighted as a commonly used strategy following adverse events (Amstadter & Vernon, 2006) and was related to avoidance, which is a main symptom cluster of PTSD and has been proposed to contribute to the maintenance of the disorder (Ehlers & Clark, 2000). Hayes, VanElzakker and Shin (2012) suggested individuals with PTSD may have enhanced ability to forget information, due to utilising avoidant-coping skills to suppress memories from their traumatic event. Therefore, it was possible that on the active inhibition task, which required cognitive control to suppress the distractors, people with potential PTSD were well practised at controlled conscious awareness of inhibition, which led to better active inhibition scores for these participants.

3.4.4.1. Evidence From Memory Suppression Studies

Although a limited research area, some studies have been conducted to investigate whether individuals, with PTSD, or who have experienced traumatic events, show better evidence of suppression using memory tasks. Hulbert and Anderson (2018) used a Think/No-Think paradigm with undergraduate students split into no trauma and high trauma groups, depending on how many traumatic events they reported. In the paradigm, individuals completed learning trials where they had to memorise 60-word pair associations (half negative words, half neutral). Then in the Think/No-Think phase, for some of the word pairs, individuals were told to suppress the response word, whereas for the others they had to try to recall the associated word. Following this stage, surprise recall tests were given. It was found that individuals who had experienced more traumatic events, showed an enhanced ability at suppressing the to-be-suppressed negative and neutral word pair associations during the memory task. The authors concluded that experience of traumatic events could aid suppression, due to the practice of suppressing traumatic reminders. A strength of their study was the use of a financial incentive for recalling word pairs to reduce the likelihood that lower motivation to recall word pairs

accounted for the difference. Also, since the increased ability was found for neutral and negative stimuli, this suggested the same cognitive processes were involved in this suppression. This provided support to the explanation that better active inhibition could be due to the increased practice of suppression related to traumatic experiences, which would have aided participants in suppression of neutral distractors in the active inhibition task.

The previous study was only conducted with individuals who had experienced a traumatic event and did not measure PTSD or PTSD symptoms. Using a similar Think/No-Think paradigm, this was investigated in a study by Catarino, Küpper, Werner-Seidler, Dalgleish and Anderson (2015), who compared a sample of participants with current diagnoses of PTSD, compared to trauma-exposed individuals. In opposition to the above results, they found the participants with PTSD showed worse suppression of trauma stimuli and reported lower self-perceived control ability than the control group. However, a key difference in this study was the use of unpleasant images in the Think/No-Think task rather than neutral and negative words. Perhaps aversive stimuli are too intrusive for people with PTSD to suppress, whereas less arousing stimuli, such as words, may be within the capabilities of people with PTSD or trauma experience to show a benefit. Since the online study used neutral stimuli, this explanation would also fit with the findings.

3.4.4.2. Evidence of Attentional Control and Inhibitory Tasks

Other supporting evidence has looked at the association of attentional control and performance on inhibitory tasks in relation to PTSD and anxiety. A study by Price and Mohlman (2007) investigated the role of inhibitory control in individuals with generalised anxiety disorder using a standard Stroop task as a measure of inhibition. Individuals with increased trait anxiety and with higher self-reported worry (seen as an avoidance coping style) were found to have increased inhibition on the Stroop task. The authors suggested that this may be due to increased inhibitory skills implementing processes that maintain symptoms of anxiety. They cautioned against potentially over-simplistic claims of inadequate top-down inhibitory control related to emotional psychopathology. This provided support to the explanation that individuals who engage in more avoidance processing of cognitions may show better inhibition. Although this study did not look at the inhibitory ability of individuals with PTSD, it is likely these findings can still be applied to PTSD, since there is substantial overlap in symptoms of PTSD and anxiety, such as negative affect and worry.

Additionally, an inhibitory study conducted by Bardeen and Orcutt (2011) assessed undergraduate individuals with post-traumatic stress symptoms (PTSS) using the dot-probe task. In each trial of the task, a dot was shown on a computer screen, on either the left or right side and participants had to indicate using a computer key, which side of the screen the dot was displayed. Prior to the dot appearing, a pair of images (one threat and one neutral) were presented with one image on the left side and the other on the right side, and the reaction time was recorded when participants identified the location of the dot. An attentional bias score was calculated by subtracting the reaction time to the probe in the location of a threat image, from the reaction time to when the dot was in the location of a neutral image. They found that individuals with higher PTSS and better attentional control (measured using a self-report questionnaire called the Attentional Control Scale), showed a better ability to disengage from threat stimuli when they were presented for 150ms. Those with lower attentional control and higher symptoms were less able to disinhibit from the threat stimuli. The authors proposed that individuals with high attentional control and PTSD symptoms, employed shifting from threat stimuli to reduce emotional distress in the short term. This was because they showed increased disengagement, compared to the participants with high attentional control and low PTSS. Thus, this indicated how attention control in PTSD may alter performance on inhibitory tasks, with better attentional control resulting in more inhibition. Although this finding was for threat stimuli, it provided support that individuals with attentional control and higher levels of PTSD can disengage faster from distractor stimuli, an indication of better inhibition.

3.4.5. Strengths and Limitations

A main strength of the study was the successful creation of an online active inhibition paradigm. Previously it appeared this ability had only been studied in laboratory settings, so this research study showed it was possible to investigate active inhibition using an online study. This could be useful for future studies, particularly in situations such as the COVID-19 pandemic, where online methods are favoured for conducting research. The study also showed the effect of active inhibition was robust to potential differences in the task presentation, such as monitor size and environmental conditions, that cannot be controlled in online research. An additional strength of the study was that the active inhibition task was a more specific measure of visual inhibition, compared to other inhibitory tasks, that require the use of additional cognitive abilities. This allowed the study to provide greater insight into how PTSD symptoms affect inhibition processes, particularly one involving top-down attentional abilities. It also reduced the likelihood that other processes, such as memory processes, may have affected the results.

The categorisation of participants into PTSD and no PTSD was based on responses from the PCL-5. This method of using self-report measures to assess PTSD status has been used in previous research studies to create a "probable" diagnosis group (e.g., Leskin & White, 2007). However, such self-report questionnaires are likely to be less accurate and comprehensive than interviews such as the Clinician Administered PTSD Scale (Sheynin et al., 2017). Since this study was restricted to online methodology, it was infeasible to use an interview assessment method. Future research could be conducted using clinically assessed samples of PTSD on a task of active inhibition to establish if the effects are found using more accurate assessments of PTSD.

The study had a greater number of participants than expected in the potential PTSD group, compared to reported prevalence rates of PTSD in the general population (Greenberg, Brooks, & Dunn, 2015; Kessler et al., 2005). The greater prevalence could have been because individuals were not asked to endorse if they had experienced a traumatic event. If this had been used in the study, it may have reduced the number of participants who fitted PTSD criteria, since, for a clinical diagnosis of PTSD, it is required that a traumatic event has been experienced.

Lastly, the results were based on correlational and cross-sectional analysis, therefore causality of the results cannot be confirmed. Although I have speculated that these results suggest PTSD could result in better suppression of distractors, it could be that individuals had this suppression benefit prior to the development of increased symptoms of PTSD. Longitudinal research would help establish the direction of this effect.

3.4.6. Future Research

Future research is required using clinically diagnosed PTSD individuals since the current study relied on a self-report measure and a non-clinical sample. Additionally, it could be useful to have a non-PTSD clinical group, potentially using participants with obsessive-compulsive disorder or generalised anxiety disorder. This would allow for exploration of whether the apparent benefit in active inhibition is unique to PTSD or can be shown in other disorders known for increased suppression.

It would also be interesting to investigate if these results are replicated when attentional demands of active inhibition paradigm are increased. Watson and Maylor (2002) investigated the effect of using moving distractor stimuli on the preview benefit in young and older adults. Older adults showed active inhibition to stationary distractor stimuli but were impaired for

moving distractors. It was suggested that older adults may have been impaired for moving stimuli since the processing of moving stimuli requires increased attentional capacity. It would therefore be interesting to see if the benefit in active inhibition in PTSD would be greater using a task of increased attentional demands or whether increasing task difficulty would remove the improvement due to potential PTSD and increased levels of PTSD symptoms. As well as investigating if the results differ with moving stimuli, it would also be interesting to see if trauma related stimuli cause the opposite result. As in the study by Catarino et al. (2015) discussed previously, they found individuals with PTSD showed worse suppression of trauma stimuli using a Think/No Think paradigm. Therefore, it would be interesting to see if using trauma stimuli results in an impairment on the active inhibition task in individuals with PTSD.

Chapter Four: General Discussion

4.1. Aims and Objectives

The original aim of this thesis was to identify measures that could be used to aid the detection of individuals under stress. Following necessary research changes due to COVID-19 restrictions, the focus of the thesis changed to looking at the associations of active inhibition with personality traits and PTSD symptoms. Chapter One reviewed previous measures used, which began with physiological methods, then psychological tasks and ended with inhibition paradigms. Chapter Two intended to assess the feasibility and ability of using four different measures (heart rate, heart rate variability, latent inhibition, and active inhibition) to detect change following two laboratory stress inductions. The restrictions imposed by the COVID-19 pandemic meant it was necessary to change the study design and move to online testing. Chapter Three aimed to identify if an online active inhibition paradigm was associated with symptoms of PTSD, and personality traits that have been proposed to increase the risk of developing PTSD.

4.2. Summary of Findings

The early termination of the Chapter Two study, due to the COVID-19 pandemic, limited the conclusions that could be made, although it still allowed for the preliminary evaluation of different physiological and psychological measures of stress. Both heart rate and heart rate variability were sensitive to the stress inductions, providing support for their use as objective measures. Latent inhibition appeared to be unaffected by the stress manipulations, which was unexpected based on the previous research study by Braunstein-Bercovitz et al. (2001). The findings using the active inhibition task were unclear, as no significant result was found. However, a small effect size was found for the number task manipulation, but in the opposite direction than hypothesised. More research is needed using these two tasks, potentially using more realistic stress manipulations, and a larger sample size to verify whether there is an effect of acute stress on the two inhibition tasks.

Further research is especially important for active inhibition, since the findings from the online study showed individuals who met the criteria for a provisional diagnosis of PTSD had greater active inhibition. Additionally, significant positive associations were found between PTSD symptom clusters (intrusions, avoidance, and alterations in cognition and mood) and active inhibition score. It was proposed that the possible explanation for the findings could be that

people with PTSD may have better suppression, due to practice of inhibiting intrusive thoughts and reminders associated with their trauma (Hayes et al., 2012; Hulbert & Anderson, 2018). This finding may show that, rather than individuals with PTSD having a deficit in inhibition, which was the main finding shown in previous research (DeGutis et al., 2015; Leskin & White, 2007; McFarlane et al., 1993), that on some tasks, they can suppress distractors, and show better inhibition. Although, as emphasised in the discussion of Chapter Three, future research must be conducted using individuals with formally diagnosed PTSD to confirm this.

4.4. Impact of COVID-19

It is important to reflect on the coronavirus pandemic, which occurred during the data collection for study one, and consider how the pandemic impacted on the online study research. In order to prevent the spread of coronavirus, in March 2020, the United Kingdom implemented a variety of "lockdown" restrictions, designed to prevent the spread of COVID-19 (White & Van Der Boor, 2020). This meant individuals were not allowed to leave their homes without a suitable reason, many people were unable to work and were unable to meet with friends and family. Additionally, there was the worry of contracting the virus and constant media reporting of COVID-19 cases and death rates.

In terms of the online study, the pandemic may have affected how people responded to certain items on the EPQ-R. This study was conducted during a unique time where restrictions that were introduced to control the spread of COVID-19, also had a negative impact on individuals' lives. Therefore, instead of answers representing solely personality traits, the feelings caused by the restrictions may have had an influence on responding on the EPQ-R, especially on the items about feeling fed-up/lonely, suffering from sleeplessness, and finding life dull. The average scores on the personality variables appeared to support this explanation, as participants in this study had increased scores for psychoticism and neuroticism, but a slightly lower mean score for extraversion, compared to the questionnaire norms. This potentially suggests that the personality results may have been affected by COVID-19.

Also, it was discussed in Chapter Three that more participants met symptom criteria for the potential PTSD group, than would be expected using prevalence rates of PTSD in the general population (Greenberg et al. 2015; Kessler et al., 2005). Due to the situation of COVID-19, it is likely, more people were at risk of experiencing a traumatic stressor, especially as the pandemic created novel stressors as reported in a very recent article by Bridgland et al. (2021). In their online study, they found that individuals reported having contact with the COVID-19

virus, media reports and the effects of lockdown as being traumatic stressors. Additionally, as with the EPQ-R, responding on items of the PCL-5 such as “difficulty concentrating” and “trouble falling or staying asleep?” may have been increased due to the situation of the pandemic. Although it is also likely that mental health difficulties are increased during a pandemic, which may explain increased reporting of PTSD symptoms. A rapid review conducted by Zürcher et al. (2020) reviewed 74 articles investigating mental health problems during virus epidemics and concluded epidemics can lead to a range of mental health problems including PTSD and stress-related symptoms, although the prevalence of mental health problems did vary among articles reviewed. Therefore, the data collected on the PCL-5 may have been affected by circumstances relating to the COVID-19 pandemic.

Aside from the effect of COVID-19 on the findings, it also affected the methodological choices made. The restrictions implemented due to the pandemic meant that the study in Chapter Three also provided insight into the feasibility of conducting the active inhibition task using online methods, which had not been researched previously. As well as implications related to individuals with PTSD, this study has also shown that an inhibitory active inhibition task can be used successfully online. This would make it easier to conduct cross-cultural studies and longitudinal research as the task is now easily accessible.

4.5. Future Research and Implications

In order to think about the future direction for research, it is important to consider the methodological choices made and how these related to the aims of the study. The first study was designed to be a pilot study, to provide initial evidence of potential measures that could be used to evaluate a resilience intervention. On reflection, despite finding expected changes in heart rate and heart rate variability results, the stressors chosen (the maths task and emotional films) appear to have acted as relatively mild stressors, based on the results with heart rate and heart rate variability. Although laboratory stressors have the advantage of high control, in order to better answer the effects of stress on the measures, more realistic or intense stressors might have generated a greater physiological response and thus provided more insight into the effectiveness of the measures to detect stress. An avenue of future research in stress literature could be to validate new stress paradigms that can be relatively easily implemented as current paradigms, such as the Trier Social Stress Test (Kirschbaum et al. 1993) are timely and require multiple researchers. The situation caused by the pandemic has led to development of innovative adaptions which may lead to standardised, easier-to-implement, paradigms. For

example, an online version of the Trier Social Stress Test, was successfully implemented with children (Gunnar et al., 2021). Additionally, the possibility of using smart phones as a method of stress induction has been explored (Pfeifer, Heyers, Ocklenburg & Wolf, 2021). Future research looking at how to adapt validated inducers of stress, that reduces the resources and time required to implement them would be beneficial.

In addition to the choice of stressors, some of the methodological choices made in relation to latent inhibition restricted the conclusions that could be drawn on the effects of stress on this measure. The results found in the study, opposed the finding by Braunstein-Bercovitz et al. (2001) and suggested that latent inhibition is not vulnerable to induced stress, an addition to latent inhibition and stress literature. Although an issue of the study design was that a non-pre-exposed group was not included for comparison to the pre-exposed group which would have better established the effect of latent inhibition under stress. Additionally, several variables and tasks, were included in the study which may have reduced the ability of inducing latent inhibition, since sufficiently simple study procedures are needed in latent inhibition studies (Byrom, Msetfi & Murphy, 2018). Future research is therefore needed using a simplified design, where stress is induced to half of participants and a control condition to the other half of participants and for both stress conditions, a non-pre-exposed and pre-exposed latent inhibition condition are included. This would provide a more suitable design to determine if latent inhibition is affected by stress.

For Study Two, active inhibition had not been researched in relation to PTSD symptomology before. This was an addition to the literature, as previous research in active inhibition has been in the visual psychology domain or focused on other individual differences, such as proneness to psychosis, age, and ADHD. Although active inhibition is a known phenomenon, the construct validity behind active inhibition is still debated in the literature. As discussed in Chapter One, there are different perspectives on active inhibition as either being a top-down process inhibiting old distractors (Watson et al. 2003) or one that requires bottom-up onset of attention on the new target stimuli (Donk & Theeuwes, 2001). If future research is conducted looking further into associations of PTSD and active inhibition, additional construct validation work of active inhibition tasks would provide further clarification of the exact nature of altered attentional inhibitory processes in PTSD.

Despite the online study providing a novel finding of the association of PTSD symptoms and active inhibition, one of the major limitations of the study was the fact that individuals with an

established diagnosis of PTSD were not chosen as participants and instead a non-clinical sample was used. This sample was chosen mainly due to practical reasons, but this does reduce the ability of this study to fully answer how PTSD symptoms are associated with active inhibition performance. The findings from the online study suggested that active inhibition task performance was positively related to PTSD symptoms (the opposite direction to what was expected). However, the sample chosen prevented strong conclusions to be made, since they did not have a confirmed diagnosis of PTSD. In order to better answer the aim of how PTSD affects active inhibition performance, using a sample of PTSD participants compared to non-PTSD participants, would be more appropriate. Furthermore, a measure that does not require self-report of PTSD symptoms would be beneficial as self-report has potential for participant error. Thus, a future study that uses the interview method of the Clinician-Administered PTSD Scale for DSM-5 (CAPS-5), which is the gold standard in PTSD assessment, could provide more valid PTSD vs No PTSD groups and better answer whether PTSD is associated with active inhibition.

Additionally, the design chosen for the online study was cross-sectional. This means it only looked at the association of PTSD symptoms with active inhibition scores, at one point in time. This type of study design is suitable for initial research looking at associations between variables and active inhibition task performance, which is what the online study aimed to provide. Although this methodology limits the conclusion that can be drawn on the causal influence on PTSD on active inhibition, since cross sectional studies cannot provide insight into a temporal association between two variables (Sedgwick, 2014). Therefore, the fact that PTSD symptoms correlated with active inhibition scores, does not provide evidence that PTSD symptoms cause heightened active inhibition. In order to fully answer if PTSD status alters scores on active inhibition, it would be beneficial to conduct a longitudinal design instead, which could be a potential direction for future research.

Longitudinal research could also allow for changes in active inhibition scores to be investigated following treatment. As discussed in Chapter One, Echiverri-Cohen et al. (2016) looked at changes in inhibitory ability following treatment using an attentional blink paradigm. They found that the attentional blink paradigm was able to be used as an indicator of treatment outcome for individuals that received exposure therapy. Although before the active inhibition task can be used in this manner, it would be important to clarify the nature of the benefit in individuals on active inhibition tasks. For example, whether the benefit in performance arises following development of PTSD, and if it is abolished following treatment. This would confirm

the extent that active inhibition could be used as a measure of psychological processing differences in people with PTSD. Therefore, longitudinal research would be an important avenue for future research, following studies with individuals with a clinical diagnosis of PTSD.

4.6. Closing Statement

The original aim of this thesis was looking at measures of stress. As explained, due to the COVID-19 restrictions, the research focus was adapted to be suitable for online research. This changed the focus and aim to instead investigating personality traits and PTSD symptoms that are associated with performance on an active inhibition task.

Heart rate and heart rate variability showed expected results of the effects of stress, supporting the use of these measures for stress. From the online study, the main achievement of this thesis was the finding that the use of a temporal inhibitory task, provided initial evidence, to suggest that individuals with potentially higher levels of PTSD may show better inhibition on an active inhibition task.

The ability to measure psychological processes affected by PTSD symptoms using objective measures is an important area of research. This could have potential benefits in improving understanding of the nature of inhibitory deficits in PTSD. Additionally, this task could possibly indicate psychological processing differences, which could be used in conjunction with self-report instruments and physiological measures to aid measurement of PTSD. Although, the ability of this task to identify individuals with PTSD, needs to be explored further in future research before these findings can have any clinical applications.

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Appendices

Appendix A. Study One: Demographic Questionnaire

Participant ID: _____ Experiment Date / Time: _____

Demographic Questionnaire - HRV Psychophysiological Experiment

Please answer the questions honestly. Your answers will remain anonymous.

Gender: Male / Female/Other **Age:** _____ **Psychology Student:** Yes/No

	YES	**NO**
1. Have you rushed in order to arrive on time for this experiment?	❒	❒
2. Have you taken part in any intensive physical activity in the past 24 hours? If yes please describe activity type and length.	❒	❒
3. When was the last time you exercised?		
4. Have you eaten in the past two hours?	❒	❒
5. Have you consumed any caffeine/theine-containing beverages in the past two hours?	❒	❒
6. How many hours have past since your last caffeinated drink? (If you have not had a caffeinated drink in the last 24 hours, tick more than 24 hours)	_____ ❒ More than 24 hours	
7. Have you consumed any alcoholic beverages in the past 24 hours?	❒	❒
8. Do you usually smoke?	❒	❒
If yes, please report the number of cigarettes you smoke on a daily basis.		
9. Have you smoked in the past two hours?	❒	❒
10. Do you currently take any medication?	❒	❒
If yes, please write down the name of the medication/s.		
11. For female participants, are you taking a form of oral contraceptive?	❒	❒
12. Do you have any known blood pressure conditions?	❒	❒
13. Did you follow your usual sleep routine last night?	❒	❒
14. When did you get up this morning?		
15. When did you go to sleep last night?		
16. Do you suffer from any mental health disorders, for example severe depression or anxiety disorder?	❒	❒
17. Do you have any chronic heart issues or respiratory conditions?	❒	❒
18. Do you need to use the bathroom?	❒	❒

Appendix B. Study One: Latent Inhibition Task Instructions

TASK 1.

In this task you will see two letters in the center of the screen. If the two letters are the same (e.g. TT or LL) press the left button (A), if they are different (TL or LT) press the right button (L)

A = LEFT L = RIGHT

Try and respond **as fast as you can**, without making many errors.

Press the space bar to proceed.

TASK 2

You are now starting a new task. In this task , anything you can see on the screen may be relevant. Some of the screens will be followed by the sound of a gunshot, while most will not. Your task is to try and predict the gunshots and earn points if you do. After each presentation press the left button (A) if you think there will NOT be a gunshot, and press the right key (L) if think there will be. As a help, most trials will not have a gunshot, so if you are unsure press the left key!

The gun is predicted by a rule and the rule is 100% true throughout the task.

A = NO GUNSHOT L = GUNSHOT

Try and respond as fast as you can, without making many errors.

Press the space bar to proceed.

Appendix C. Study One: Active Inhibition Task Instructions

INSTRUCTIONS

In this experiment we are going to show squares containing arrows

In each square there is one target red arrow pointing either left or right. The other red arrows will be pointing up or down

Your task is to decide if the target red arrow is pointing left (in which case press the A button for "left") or whether the red arrow is point right (in which case press the L button for "right")

The presentations are very brief and the red arrows may be accompanied by green arrows before or during their presentation

"Left" (A) "Right" (L)

Try to press as quickly as you can but also try to avoid making errors.

Press the space bar to proceed with the practice trials.

INSTRUCTIONS

That is the end of the practise.

The main experiment is the same but with more trials

The task will take around 3 minutes. Try to concentrate all the time.

"Left" (A) "Right" (L)

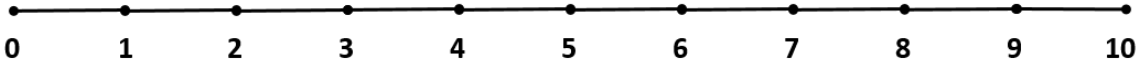
Try to press as quickly as you can but also try to avoid making errors.

Press the space bar to proceed with the main experiment.

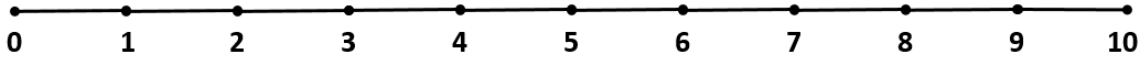
Appendix D. Study One: Visual Analogue Scales

Participant ID:

First Task Rating



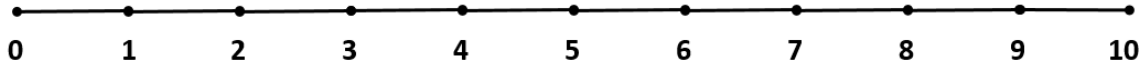
Not Stressed Extremely Stressed



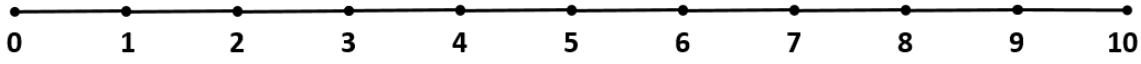
Not relaxed Extremely relaxed

Participant ID:

Video Task Rating



Not Stressed Extremely Stressed



Not relaxed Extremely relaxed

Appendix E. Study One: Ethical Permission Letter

28 January 2020

Dear IMOGEN HOPKINS, , , Professor Nicola Gray,

Re: 2730 , Physiological and Psychological Measures of Stress

Your application - https://swansea.forms.ethicalreviewmanager.com/ProjectView/Index/2730 - has been reviewed and approved by the Department of Psychology Ethics Committee.

The list of additional students (if any) are included in the table below:

Other student applicant - first name	Other student applicant - Surname	Other student applicant - email

additional researcher or student - first name	additional researcher or student - surname	additional researcher or student - email

The conditions of this approval are as follows:

1. To conduct your study strictly in accordance with the proposal that has been approved by the committee, including any approved amendments
2. To advise the ethics committee chair of any complaints or other issues that may warrant ethical review of the project
3. To submit for approval any changes to the approved protocol before implementing any such changes
4. To keep any information obtained from your participants absolutely confidential

Please note that failure to comply with these conditions of approval may result in the withdrawal of approval for the project.

To advertise your study on the departmental Participant Pool: You will need to send send a request for your study to be made visible, via the link on the Experiment Management System website (see Researcher Documentation for details). Please ensure that you attach this letter to your request. (If you are unable to attach the Ethics approval, send it in a separate email to Dr. Phil Tucker p.t.tucker@swan.ac.uk).

For students: Please ensure that the signed copy of this Ethical Approval, together with any other paperwork associated with your research, is included in your final write up.

Yours Sincerely,

Dr GABRIELA

JIGA-BOY

(Reviewer of

Application) Dr

Gabriela Jiga-Boy

(Committee Chair)

Appendix F. Study One: Experimental Protocol

Experimental Protocol:

Experimental condition:

Date/Time: _____ Participant ID: _____ Randomization code: _____

EXPERIMENT PROTOCOL	
Researcher instructions	Done?
AT LEAST ONE DAY BEFORE THE EXPERIMENT	
Send instructions via email regarding which rules to observe before the experiment (e.g. no food/caffeine 2 hours before).	
EXPERIMENT DAY: BEFORE PARTICIPANT ARRIVES	
Get water ready for the participant to stick the HRV belt on	
Put a ”do not disturb” sign on the lab door	
Check randomization order on randomization list	
Prepare documents related to the experiment: - Questionnaires + Visual analogue scales + HRV info sheet	
Get timer ready to record times 1. Plug in receiver 2. Check belt is connecting to the computer	
Prepare videos and maths test documents	
Check the volume of the computer and windows media player	
Check headphones	
WELCOME PARTICIPANT TO EXPERIMENT	
Explain procedure/ give information sheet/ any questions?	
Sign the informed consent form	
Ask the participant to turn off their mobile phone	
Fill out HRV demographic questionnaire	
HRV MEASUREMENT PREPARATION	
Ask participant to attach the HRV belt and leave the room	
Check HRV device is working	
PARTICIPANT TAKES SEAT IN FRONT OF THE COMPUTER	
Show short instruction sheet (limit movement, watch/rate videos etc..)	

BASELINE MEASUREMENT (3 min)	
Baseline recording start (at same time as playing baseline video)	**TIME:** _____:_____:_____
Baseline video end	**TIME:** _____:_____:_____
MATHS TASK (3 min)	
Questions start	**TIME:** _____:_____:_____
Questions end	**TIME:** _____:_____:_____
Hand out questionnaire (VAS): stress: _____ relax: _____	
INHIBITION TASK ONE (3 min/10 min)	
Play Software	
Task start	**TIME:** _____:_____:_____
Task end	**TIME:** _____:_____:_____
Stop HRV recording	**TIME:** _____:_____:_____
BASELINE MEASUREMENT TWO (3 min)	
Start HRV recording	**TIME:** _____:_____:_____
Baseline recording start (at same time as baseline video)	**TIME:** _____:_____:_____
Video end	**TIME:** _____:_____:_____
VIDEO TASK (3 min)	
Play Video in Windows Media Player	
Video start	**TIME:** _____:_____:_____
Video end	**TIME:** _____:_____:_____
Hand out questionnaire (VAS): stress: _____ relax: _____	
INHIBITION TASK TWO (3 min/10 min)	

Play Software

Task start	**TIME:** **_____:_____:_____**
Task end	**TIME:** **_____:_____:_____**
Stop HRV recording	**TIME:** **_____:_____:_____**

QUESTIONNAIRES
Fill out EPQ
Fill out MBI
Fill out PCL-5
RECOVERY
Play recovery video in Windows Media Player
Leave room while participant removes HRV device
Thank and debrief participant
STEPS AFTER THE EXPERIMENT
Clean HRV belt
Save Data and export data files to separate folder
Backup copy of data files

Appendix G. Study One: Information Sheet

PARTICIPANT INFORMATION SHEET

STUDY MEASURING HEART RATE VARIABILITY AND COGNITIVE PROCESSES

You are being invited to take part in some research. Before you decide whether or not to participate, it is important for you to understand why the research is being conducted and what it will involve. Please read the following information carefully.

What is the purpose of the research?

The purpose of the study is to inform the measures for research that will test the effectiveness of a PTSD resilience intervention. The research aims to test whether heart rate variability, and tests of cognition can be used as suitable measures in the intervention study. Your participation in this study will take approximately 60 minutes. The exclusion criteria are any participants with current mental health problems or who are taking psychotropic medication. Participants are requested to abstain from caffeine and alcohol two hours prior to the study.

Who is carrying out the research?

The data are being collected by Imogen Hopkins, from the psychology department within the College of Human and Health Sciences. The student is working under supervision of Professor Nicola Gray and Professor Paul Bennet. The research has been approved by the College of Human and Health Sciences Research Ethics Committee.

What happens if I agree to take part?

The study will be a one-off experiment and will take place at either Swansea University. Firstly, you will sign a paper consent form. We will ask you to attach a heart rate belt to your chest; this is a piece of equipment that can record information about your heartbeats during the experiment. You will watch a neutral video to allow a baseline recording of your heart to be taken. Then you will watch a video and complete a maths task, the order depending on your allocated condition. The video may contain emotional stimuli. Following this, you will complete a cognitive task that either involves either finding a shape within a set of shapes or having to predict whether a noise will occur. The whole experiment will take approximately 60 minutes. Additionally, we will ask you to complete some questionnaires; including demographic information, a personality questionnaire, a previous event questionnaire and questionnaire about your studies and your reactions to academic work. All data will be anonymous and may be available publicly consistent with open science.

Are there any risks associated with taking part?

The research has been approved by the College of Human and Health Sciences Research Ethics Committee. There are no significant risks associated with participation.

Data Protection and Confidentiality

Your data will be processed in accordance with the Data Protection Act 2018 and the General Data Protection Regulation 2016 (GDPR). All information collected about you will be kept strictly confidential. Your data will only be viewed by the researcher/research team.

All electronic data will be stored on a password-protected computer file at Swansea University. All paper records will be stored in a locked filing cabinet at Swansea University. Your consent

information will be kept separately from your responses to minimise risk in the event of a data breach.

Please note that the data we will collect for our study will be made anonymous at Swansea University, thus it will not be possible to identify and remove your data at a later date, should you decide to withdraw from the study. Therefore, if at the end of this research you decide to have your data withdrawn, please let us know before you leave.

What will happen to the information I provide?

An analysis of the information will form part of our report at the end of the study and may be presented to interested parties and published in scientific journals and related media. Note that all information presented in any reports or publications will be anonymous and unidentifiable.

Is participation voluntary and what if I wish to later withdraw?

Your participation is entirely voluntary – you do not have to participate if you do not want to. If you decide to participate, but later wish to withdraw from the study, then you are free to withdraw at any time, without giving a reason and without penalty.

Data Protection Privacy Notice

The data controller for this project will be Swansea University. The University Data Protection Officer provides oversight of university activities involving the processing of personal data, and can be contacted at the Vice Chancellors Office. Your personal data will be processed for the purposes outlined in this information sheet. Standard ethical procedures will involve you providing your consent to participate in this study by completing the consent form that has been provided to you. The legal basis that we will rely on to process your personal data will be processing is necessary for the performance of a task carried out in the public interest. This public interest justification is approved by the College of Human and Health Sciences Research Ethics Committee, Swansea University. The legal basis that we will rely on to process special categories of data will be processing is necessary for archiving purposes in the public interest, scientific or historical research purposes or statistical purposes.

How long will your information be held?

Data will be preserved and accessible for a minimum of 10 years after completion of the research. Records from studies with major health, clinical, social, environmental or heritage importance, novel intervention, or studies which are on-going or controversial should be retained for at least 20 years after completion of the study. It may be appropriate to keep such study data permanently within the university, a national collection, or as required by the funder's data policy.

What are your rights?

You have a right to access your personal information, to object to the processing of your personal information, to rectify, to erase, to restrict and to port your personal information. Please visit the University Data Protection webpages for further information in relation to your rights.

Any requests or objections should be made in writing to the University Data Protection Officer:

University Compliance Officer (FOI/DP)

Vice-Chancellor's Office

Swansea University, Singleton Park, Swansea, SA2 8PP; Email: dataprotection@swansea.ac.uk

How to make a complaint

If you are unhappy with the way in which your personal data has been processed you may in the first instance contact the University Data Protection Officer using the contact details above.

If you remain dissatisfied then you have the right to apply directly to the Information Commissioner for a decision. The Information Commissioner can be contacted at:

Information Commissioner's Office, Wycliffe House, Water Lane, Wilmslow, Cheshire, SK9 5AF; www.ico.org.uk.

What if I have other questions?

If you have further questions about this study, please do not hesitate to contact us:

Imogen Hopkins

Department of Health and Human Sciences

Swansea University

[redacted]

Professor Nicola Gray

Department of Health and Human Sciences

Swansea University

[redacted]

Appendix H. Study One: Consent Form

PARTICIPANT CONSENT FORM

STUDY MEASURING HEART RATE VARIABILITY AND COGNITIVE PROCESSES

Name and Contact details of the principal researcher

Imogen Hopkins
Department of Health and Human Sciences
Swansea University
[redacted]

Supervised by: Professor Nicola Gray
Department of Health and Human Sciences
Swansea University
[redacted]

	Participant initial
1. I (the participant) confirm that I have read and understand the information sheet for the above study (dated) which is attached to this form.	
2. I understand that my participation is voluntary and that I am free to withdraw at any time, without giving any reasons.	
3. I understand what my role will be in this research, and all my questions have been answered to my satisfaction.	
4. I understand that I am free to ask any questions at any time before and during the study.	
5. I have been informed that the information I provide will be safeguarded.	
6. I am happy for the information I provide to be used (anonymously) in academic papers and other formal research outputs.	
7. I have been provided with a copy of the Participant Information Sheet.	
8. I agree to the researchers processing my personal data in accordance with the aims of the study described in the Participant Information Sheet.	

Thank you for your participation in this study. Your help is very much appreciated.

Print name of participant	Signature	Date
Print name of researcher	Signature	Date

This study is being conducted by Swansea University, College of Human and Health Science.

Thank you for your participation in this study. Your help is very much appreciated.

Appendix I. Study One: Difficult Number Task Questions

Number Series Task 2

This number series task is a subscale of an intelligence test.

I will read out some number sequences which you can also see on the paper in front of you. The sequences of five numbers will vary according to a mathematical rule. There will be four possible answers and I need you to tell me which one is correct. I will read out the sequence and the possible answers and then you can answer. You cannot make any written calculations.

There is a time limit of 30 seconds per sequence. You will be informed when to move on if this time limit is reached and it will also be shown on your screen.

Sequence One

Start

1, 2, 4, 7, 11, __

a) 15
b) 16
c) 20
d) 13

Sequence Two

Start

1, 4, 9, 16, 25, __

a) 30
b) 45
c) 27
d) 36

Sequence Three

Start

39, 52, 65, 78, __

a) 100
b) 89
c) 91
d) 79

Sequence Four

Start

3, 13, 27, 45, 67, __

a) 91
b) 85
c) 93
d) 71

Sequence Five

Start

6, 20, 42, 72, 110, __

a) 150
b) 172
c) 134
d) 156

Sequence Six

Start

95, 73, 68, 32, 45, __

a) 21
b) 37
c) 54
d) 23

Sequence Seven

Start

16, 33, 44, 79, 121, __

a) 136
b) 153
c) 219
d) 188

Sequence Eight

Start

36, 59, 7, 29, 54, __

a) 27
b) 15
c) 26
d) 70

Sequence Nine

Start

3, 18, 20, 82, 83, __

a) 105
b) 7
c) 26
d) 58

Sequence Ten

Start

2, 2, 5, 8, 19, __

a) 22
b) 31
c) 28
d) 27

Sequence Eleven

Start

-75, -61, -47, -41, -33,_

a) -30
b) -32
c) -12
d) -3

Sequence Twelve

Start

2.0, 2.25, 2.32, 2.45, 2.48, _

a) 2.49
b) 3.55
c) 2.63
d) 3.0

Sequence Thirteen

Start

1.72, 3.63, 7.1, 14.5, 28.2, _

a) 31.5
b) 42
c) 32
d) 35

Sequence Fourteen

Start

1, 3.5, 4.7, 7.9, 11.4, __

a) 15.2
b) 18.1
c) 20.8
d) 12.1

Appendix J. Study One: Easy Maths Task Questions

Number Series Task 1

I will read out some number sequences which you will also see on the screen in front of you. The sequences of five numbers will vary according to a mathematical rule. There will be four possible answers and I need you to tell me which one is correct. I will read out the sequence and the possible answers and then you can answer.

Sequence One

5, 10, 15, 20, 25, __

a) 30
b) 32
c) 12
d) 35

Sequence Two

7, 9, 11, 13, 15, __

a) 14
b) 19
c) 17
d) 23

Sequence Three

204, 207, 210, 213, 216, __

a) 230
b) 223
c) 220
d) 219

Sequence Four

28, 24, 20, 16, 12, __

a) 6
b) 10
c) 0
d) 8

Sequence Five

99, 97, 95, 93, 91, __

a) 89
b) 90
c) 95
d) 87

Sequence Six

30, 37, 44, 51, 58, __

a) 65
b) 70
c) 74
d) 56

Sequence Seven

8, 16, 24, 32, 40, __

a) 60
b) 48
c) 56
d) 50

Sequence Eight

70, 60, 50, 40, 30, __

a) 10
b) 15
c) 20
d) 25

Sequence Nine

27, 26, 24, 21, 17, __

a) 18
b) 15
c) 10
d) 12

Sequence Ten

100, 91, 82, 73, 64, __

a) 50
b) 55
c) 45
d) 60

Sequence Eleven

-5, -10, -15, -20, -25,

a) -30
b) -32
c) -12
d) -35

Sequence Twelve

2.0, 2.2, 2.4, 2.6, 2.8, _

a) 2.9
b) 3.2
c) 3.0
d) 4.0

Sequence Thirteen

1.75, 3.5, 7, 14, 28, _

a) 56
b) 42
c) 32
d) 50

1, 3, 4, 7, 11, __

a) 15
b) 18
c) 20
d) 12

Sequence Fifteen

2, 4, 8, 16, 32, __

a) 48
b) 64
c) 60
d) 55

Appendix K. Study One: Font Task Questions

Font Task 1

We are looking at the identification of different computer letter fonts

You will be shown five numbers and you need to say the letter (a,b,c,d) for the number that is in a different font

You do not need to rush, just go at your own pace

Sequence One

1, 2, 4, 7, 11

a) 1
b) 2
c) 4
d) 7

Sequence Two

1, 4, 9, 16, 25

a) 16
b) 4
c) 25
d) 1

Sequence Three

39, 52, 65, 78, 91

a) 52
b) 39
c) 78
d) 65

Sequence Four

3, 13, 27, 45, 67

a) 67
b) 13
c) 3
d) 45

Sequence Seven

16, 33, 44, 79, 121

a) 44
b) 79
c) 121
d) 16

Sequence Eight

36, 59, 7, 29, 54

a) 59
b) 54
c) 36
d) 7

Sequence Five

6, 20, 42, 72, 110

a) 72
b) 42
c) 110
d) 6

Sequence Six

95, 73, 68, 32, 45

a) 45
b) 73
c) 32
d) 95

Sequence Nine

3, 18, 20, 82, 83

a) 18
b) 3
c) 83
d) 82

Sequence Ten

2, 2, 5, 8, 19

a) 5
b) 2
c) 19
d) 8

Sequence Eleven

-75, -61, -47, -41, -33

a) -61
b) -47
c) -41
d) -33

Sequence Twelve

2.0, 2.25, 2.32, 2.45, 2.48

a) 2.0
b) 2.32
c) 2.45
d) 2.48

Sequence Thirteen

1.72, 3.63, 7.1, 14.5, 28.2

a) 1.72
b) 3.63
c) 7.1
d) 14.5

Sequence Fourteen

1, 3.5, 4.7, 7.9, 11.4

a) 4.7
b) 11.4
c) 7.9
d) 3.5

Sequence Fifteen

15.2, 4.5, 8.1, 16.8, 33.5

a) 15.2
b) 4.5
c) 16.8
d) 33.5

Sequence Sixteen

3, 6, 11, 18, 27

a) 6
b) 18
c) 27
d) 3

Sequence Seventeen

-4, -1, 4, 11, 20

a) -1
b) -4
c) 20
d) 11

Sequence Eighteen

2, 8, 18, 32, 50

a) 2
b) 32
c) 18
d) 50

Sequence Nineteen

5, 20, 45, 80, 125

a) 5
b) 20
c) 45
d) 125

Sequence Twenty

2, 6, 12, 20, 30

a) 6
b) 2
c) 20
d) 30

Sequence Twenty One

10, 15, 22, 31, 42

a) 15
b) 22
c) 31
d) 42

Sequence Twenty Two

6, 15, 28, 45, 66

a) 15
b) 28
c) 45
d) 66

Sequence Twenty Three

8, 21, 50, 101, 180

a) 21
b) 50
c) 101
d) 180

Sequence Twenty Four

7, 9, 11, 13, 15

a) 7
b) 9
c) 11
d) 15

Sequence Twenty Five

204, 207, 210, 213, 216

a) 210
b) 213
c) 216
d) 207

Sequence Twenty Six

28, 24, 20, 16, 12

a) 16
b) 12
c) 20
d) 28

Sequence Twenty Seven

99, 97, 95, 93, 91

a) 99
b) 97
c) 95
d) 93

Sequence Twenty Eight

30, 37, 44, 51, 58

a) 30
b) 37
c) 44
d) 58

Sequence Twenty Nine

8, 16, 24, 32, 40

a) 8
b) 16
c) 24
d) 32

Sequence Thirty

27, 26, 24, 21, 17

a) 27
b) 26
c) 24
d) 21

Sequence Thirty One

100, 91, 82, 73, 64

a) 100
b) 91
c) 82
d) 73

Sequence Thirty Two

3, 9, 15, 45, 51

a) 3
b) 9
c) 15
d) 45

Sequence Thirty Three

4, 8, 9, 18, 19

a) 8
b) 9
c) 18
d) 19

Sequence Thirty Four

1, 3, 8, 24, 29

a) 1
b) 3
c) 8
d) 9

Sequence Thirty Five

4, 12, 7, 21, 16

a) 4
b) 12
c) 7
d) 21

Sequence Thirty Six

5, 15, 8, 24, 17

a) 5
b) 15
c) 24
d) 17

Sequence Thirty Seven

20, 22, 17, 19, 14

a) 20
b) 17
c) 19
d) 14

Sequence Thirty Eight

2, 4, -3, -6, -13

a) -3
b) -6
c) 4
d) -13

Sequence Thirty Nine

13, 17, 12, 16, 11

a) 17
b) 12
c) 16
d) 11

Sequence Forty

25, 28, 21, 24, 17

a) 28
b) 25
c) 21
d) 24

Appendix L. Study One: Debrief Form

DEBRIEF FORM

STUDY MEASURING HEART RATE VARIABILITY AND COGNITIVE PROCESSES

Thank you for taking part in our research. Now that your contribution has finished, let me explain the rationale behind this work.

We are interested in the validity and feasibility of different measures of stress and the research aims to test whether heart rate variability, latent inhibition and active inhibition can be used to measure stress. The purpose of the study is to inform the measures for research that will test the effectiveness of a PTSD resilience intervention.

Previous research has shown that heart rate variability is reduced in individuals with PTSD and can indicate psychological resilience. Latent inhibition has been chosen as a psychological measure because it has been found to be abolished under high stress. Active inhibition involves similar attentional processes to latent inhibition but there is limited research investigating the relationship of latent and active inhibition and the effects of stress on active inhibition. It is hypothesized that active inhibition will be reduced in the high stress group and results will be related to latent inhibition.

If you would like more detailed information on this topic please refer to …

- Watson, D. G., & Humphreys, G. W. (1997). Visual marking: prioritizing selection for new objects by top-down attentional inhibition of old objects. *Psychological review,* 104(*1*), 90-122
- Braunstein-Bercovitz, H., Dimentman-Ashkenazi, I., & Lubow, R. E. (2001). Stress affects the selection of relevant from irrelevant stimuli. *Emotion*, 1(*2*), 182-192
- Walker, F. R., Pfingst, K., Carnevali, L., Sgoifo, A., & Nalivaiko, E. (2017). In the search for integrative biomarker of resilience to psychological stress. *Neuroscience & Biobehavioral Reviews*, *74*, 310-320.

In this research, I am looking to check that our stress manipulations alter our dependent variables (heart rate variability, latent inhibition and active inhibition). In the experiment, participants either completed high or low stressful tasks prior to completing measures of stress. Additionally, the questionnaires were used collect to measure demographic information, personality traits and the impact of stressful events. We expected to find that following completing a high stress condition, participants will have reduced heart rate variability, reduced latent inhibition and increased active inhibition.

Your personal data will be processed for the purposes outlined in this information sheet. Standard ethical procedures will involve you providing your consent to participate in this study by completing the consent form that has been provided to you. Data will be preserved and accessible for a minimum of 10 years after completion of the research. Records from studies with major health, clinical, social, environmental or heritage

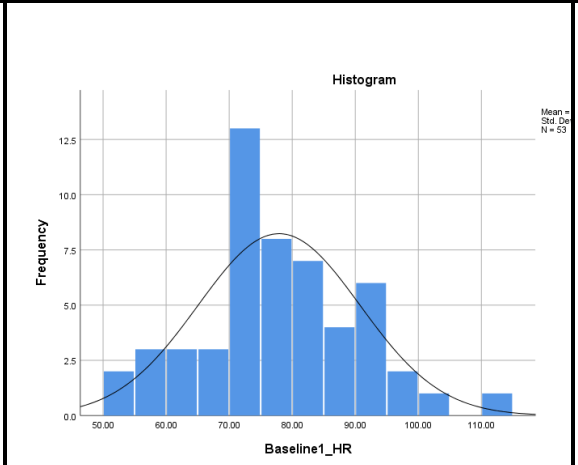
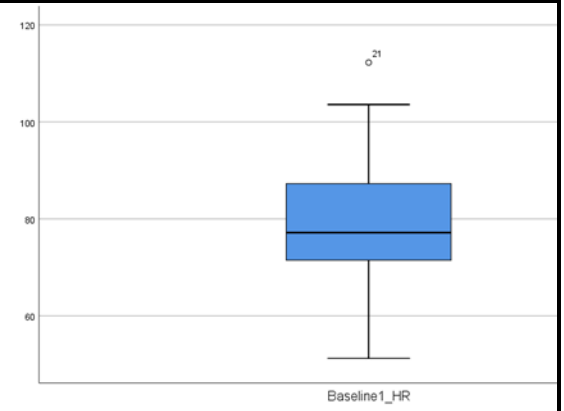
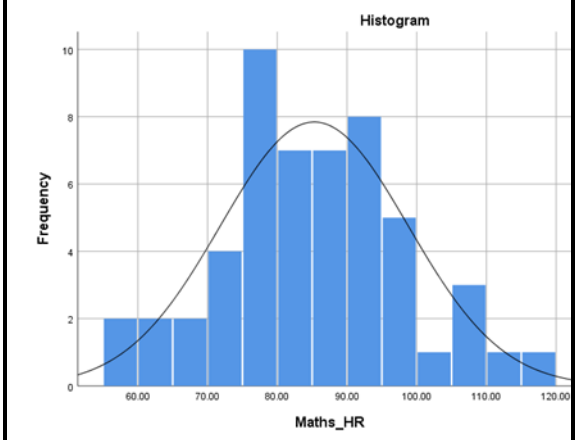
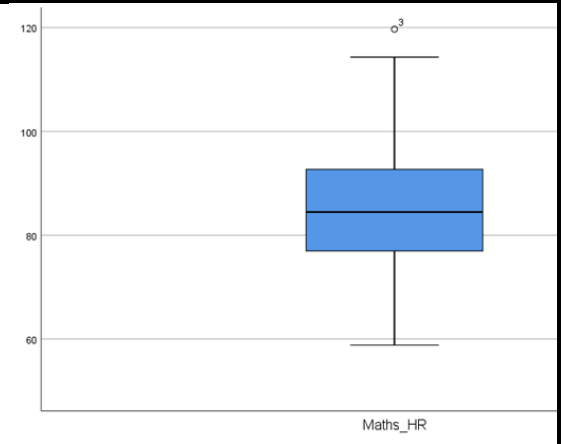
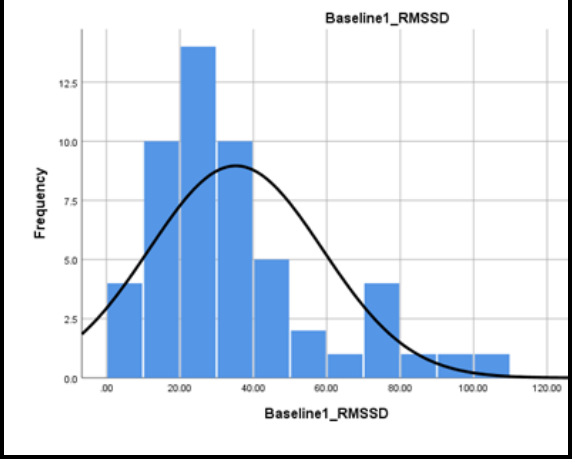
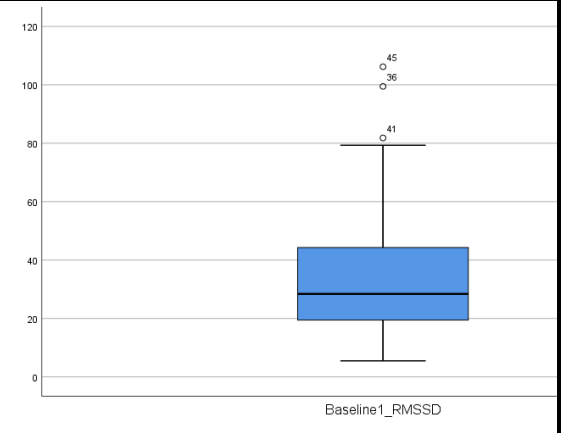
importance, novel intervention, or studies which are on-going or controversial should be retained for at least 20 years after completion of the study. It may be appropriate to keep such study data permanently within the university, a national collection, or as required by the funder's data policy.

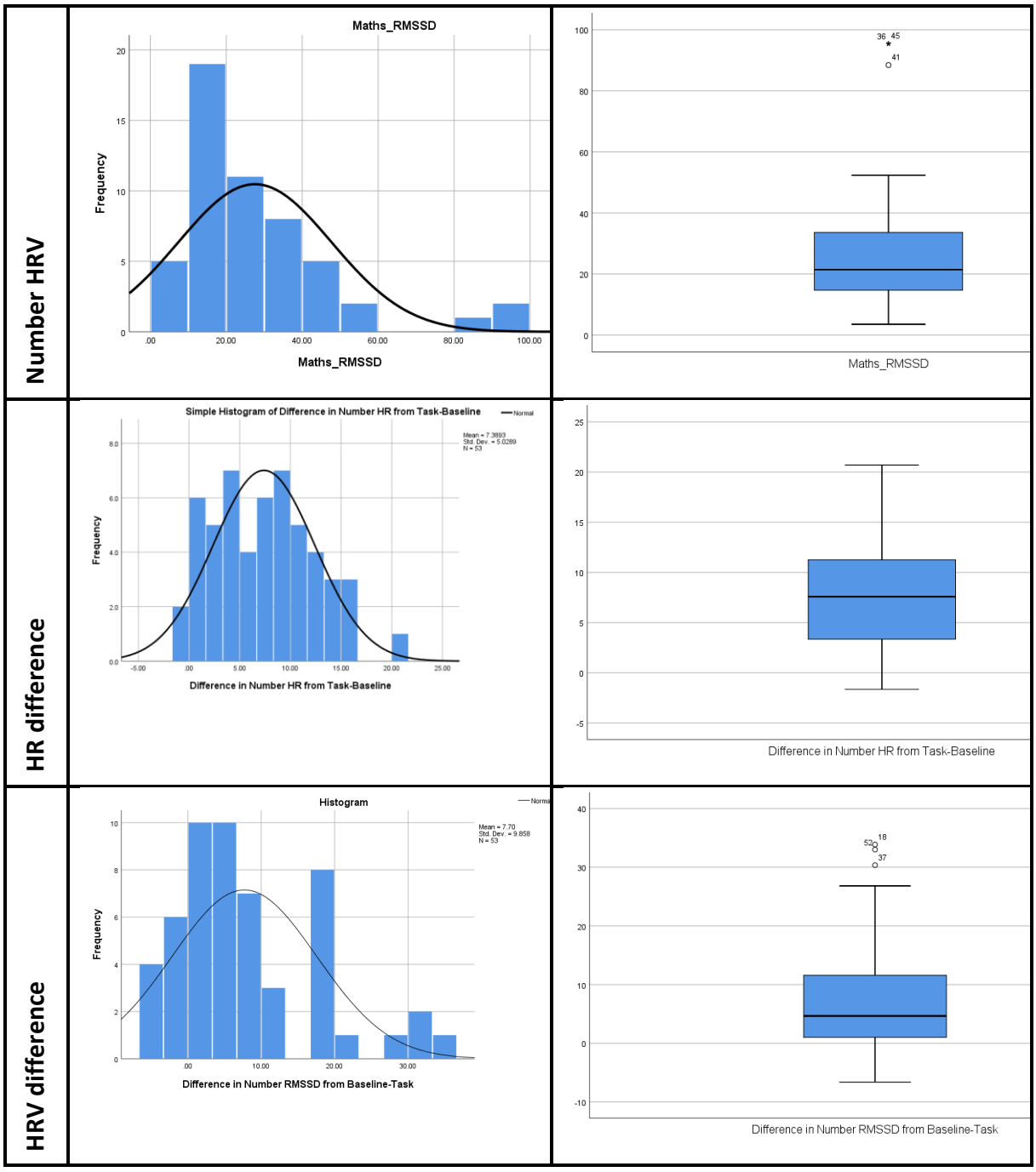
If you feel affected by issues raised by this research and would like to discuss any concerns, please contact the study supervisor on the details provided below. Participants in the high stress group were exposed to two stressors which are designed to temporarily induce stress. The duration of the stressor was short, and it is expected participants will recover quickly. A brief mood restoring video was presented at the end of the study to aid in restoring participant's mood. If you still feel stressed at the end of the study, please inform the researchers or the study supervisor. If you feel this piece of research may have health implications for you, we advise you to contact your GP (family doctor)

Imogen Hopkins
Department of Health and Human Sciences
Swansea University
[redacted]

Supervised by: Professor Nicola Gray
Department of Health and Human Sciences
Swansea University
[redacted]

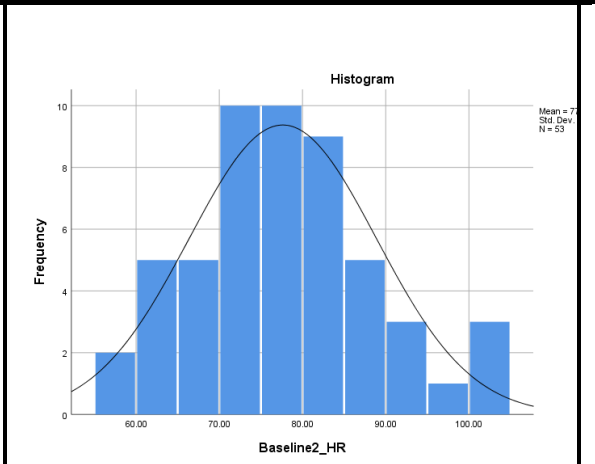
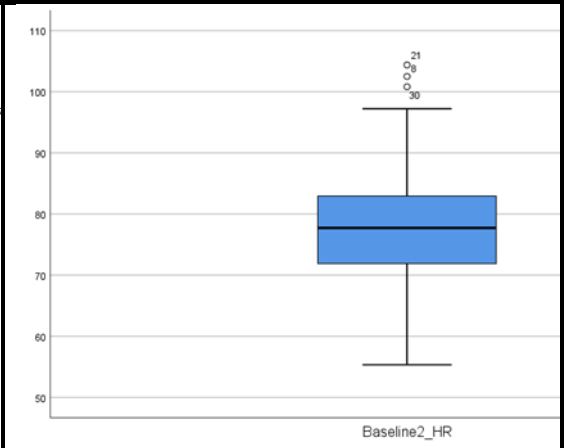
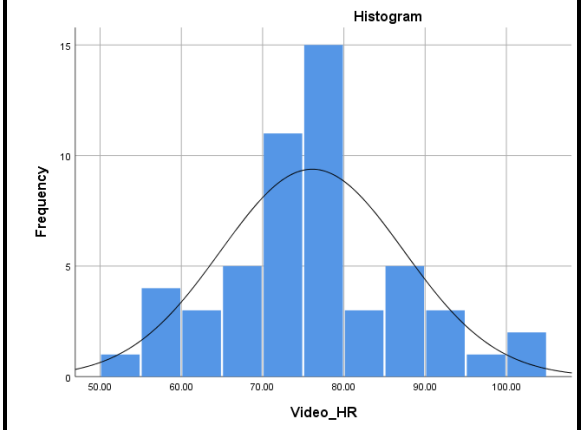
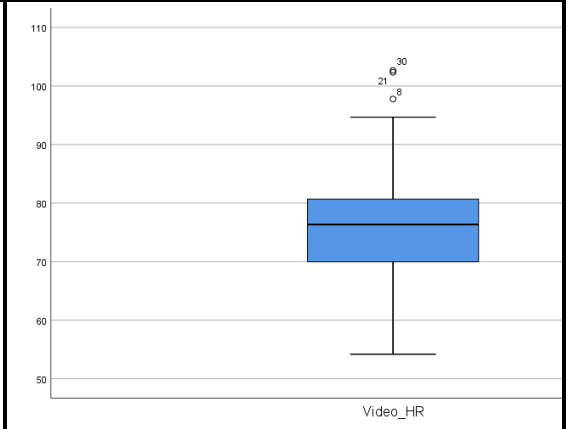
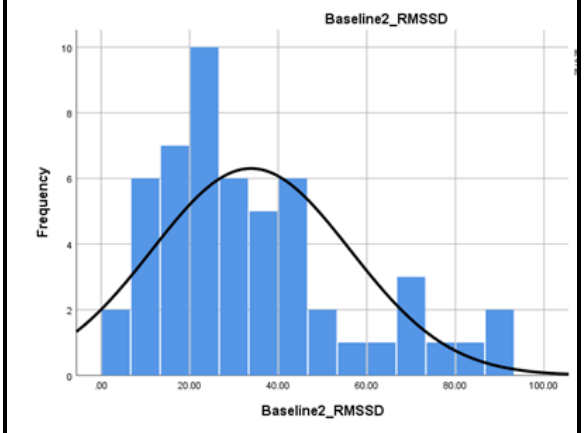
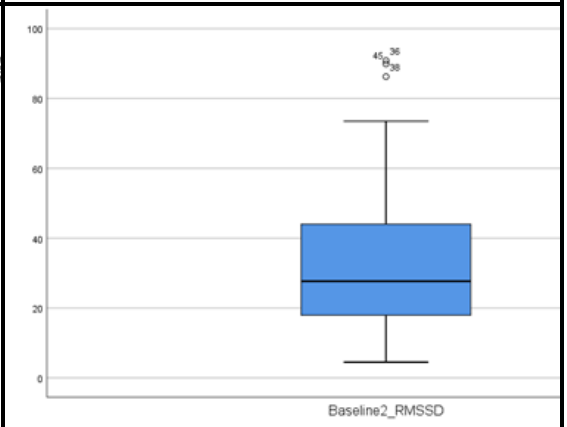
Appendix M. Study One: Box Plots and Histograms

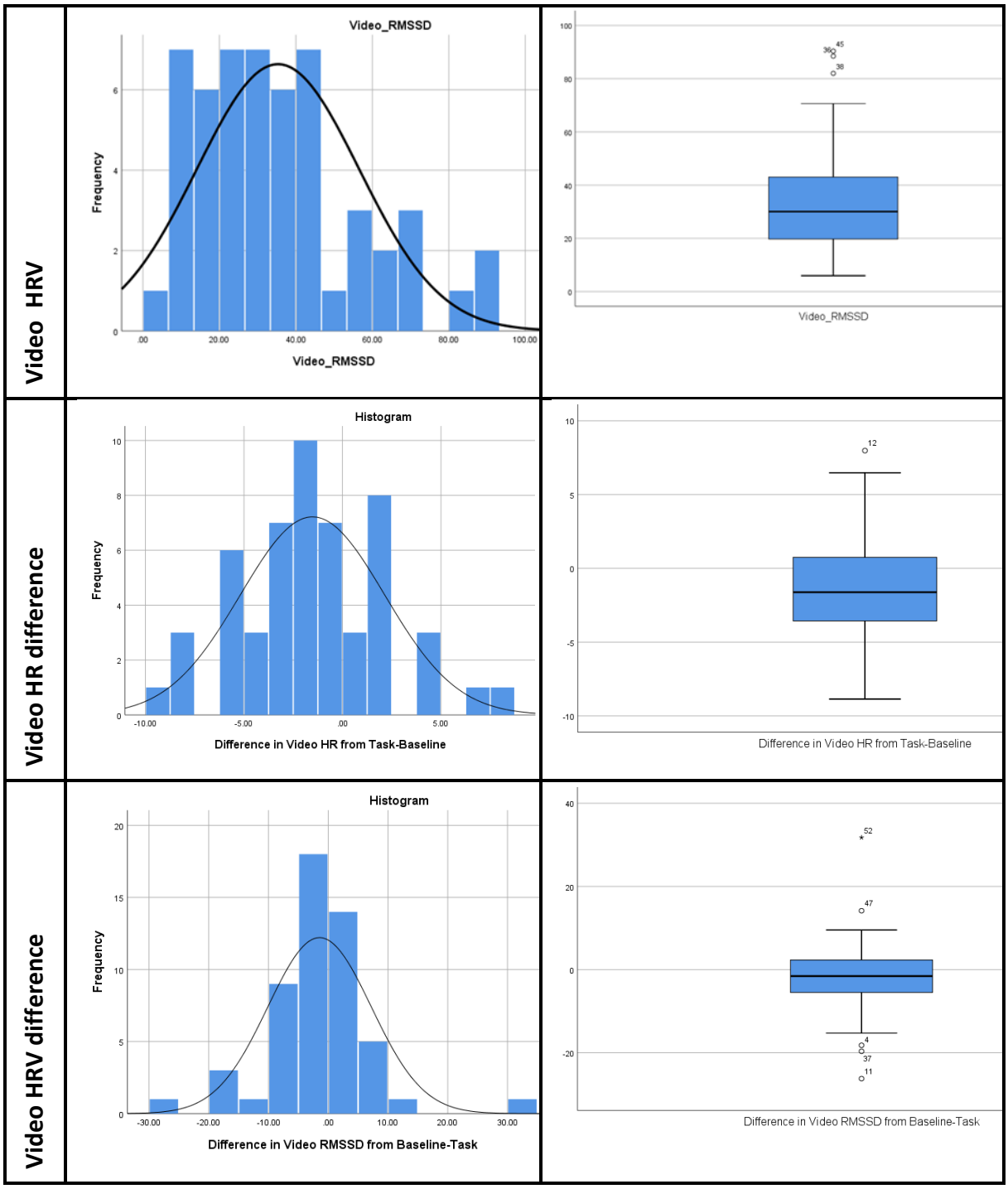
Number Task - Heart Rate and Heart Rate Variability		
Baseline 1 HR		
Number HR		
Baseline 1 HRV		



Note: Participants numbered: 3, 18, 21, 36, 37, 41, 45, 52 were removed from the analysis that used this data as showed outliers either two standard deviations above or below the mean

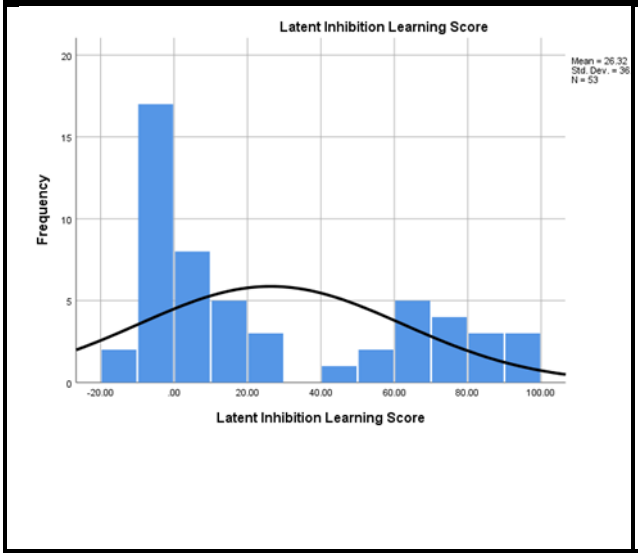
Video Task - Heart Rate and Heart Rate Variability

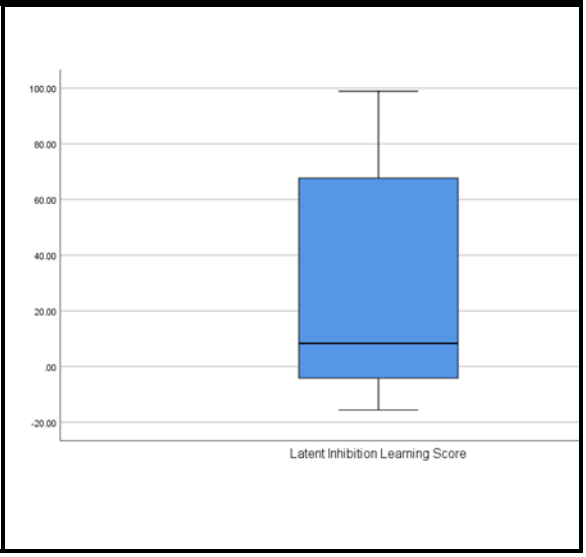
Baseline 2 HR		
Video HR		
Baseline 2 HRV		



Note: Participants numbered: 4, 8, 11, 12, 21, 30, 36, 37, 38, 45, 47, 52, were removed from the analysis that used this data as showed outliers either two standard deviations above or below the mean

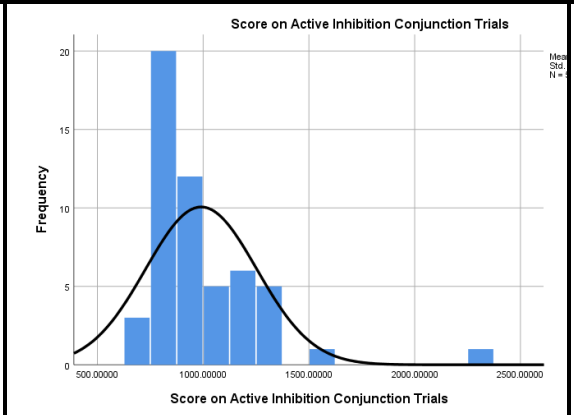
Latent Inhibition

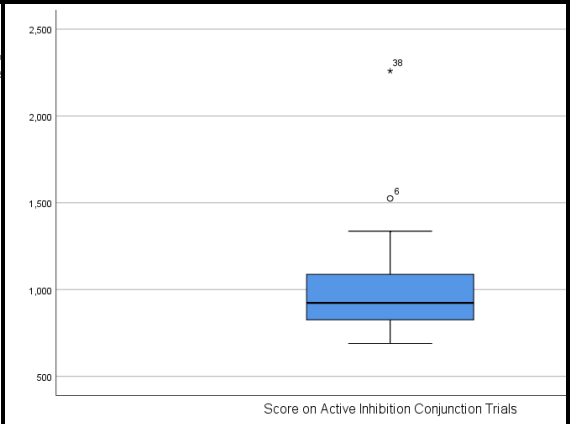




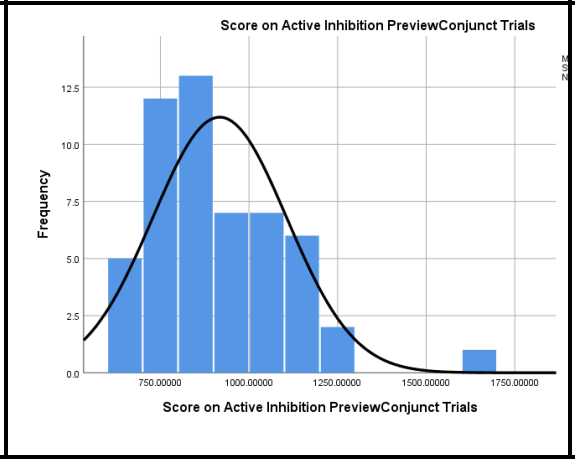
Active Inhibition

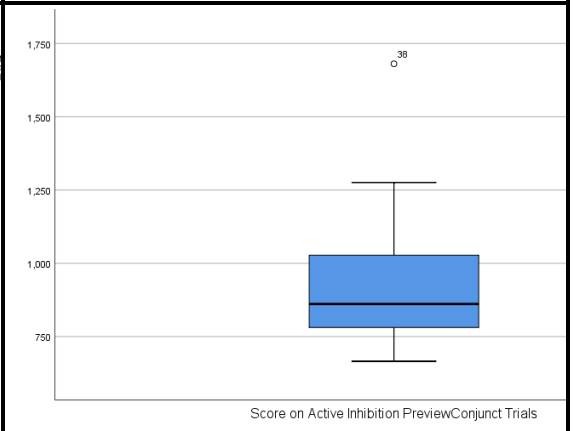
Conjunction

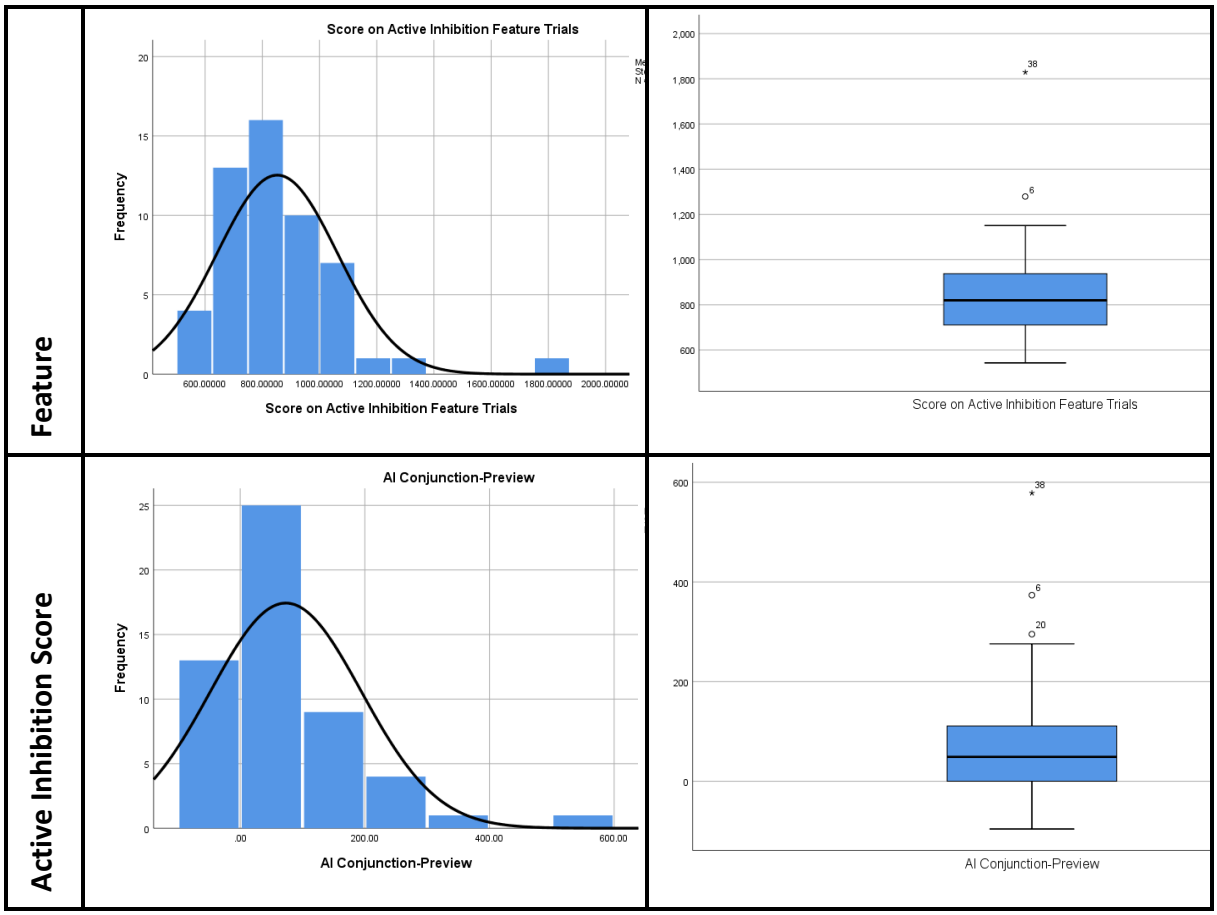




Preview







Note: Participants numbered: 6, 20, 38, were removed from the analysis that used this data as showed outliers either two standard deviations above or below the mean

Appendix N. Study One: Table showing participant size for the different stressors and measures in provide further information of outliers.

Table A1- Participant numbers for each measure and condition showing the new participant total once the outliers were removed and the easy maths task data was removed.

		Font task	**Easy Maths**	**Difficult Maths**	**Total**	**Ocean Video**	**Darkness Falls Video**	**Total**
HR and HRV	n	~~14~~ **13**	~~12~~	~~27~~ **20**	~~53~~ 33	~~27~~ 22	~~26~~ 19	~~53~~ 41
Latent Inhibition	n	7	~~6~~	13	~~26~~ 20	14	13	27
Active Inhibition	n	7	~~6 5~~	~~14~~ 12	~~27~~ 19	13	13	26

Note: Strikethrough is used to show previous participant size of the condition. All Easy maths participants were excluded from the number task and the only outlier for the easy number task was in the active inhibition data, which is why two numbers have been presented with strikethrough.

Appendix O. Study Two: Demographic Questionnaire

Questions about you

Instructions

Below are some general questions about yourself. Please answer them honestly. You can select or enter "prefer not to say" if you do not wish to answer a question.

1. Please enter your age

2. Please select your gender

Please Select...

3. Please select your ethnicity

Please Select...

4. Please select your employment status

Please Select...

Next

Appendix P – Study Two: EPQ-R

The first 10 questions are presented in the same format as shown on Gorilla.sc. The remaining questions are listed on a single line format to reduce space.

Personality Questionnaire

Please answer each question selecting either 'YES or 'NO' following the question. There are no right or wrong answers, and no trick questions. Work quickly and do not think too long about the exact meaning of the questions.

1. Do you have many different hobbies?

Yes	No

2. Do you stop to think things over before doing anything?

Yes	No

3. Does your mood often go up and down?

Yes	No

4. Have you ever taken the praise for something you knew someone else had really done?

Yes	No

5. Do you take much notice of what people think?

Yes	No

6. Are you a talkative person?

Yes	No

7. Would being in debt worry you?

Yes	No

8. Do you ever feel 'just miserable' for no reason?

Yes	No

9. Do you give money to charities?

Yes	No

10. Were you ever greedy by helping yourself to more than your share of anything?

Yes	No

11. Are you rather lively?	Yes	No
12. Would it upset you a lot to see a child or an animal suffer?	Yes	No
13. Do you often worry about things you should not have done or said?	Yes	No
14. Do you dislike people who don't know how to behave themselves?	Yes	No
15. If you say you will do something, do you always keep your promise no matter how inconvenient it might be?	Yes	No
16. Can you usually let yourself go and enjoy yourself at a lively party?	Yes	No
17. Are you an irritable person?	Yes	No
18. Should people always respect the law?	Yes	No
19. Have you ever blamed someone for doing something you knew was really your fault?	Yes	No
20. Do you enjoy meeting new people?	Yes	No
21. Are good manners very important?	Yes	No
22. Are your feelings easily hurt?	Yes	No
23. Are all your habits good and desirable ones?	Yes	No
24. Do you tend to keep in the background on social occasions?	Yes	No
25. Would you take drugs which may have strange or dangerous effects?	Yes	No
26. Do you often feel 'fed-up'?	Yes	No
27. Have you ever taken anything (even a pin or button) that belonged to someone else?	Yes	No
28. Do you like going out a lot?	Yes	No
29. Do you prefer to go your own way rather than act by the rules?	Yes	No
30. Do you enjoy hurting people you love?	Yes	No
31. Are you often troubled about feelings of guilt?	Yes	No
32. Do you sometimes talk about things you know nothing about?	Yes	No
33. Do you prefer reading to meeting people?	Yes	No
34. Do you have enemies who want to harm you?	Yes	No
35. Would you call yourself a nervous person?	Yes	No
36. Do you have many friends?	Yes	No
37. Do you enjoy practical jokes that can sometimes really hurt people?	Yes	No
38. Are you a worrier?	Yes	No
39. As a child did you do as you were told immediately and without grumbling?	Yes	No
40. Would you call yourself happy-go-lucky?	Yes	No
41. Do good manners and cleanliness matter much to you?	Yes	No
42. Have you often gone against your parents' wishes?	Yes	No
43. Do you worry about awful things that might happen?	Yes	No
44. Have you ever broken or lost something belonging to someone else?	Yes	No
45. Do you usually take the initiative in making new friends?	Yes	No
46. Would you call yourself tense or 'highly-strung'?	Yes	No
47. Are you mostly quiet when you are with other people?	Yes	No
48. Do you think marriage is old-fashioned and should be done away with?	Yes	No
49. Do you sometimes boast a little?	Yes	No
50. Are you more easy-going about right and wrong than most people?	Yes	No
For this question, please select "No" to show your attention	Yes	No
51. Can you easily get some life into a rather dull party?	Yes	No
52. Do you worry about your health?	Yes	No
53. Have you ever said anything bad or nasty about anyone?	Yes	No
54. Do you enjoy co-operating with others?	Yes	No
55. Do you like telling jokes and funny stories to your friends?	Yes	No
56. Do most things taste the same to you?	Yes	No
57. As a child were you ever cheeky to your parents?	Yes	No

58. Do you like mixing with people?	Yes	No
59. Does it worry you if you know there are mistakes in your work?	Yes	No
60. Do you suffer from sleeplessness?	Yes	No
61. Have people said that you sometimes act too rashly?	Yes	No
62. Do you always wash before a meal?	Yes	No
63. Do you nearly always have a 'ready answer' when people talk to you?	Yes	No
64. Do you like to arrive at appointments in plenty of time?	Yes	No
65. Have you often felt listless and tired for no reason?	Yes	No
66. Have you ever cheated at a game?	Yes	No
67. Do you like doing things in which you have to act quickly?	Yes	No
68. Is (or was) your mother a good woman?	Yes	No
69. Do you often make decisions on the spur of the moment?	Yes	No
70. Do you often feel life is very dull?	Yes	No
71. Have you ever taken advantage of someone?	Yes	No
72. Do you often take on more activities than you have time for?	Yes	No
73. Are there several people who keep trying to avoid you?	Yes	No
74. Do you worry a lot about your looks?	Yes	No
75. Do you think people spend too much time safeguarding their future with savings and insurance?	Yes	No
76. Have you ever wished that you were dead?	Yes	No
77. Would you dodge paying taxes if you were sure you could never be found out?	Yes	No
78. Can you get a party going?	Yes	No
79. Do you try not to be rude to people?	Yes	No
80. Do you worry too long after an embarrassing experience?	Yes	No
81. Do you generally 'look before you leap'?	Yes	No
82. Have you ever insisted on having your own way?	Yes	No
83. Do you suffer from 'nerves'?	Yes	No
84. Do you often feel lonely?	Yes	No
85. Can you on the whole trust people to tell the truth?	Yes	No
86. Do you always practice what you preach?	Yes	No
87. Are you easily hurt when people find fault with you or the work you do?	Yes	No
88. Is it better to follow society's rules than go your own way?	Yes	No
89. Have you ever been late for an appointment or work?	Yes	No
90. Do you like plenty of bustle and excitement around you?	Yes	No
91. Would you like other people to be afraid of you?	Yes	No
92. Are you sometimes bubbling over with energy and sometimes very sluggish?	Yes	No
93. Do you sometimes put off until tomorrow what you ought to do today?	Yes	No
94. Do other people think of you as being very lively?	Yes	No
95. Do people tell you a lot of lies?	Yes	No
96. Do you believe one has special duties to one's family?	Yes	No
97. Are you touchy about some things?	Yes	No
98. Are you always willing to admit it when you have made a mistake?	Yes	No
99. Would you feel very sorry for an animal caught in a trap?	Yes	No
100. When your temper rises, do you find it difficult to control?	Yes	No

Appendix Q. Study Two: PCL-5

The first 8 questions are presented in the same format as shown on Gorilla.sc. The remaining questions are listed in a plain text format to reduce space.

Stress Questionnaire

Instructions

Below is a list of problems that people sometimes have in response to a very stressful experience. Please read each problem carefully and then select the response to indicate how much you have been bothered by that problem **in the past month.**

1. Repeated, disturbing, and unwanted memories of the stressful experience?

Not at all	A little bit	Moderately	Quite a bit	Extremely

2. Repeated, disturbing dreams of the stressful experience?

Not at all	A little bit	Moderately	Quite a bit	Extremely

3. Suddenly feeling or acting as if the stressful experience were actually happening again (as if you were actually back there reliving it)?

Not at all	A little bit	Moderately	Quite a bit	Extremely

4. Feeling very upset when something reminded you of the stressful experience?

Not at all	A little bit	Moderately	Quite a bit	Extremely

5. Having strong physical reactions when something reminded you of the stressful experience (for example, heart pounding, trouble breathing, sweating)?

Not at all	A little bit	Moderately	Quite a bit	Extremely

6. Avoiding memories, thoughts, or feelings related to the stressful experience?

Not at all	A little bit	Moderately	Quite a bit	Extremely

7. Avoiding external reminders of the stressful experience (for example, people, places, conversations, activities, objects, or situations)?

Not at all	A little bit	Moderately	Quite a bit	Extremely

8. Trouble remembering important parts of the stressful experience?

Not at all	A little bit	Moderately	Quite a bit	Extremely

9. Having strong negative beliefs about yourself, other people, or the world (for example, having thoughts such as: I am bad, there is something seriously wrong with me, no one can be trusted, the world is completely dangerous)?

Not at All A little bit Moderately Quite a bit Extremely

10. Blaming yourself or someone else for the stressful experience or what happened after it?

Not at All A little bit Moderately Quite a bit Extremely

For this question, please select "Quite a bit" to show your attention

Not at All A little bit Moderately Quite a bit Extremely

11. Having strong negative feelings such as fear, horror, anger, guilt, or shame?

Not at All A little bit Moderately Quite a bit Extremely

12. Loss of interest in activities that you used to enjoy?

Not at All A little bit Moderately Quite a bit Extremely

13.Feeling distant or cut o" from other people?

Not at All A little bit Moderately Quite a bit Extremely

14.Trouble experiencing positive feelings (for example, being unable to feel happiness or have loving feelings for people close to you)?

Not at All A little bit Moderately Quite a bit Extremely

15.Irritable behavior, angry outbursts, or acting aggressively?

Not at All A little bit Moderately Quite a bit Extremely

16.Taking too many risks or doing things that could cause you harm?

Not at All A little bit Moderately Quite a bit Extremely

17.Being "superalert" or watchful or on guard?

Not at All A little bit Moderately Quite a bit Extremely

18.Feeling jumpy or easily startled?

Not at All A little bit Moderately Quite a bit Extremely

19.Having difficulty concentrating?

Not at All A little bit Moderately Quite a bit Extremely

20.Trouble falling or staying asleep?

Not at All A little bit Moderately Quite a bit Extremely

Appendix R. Study Two: Active Inhibition Task Instructions

It's now time to do the task!

Please sit about 60cm from your screen (this is about arm's length) and make sure you are in a quiet room where you will not be bothered by anything.

On the next page, you'll read some short instructions and then have a go at a practice trial of the task!

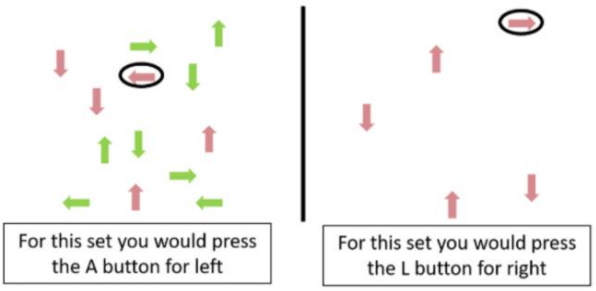
Press the space bar to continue

What to do:

You need to **find the red arrow** pointing either **left** or **right** in different images of red and green arrows or just red arrows.

Once you've found the red arrow, press either:
"A" key for an arrow pointing **Left** (using a left hand finger) or the
"L" key for an arrow pointing **Right** (using a right hand finger)

Press as quickly as you can, but try not to make any mistakes!



For this set you would press the A button for left

For this set you would press the L button for right

For each set you'll see a start screen with a star in the middle and sometimes some green arrows before the image with the red arrow.

Ignore all green arrows and any red arrows pointing up or down, you don't need to worry about them!

Let's have a one minute practice. You'll see a tick on the screen to show if you're right. 😊

Press the space bar to continue

Well done, you finished the practice!

Now it's time for the main task which is split into three blocks.

You won't see the ticks or crosses this time but will see your percentage of correct responses at the end of each block.

The whole task will take **less than 6 minutes** so please try to focus and press as quickly as you can. You can take a short break between each block if you need to.

Press the space bar to begin the real thing!

Appendix S. Study Two: Copy of Ethical Permission Letter

17 July 2020

Dear IMOGEN HOPKINS, , , Professor Nicola Gray,

Re: 2730 , Physiological and Psychological Measures of Stress

Your application - https://swansea.forms.ethicalreviewmanager.com/ProjectView/Index/2730 - has been reviewed and approved by the Department of Psychology Ethics Committee.

The list of additional students (if any) are included in the table below:

Other student applicant - first name	Other student applicant - Surname	Other student applicant - email

additional researcher or student - first name	additional researcher or student - surname	additional researcher or student - email

The conditions of this approval are as follows:

1. To conduct your study strictly in accordance with the proposal that has been approved by the committee, including any approved amendments
2. To advise the ethics committee chair of any complaints or other issues that may warrant ethical review of the project
3. To submit for approval any changes to the approved protocol before implementing any such changes
4. To keep any information obtained from your participants absolutely confidential

Please note that failure to comply with these conditions of approval may result in the withdrawal of approval for the project.

To advertise your study on the departmental Participant Pool: You will need to send send a request for your study to be made visible, via the link on the Experiment Management System website (see Researcher Documentation for details). Please ensure that you attach this letter to your request. (If you are unable to attach the Ethics approval, send it in a separate email to Dr. Phil Tucker p.t.tucker@swan.ac.uk).

For students: Please ensure that the signed copy of this Ethical Approval, together with any other paperwork associated with your research, is included in your final write up.

Yours Sincerely,

Dr GABRIELA JIGA-

BOY (Reviewer of

Application) Dr Gabriela

Jiga-Boy (Committee

Chair)

Appendix T. Study Two: Information Sheet

Personality and Resilience

This study is looking at interactions between different forms of personality measures and resilience to stress. Taking part in this study is voluntary and you can withdraw at any point. You must be aged 18 or above to take part.

The study will be conducted online. Firstly, be asked to provide some information about yourself (e.g. age, gender). You will complete a computer task that involves finding a red arrow within groups of other arrows. You will also complete three personality questionnaires. The whole study will take less than 25 minutes.

As a thank you for completing the study, you will have the opportunity to enter a raffle to have a chance to **win an Amazon voucher prize: £20 for 1st prize, £10 for 2nd prize and £5 for 3rd prize.** To enter the raffle, you will need to provide your email address. Your email address will only be used for the raffle and this will be stored in a separate file. All responses will be kept anonymous.

The data is being collected by Imogen Hopkins, under the supervision of Professor Nicola Gray and Professor Paul Bennett. This research has been approved by the Research Ethics Committee, College of Human and Health Sciences, Swansea University

Show GDPR/data Information and Complaint Contact Information

If you have further questions about this study, please contact us:

Imogen Hopkins College of Health and Human Sciences Swansea University [redacted]	Professor Nicola Gray College of Health and Human Sciences Swansea University [redacted]

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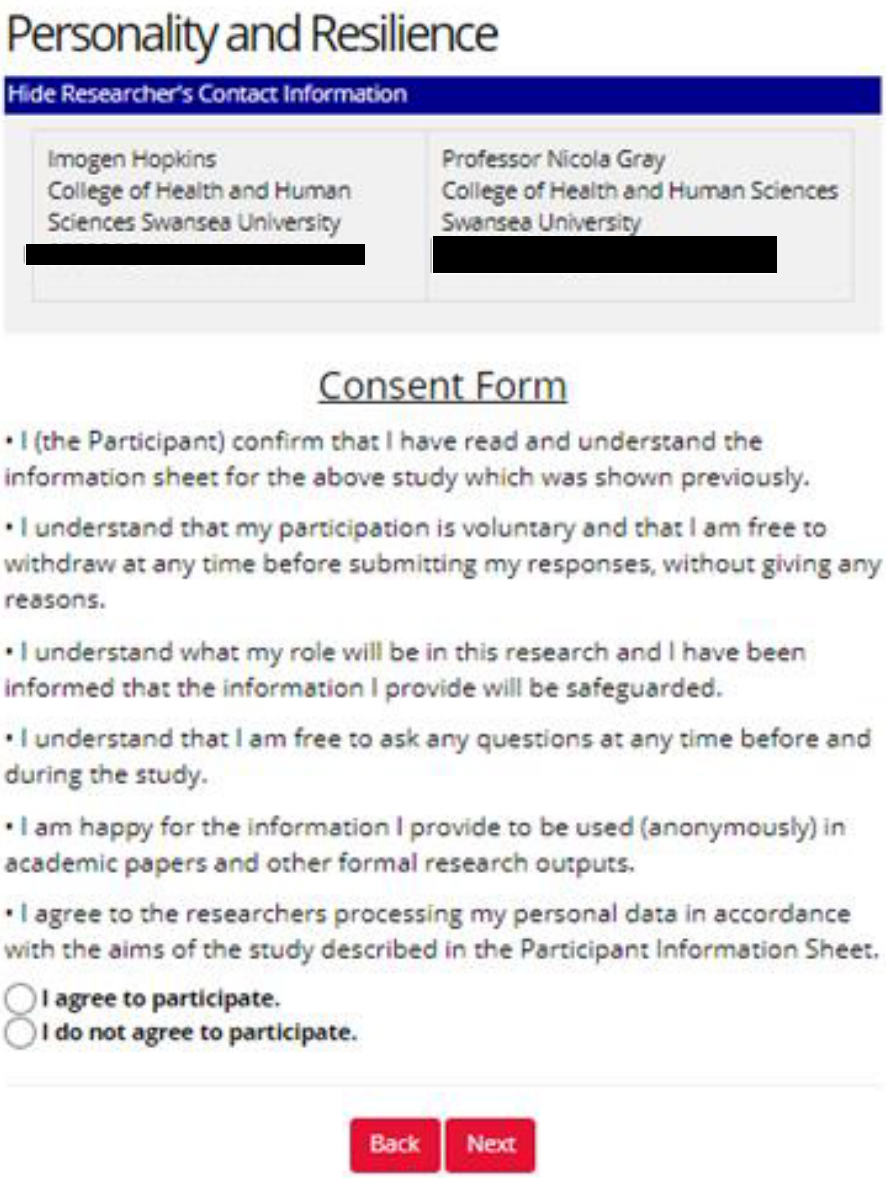
Appendix U. Study Two: Consent Form



Personality and Resilience

Hide Researcher's Contact Information

Imogen Hopkins
College of Health and Human Sciences Swansea University
[redacted]

Professor Nicola Gray
College of Health and Human Sciences
Swansea University
[redacted]

Consent Form

- I (the Participant) confirm that I have read and understand the information sheet for the above study which was shown previously.
- I understand that my participation is voluntary and that I am free to withdraw at any time before submitting my responses, without giving any reasons.
- I understand what my role will be in this research and I have been informed that the information I provide will be safeguarded.
- I understand that I am free to ask any questions at any time before and during the study.
- I am happy for the information I provide to be used (anonymously) in academic papers and other formal research outputs.
- I agree to the researchers processing my personal data in accordance with the aims of the study described in the Participant Information Sheet.

◯ **I agree to participate.**
◯ **I do not agree to participate.**

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Appendix V – Study Two: Debrief Form

Personality and Resilience

Debrief Form

Please make sure to click Next (on the bottom of the page) after reading this form so your data is saved.

For SurveyCircle users (www.surveycircle.com): The Survey Code is: W7TH-M747-FKY7-6C1J

Thank you for taking part in our research. Now that your contribution has finished, let me explain the rationale behind this work.

The task involved finding the red target arrow and to ignore the other distractor items. Sometimes we showed some of these distractors just before the target item. Some people are able to use this "preview" to make the task easier and we think this ability might be related to levels of stress and personality. We will therefore examine if this is the case by comparing this to scores on the personality measure and the stress measures.

An analysis of the information will form part of our report and may be presented to interested parties and published in scientific journals and related media. Note that all information presented in any reports or publications will be anonymous. Data will be preserved and accessible for a minimum of 10 years after completion of the research.

For any queries or questions please contact Imogen Hopkins or Professor Nicola Gray on the contact details on the details provided below.

Imogen Hopkins College of Health and Human Sciences Swansea University [redacted]	Professor Nicola Gray College of Health and Human Sciences Swansea University [redacted]

Close Sources of support

Samaritans

Samaritans are a confidential listening service. They offer a safe place to talk about any difficulties you may be experiencing. Contact them on 116 123, the number is free to call and they have people working 24 hours a day, 365 days a year. You can also e-mail them at jo@samaritans.org or visit their website at samaritans.org/how-we-can-help-you

MIND

Mind is a mental health charity in England and Wales. Founded in 1946 as the National Association for Mental Health, Mind offers information and advice to people with mental health problems https://www.mind.org.uk/information-support/

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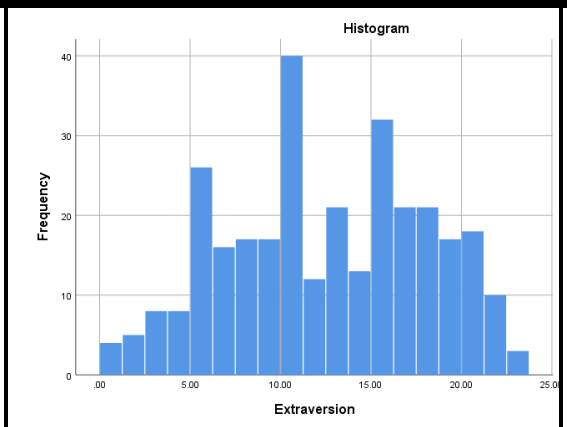
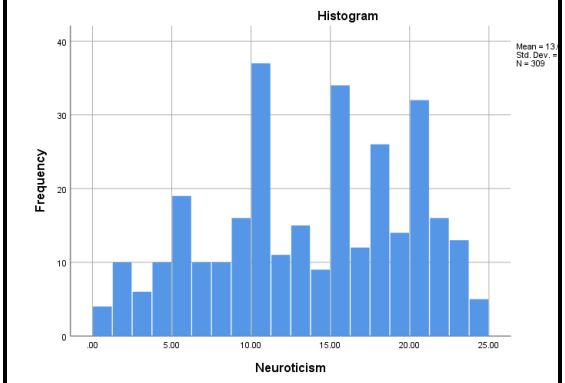
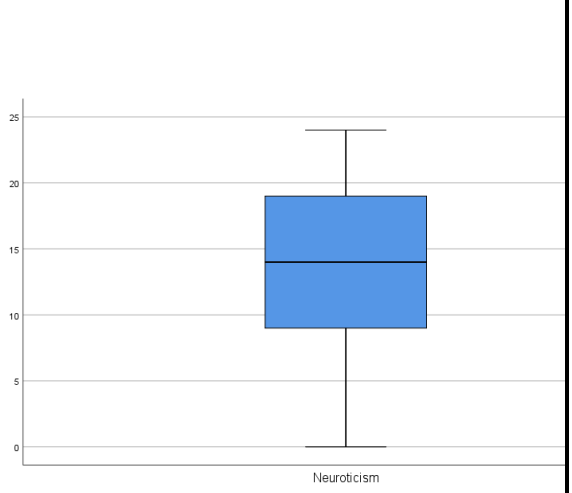
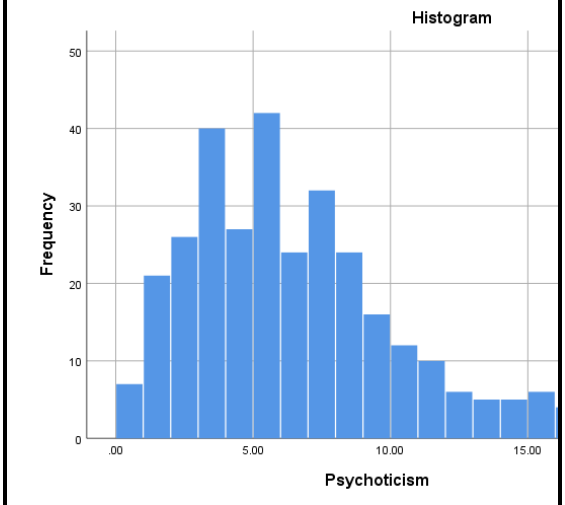
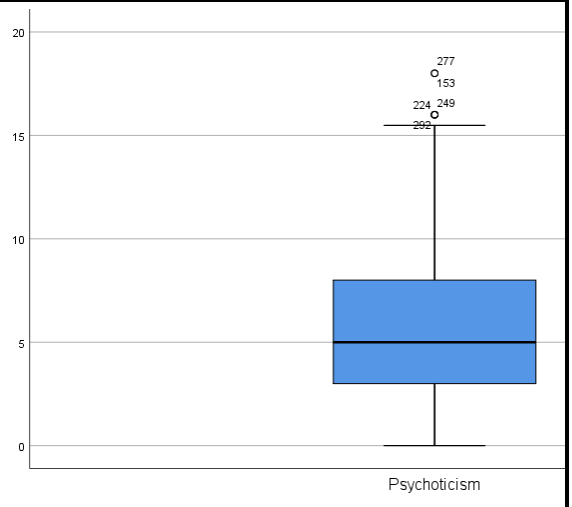
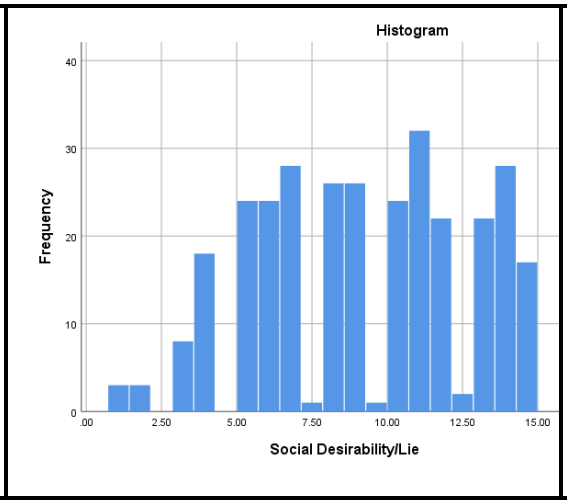
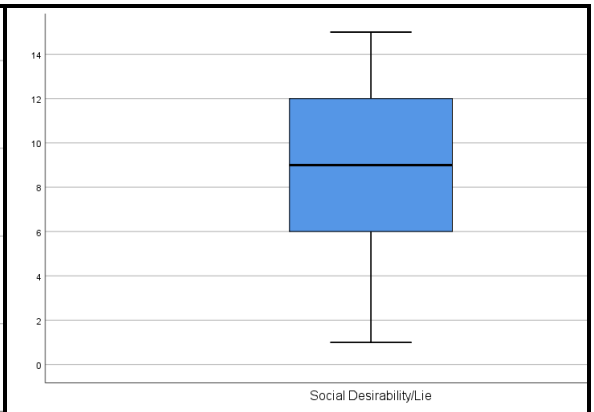
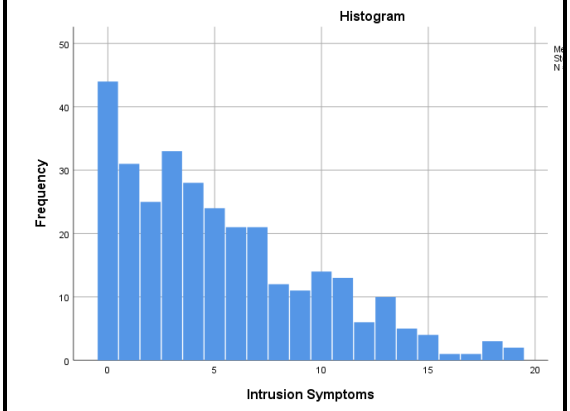
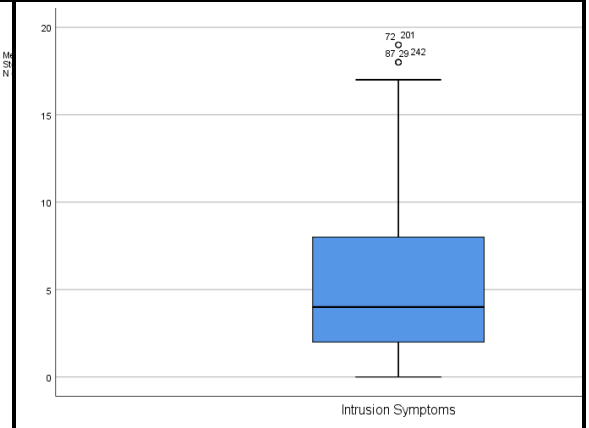
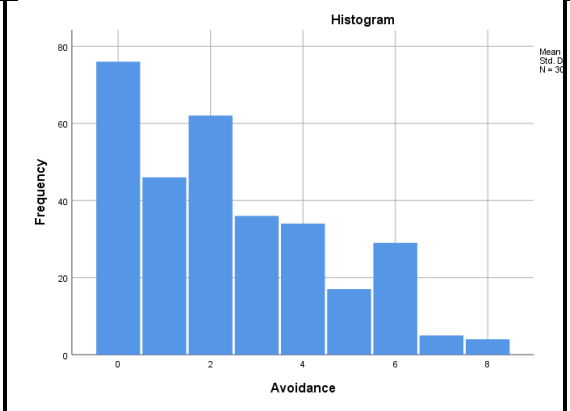
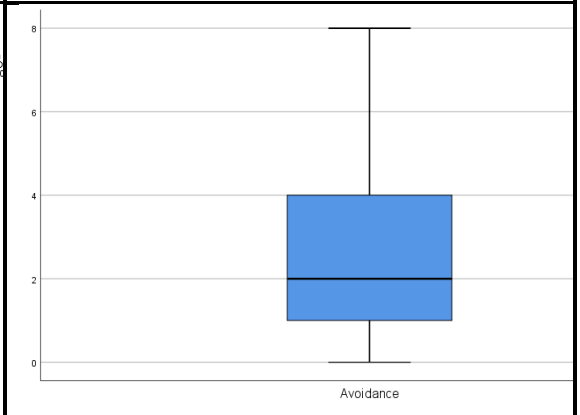
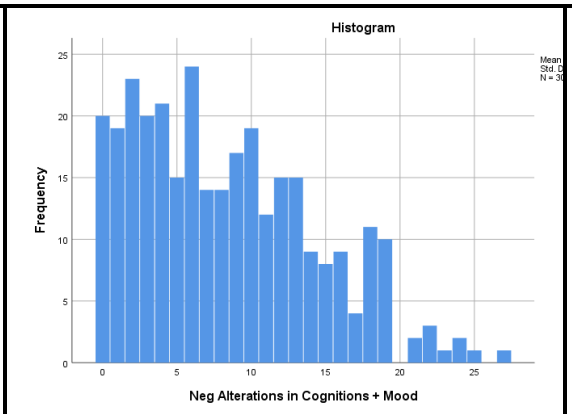
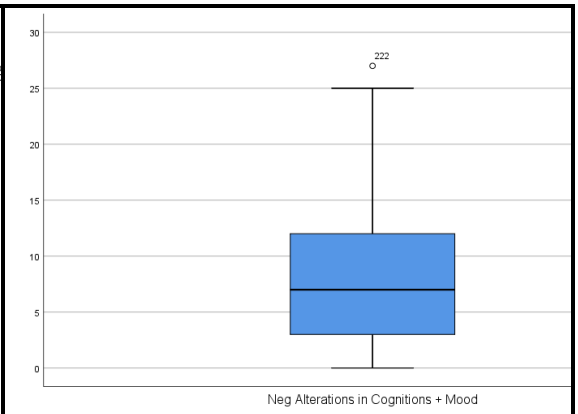
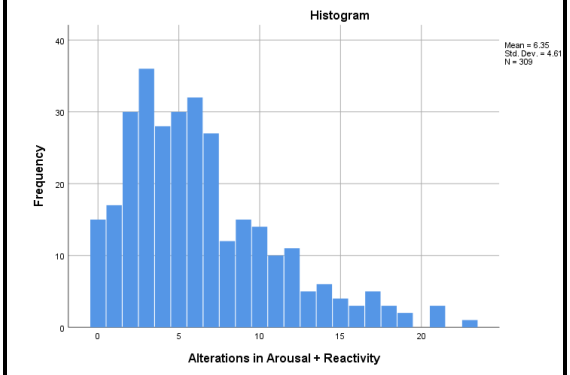
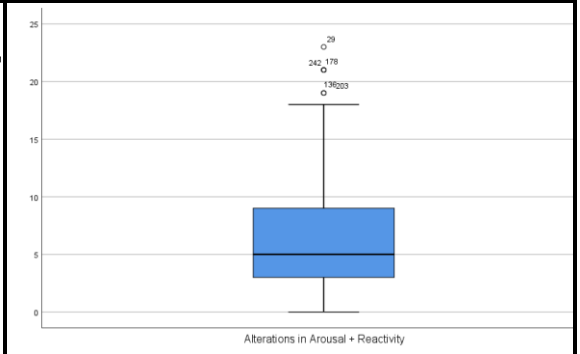
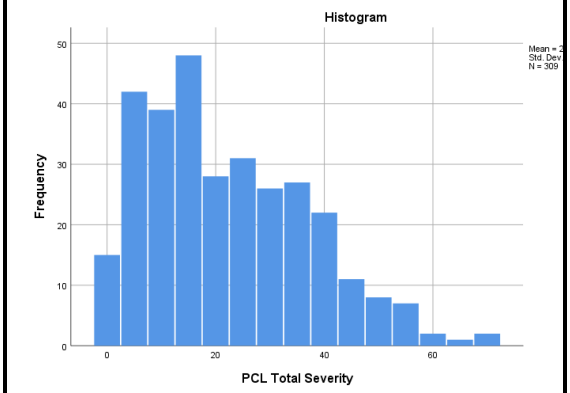
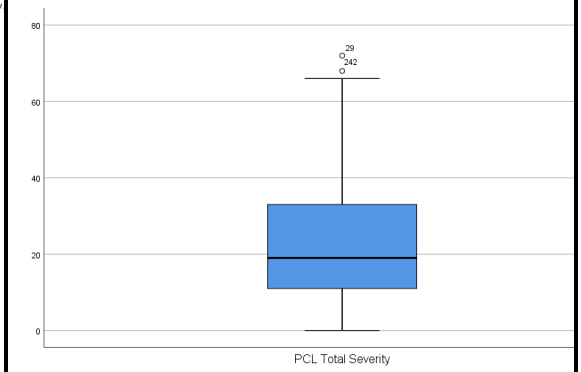
Appendix W. Study Two: Box Plots and Histograms

EPQ Variables		
Extraversion		
Neuroticism		
Psychoticism		

Lie Scale		

Note: No participants were removed from the analysis that used this data as high scorers were of interest to the analysis

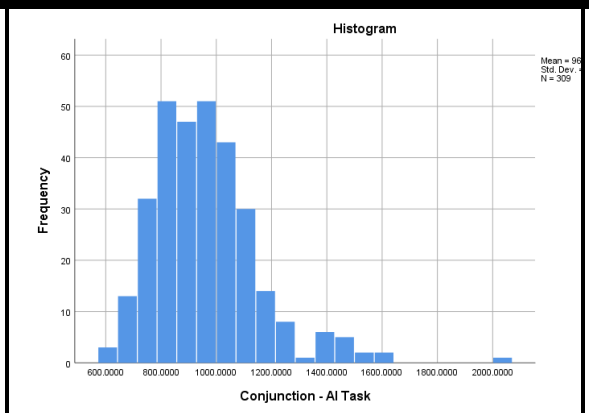
PCL-5 Variables		
Intrusion		
Avoidance		

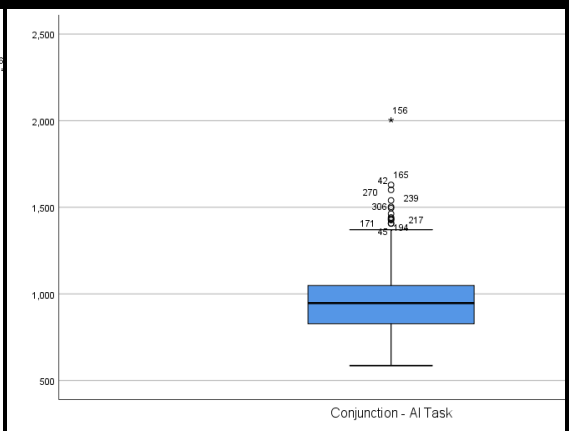
Neg alterations in cog and mood		
Neg alterations in arousal & reactivity		
Total PTSD Severity		

Note: No participants were removed from the analysis that used this data as high scorers were of interest to the analysis

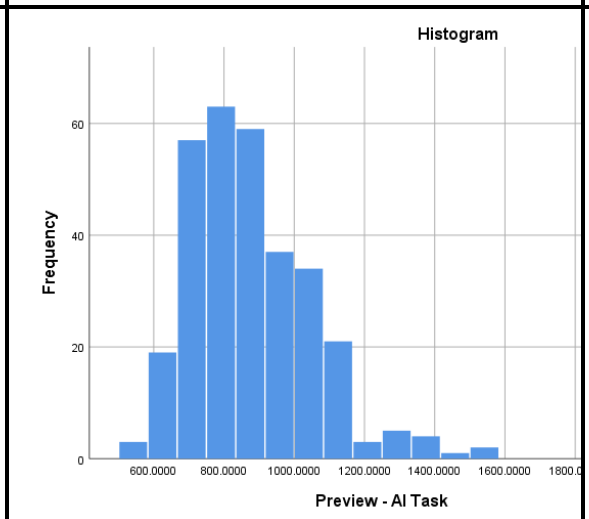
Active Inhibition Variables

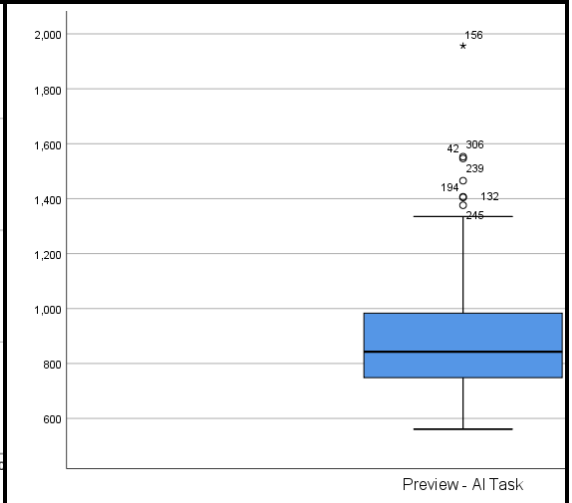
Conjunction



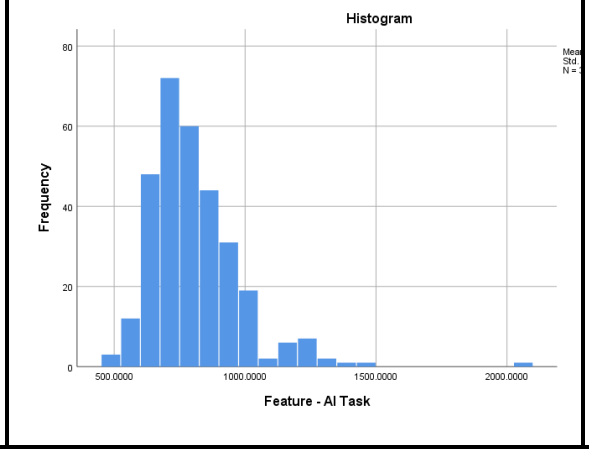


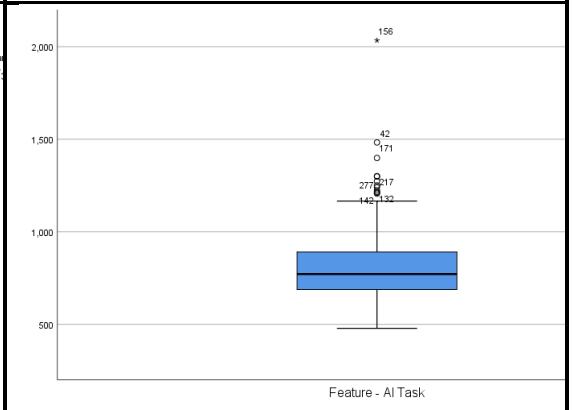
Preview

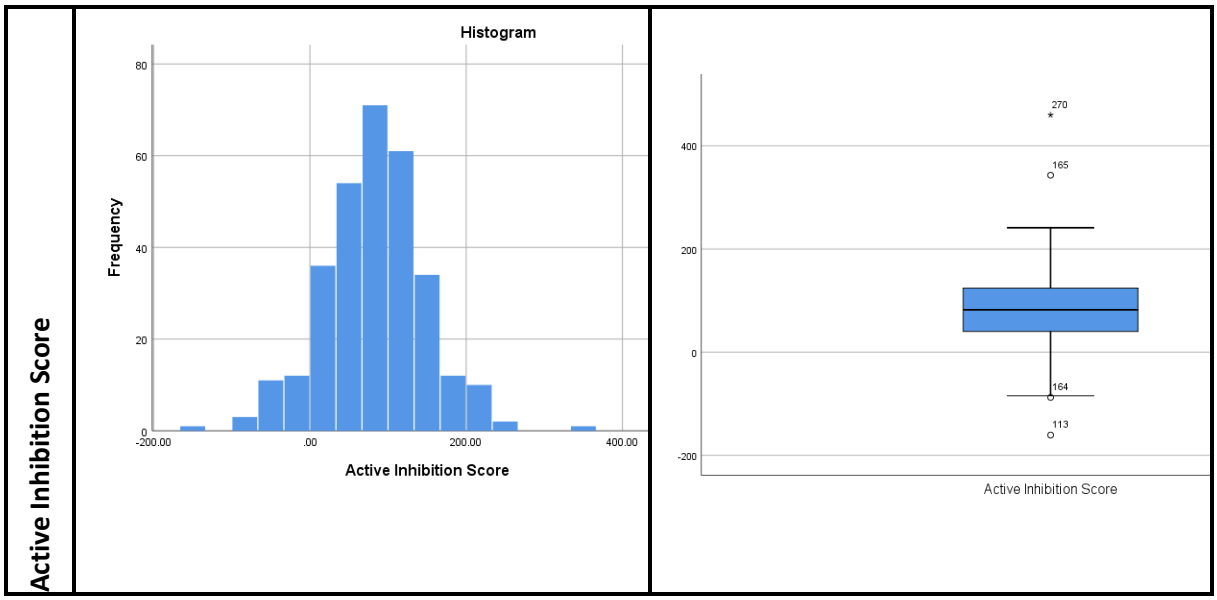




Feature







Note: Participants numbered: 42, 45, 113, 132, 142, 156, 164, 165, 171, 194 217, 239, 245, 270, 277, 306 were removed from the analysis that used this data as showed outliers either two standard deviations above or below the mean