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Are you threatening me?: Exploration of generalised anxiety and social anxiety's influence on responses to social and non-social threats.

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Abstract

Anxiety disorders are some of the most prevalent disorders in modern times and often seriously impact the daily lives of sufferers. Although there is an abundance of research investigating potential links between anxiety and threat response, there is a lack of study into the nuanced relationships between different anxiety types and threat types. In addition, there are considerable limitations to much of the methodology selected for use in previous research. This thesis first aims to explore how generalised anxiety and social anxiety levels impact threat responses towards social threats and non-social threats. The second aim is to test the effectiveness of video stimuli with an audio component to convey threat in psychological research. Multiple measures of threat response, including subjective ratings, electrodermal activity measures, and heart rate variability are tested. The analyses shows that social anxiety levels significantly predict threat response towards social threat, but not non-social threat, in the present sample. Generalised anxiety level's influence on threat response remains unclear, but hints are provided of possible hypotheses for future study. The strengths and weaknesses of the new methodology employed are tested and discussed. This research is mainly exploratory and therefore should be used as a starting point for future research in this field, both from a theoretical and methodological perspective.

Keywords: generalised anxiety, social anxiety, threat response, electrodermal activity, heart rate variability.

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According to the APA Dictionary of Psychology (American Psychological Association, 2022b), threat can be defined as "a condition that is appraised as a danger to one's self or well-being or to a group." No matter where we live or what our daily lives entail, all of us will occasionally face some potential threats in our regular lives. Some threats, such as an invading army, pose significant risks to our wellbeing and our response is key for our survival. However, more minor threats, such as an aggressive customer, still rely on our ability to respond accordingly to avoid negative consequences or harm. Our ability to detect potential threats around us and act accordingly has been key for our survival throughout human history. The way that we react to detected threats is known as threat response in the current psychological literature (Hodgins et al., 2010).

Many factors may influence the magnitude of an individual's threat response, the most obvious being the nature of the threat itself. Research has found that "Contextual information is particularly important in regulating the expression of responses to threat after these responses have been extinguished" (Battaglia et al., 2018, p. 9). Both the nature of the perceived threat and the context in which it is presented can be considered external factors that alter threat response. However, it is also important to consider potential internal factors. One such factor that may play a major role in our threat responses is our anxiety levels, where we would expect the effects of anxiety levels to be most extreme in sufferers of anxiety disorders (ADs) (Bar-Haim et al., 2007).

Anxiety Disorders and Threat Response

ADs are some of the most common psychological disorders, affecting up to 33.7% of the population at some point in their lifetime (Bandelow & Michaelis, 2015). Previous research has investigated the relationship between threat response and anxiety; for example, multiple studies have found a relationship between anxiety and increased attentional focus on threatening stimuli (MacLeod & Mathews, 1988; Martin et al., 1991). More recently, research has begun to explore the relationships between ADs and threat response. Two of the most common types of ADs are Generalised Anxiety Disorder (GAD) and Social Anxiety Disorder (SAD), also referred to as Social Phobia (Bandelow & Michaelis, 2015); their relationships with threat response have been a subject of study in the literature in recent years.

Generalised Anxiety Disorder (GAD)

GAD is characterised by excessive and persistent worrying (American Psychiatric Association, 2013) and affects approximately 6.2% of individuals in their lifetime (Bandelow & Michaelis, 2015). Research has found that those with GAD show heart rate acceleration towards threat-related words, when non-anxious controls show deceleration (Thayer et al., 2000). The authors suggest that GAD sufferers show a “rigid responsiveness” to threats in their environment, with an inability to adjust to their ever-changing surroundings. The authors argue that this, in turn, leads to a hindrance in distinguishing threats from non-threats. As heart rate acceleration in response to threat stimuli was only found in the GAD group, while the healthy control group instead experienced heart rate deceleration, it can be argued that this is the result of excessive panic or worry for GAD sufferers.

Other research found that GAD sufferers also showed improved memory of threat-related words compared to healthy controls (Friedman et al., 2000). However, no significant difference for recall was found between groups for the non-threat words. The authors discuss how methodological differences between studies may have led to the current inconsistencies in the literature, such as the use of incidental learning or free recall to test memory bias

(Becker et al., 1999; Friedman et al., 2000). It is also noted how extended stimulus presentation may be an important component in uncovering GAD's relationship with threat stimuli. This paper highlights the complexity of GAD's relationship with threat stimuli and discusses how both cognitive avoidance and hypervigilance to threat cues may influence this relationship (Friedman et al., 2000).

One study uncovered specific brain regions that show increased activation to threatening stimuli in GAD patients only when compared to SAD sufferers, Specific Phobia sufferers, and healthy controls (Buff et al., 2016). These brain regions included the anterior mid cingulate cortex (aMCC), posterior mid cingulate cortex (pMCC), and the dorsal posterior cingulate cortex (dPCC), which are known to be involved with the processing of fear, pain, motor tasks, and visuospatial orientation, among other functions (Yu et al., 2011). An increased activation in these areas, therefore, may suggest increased processing of pain and fear. The authors note that GAD patients showed a particular sensitivity to threatening stimuli that was not as evident in other AD sufferers. They suggest that increased attention to threats may result in increased neural activity in these brain regions in GAD sufferers relative to non-sufferers.

It seems that GAD patients may show an increased response to threat-related stimuli when compared to healthy controls, as well as unique biological responses to threat when compared with other common anxiety disorders. However, it is important to note that findings are inconsistent and the relationship between GAD and threat response is markedly complex.

Social Anxiety Disorder (SAD)

SAD sufferers tend to avoid social situations and experience them with intense fear (American Psychiatric Association, 2013). SAD affects approximately 13% of individuals in their lifetime (Bandelow & Michaelis, 2015). One article highlights some inconsistencies in the literature regarding the relationship between SAD and threat response; some studies suggests that SAD sufferers hyper-focus on socially threatening stimuli, whilst others suggest they use distraction methods to divert their attention away from threatening stimuli (Schofield et al., 2012). Schofield et al.'s (2012) study found that individuals experiencing more SAD symptoms also experienced greater difficulty disengaging from socially threatening stimuli. This suggests a bias in SAD sufferers towards socially threatening stimuli relative to non-threatening stimuli. However, the relationship between social anxiety and visual attention to socially threatening stimuli did not differ significantly from depression's relationship with socially threatening stimuli. Both depression and social anxiety were found to relate to a longer dwell time on negative emotional expressions. It seems that there is evidence suggesting stronger attention towards socially threatening stimuli in SAD sufferers, although it is important to note that this relationship may not be unique to SAD sufferers.

Goldin et al. (2009) found differences in brain activity between SAD sufferers and controls when viewing socially threatening stimuli, but no significant differences were found when viewing scenes that were threatening otherwise. More specifically, SAD sufferers showed larger emotionally negative reactions and reduced cognitive-linguistic regulation–related neural activation for socially threatening stimuli only. This research suggests that SAD sufferers react uniquely to socially threatening stimuli in comparison to threats that are not socially natured.

However, Högström et al. (2019) found little difference between SAD sufferers and non-anxious controls when viewing socially threatening stimuli with non-socially threatening stimuli in peripheral vision when measuring vigilance, attention speed, and disengagement speed. This research suggests that patterns of attentional bias in SAD patients found in other research may not be unique for this disorder when compared to healthy controls. The authors recognise the inconsistencies between their findings and previous research and attribute this lack of found differences to a methodological difference: while most studies in this field use reaction-time measures, this study used eye-tracking to study attention (Dudeney et al., 2015). This research highlights the importance of the methodology used to study threat detection and response.

In sum, it seems that SAD sufferers may show unique biases for socially threatening stimuli, but the current literature is inconsistent and limited. These inconsistencies may be due to the methods used to measure attention to the stimuli and how threat response can be inferred from the measures employed.

Limitations of Previous Research

Previous research into the relationship between anxiety and threat response appears to be lacking in several areas. Firstly, there is a lack of comparison between different anxiety types within studies. Previous research tends to either treat all AD sufferers as a singular category, or study only one type of AD specifically by comparison to healthy control groups. The exception to this is Buff et al.'s (2016) study, which finds significant differences in the neural activation of GAD sufferers in comparison to SAD and panic disorder sufferers when viewing threatening stimuli. It can be predicted, therefore, that GAD sufferers may also differ in their perception of threat, as well as their psychophysiological responses to threat. Many studies appear to assume that all ADs affect threat response in a similar fashion when this is yet to be thoroughly tested. This may have serious implications for treatments that target threat responses in AD sufferers as differences in threat response may require different approaches for treatment.

Research comparing threat types is also limited. There is a lack of comparison of threat types when studying GAD sufferers' threat responses; many studies either use socially threatening stimuli, such as images of angry faces, or threat-related words. In addition, the literature comparing threat types in SAD is inconsistent and limited. The small volume of research studying different threat types in SAD sufferers finds that extreme responses occur for socially threatening stimuli only (Goldin et al., 2009); this view is later contested by research suggesting no significant differences between SAD sufferers and healthy controls (Högström et al., 2019). Determining the interaction between threat type and anxiety type on threat response will be key for developing personalised treatments that target threat responses in AD sufferers of different anxiety types.

There are also limitations of the methodology of many of the previous studies. More specifically, previous research largely uses either threatening words or pictures of emotional faces as stimuli. It could be argued that such types of stimuli may lack ecological validity and in turn result in a lower mean threat response than more ecologically valid stimuli would produce. Such stimuli may only induce very low levels of threat response in participants; this could account for unusual patterns in the literature, such as heart rate deceleration to threat-related stimuli in control groups (Thayer et al., 2000) and inconsistencies between studies. It could be argued that the use of images of angry faces as stimuli may be relatively weak in comparison to more realistic stimuli, for example. There is a potential, therefore, to build upon previous research and improve the stimuli chosen to attain more ecologically valid results.

Another key issue in previous research is the use of the definition of threat itself. If, as according to the American Psychological Association's (2022b) definition, threat is appraised by individuals, how can we define any stimulus as objectively threatening? This is a recurring issue in current literature that does not seem to be well addressed. It is important to ensure that participants truly perceive the threat-related stimuli as subjectively more threatening than the non-threat stimuli to ensure that the results are valid and truly reflect changes in threat response.

Many previous studies also solely use self-report measures without psychophysiological measures of threat response (e.g. Goldin et al., 2009), or rely on behavioural measures only to infer threat response (Högström et al., 2019; Schofield et al., 2012). The key disadvantages of such methods are that self-report measures can only capture conscious threat responses, such measures are affected by demand characteristics and subject expectations, and the time resolution of these measurements is poor. It is likely that threat response is also processed on an unconscious level that these scales are unable to capture. Using psychophysiological measures in conjunction to self-report measures may aid in capturing participants' threat responses more fully and will allow for data collection of both conscious and unconscious threat responses in real time. Lester et al. (1994) emphasise the importance of using a multi-measurement approach when studying stress in individuals, and how using either self-report measures or behavioural measures alone hinder our understanding of stress in research. As shown in previous research, the measure used to quantify attention in relation to threat response in SAD sufferers can drastically alter findings (Högström et al., 2019).

Psychophysiological Measures of Threat Response

We typically react to threats in a variety of ways, including nonverbal behaviours (Burgoon et al., 1992), vocal changes (Russell et al., 2003), and physiological responses (Blascovich & Tomaka, 1996). Physiological markers of the threat response include sweat gland activity and cardiac activity (Bhoja et al., 2020). As threats induce "psychophysiological stress", which in turn activates the sympathetic nervous system, threat response can be measured through electrodermal activity (Bhoja et al., 2020). It may also be possible to infer threat response through the reduced activation of the parasympathetic nervous system from changes in components of heart rate variability.

Electrodermal response (EDR) refers to sweat gland activity in response to an event. Since sweat glands are innervated by sympathetic sudomotor nerves (and no parasympathetic fibres), EDR is thought of as a pure measure of sympathetic nervous system activity (Bhoja et al., 2020). During an EDR, sweat on the skin increases electrical conductance of the skin which can be accurately measured. Due to its simplicity to measure, in addition to its reflection of the sympathetic nervous system's activity, EDR is the most popular measure for a range of psychophysiological phenomena in human subjects (Boucsein, 2012). Many studies have highlighted the significant impact that induction of stress through threat presentation has on electrodermal activity (e.g. Bhoja et al., 2020; Setz et al., 2010).

Heart rate variability refers to the variation of time between each successive heartbeat (Bhoja et al., 2020).The variability of an individual's heart rate is a result of a complex interaction of sympathetic, parasympathetic, and other physiological effects (Gordan et al., 2015). A meta-analysis of stress research concluded that heart rate variability is a suitable objective measurement for psychological stress (Kim et al., 2018). Heart rate variability measurements have also been demonstrated to be effective in measuring threat response in previous research e.g. (Thayer et al., 2000). It is important to note that the main driver of absolute heart rate variability is respiratory sinus arrythmia, which represents the decreased influence of the vagus nerve (a parasympathetic nerve) on heart rate, and sympathetic activity plays a more subtle influence on raw heart rate variability (Bhoja et al., 2020). Nevertheless, since parasympathetic activity is an indicator of the "rest and digest" response, it is often used as a relaxedness or negative stress marker in stress research. So heart rate variability, and even more prominently, the high frequency component or heart rate variability and the root mean square of successive differences (RMSSD) of heart rate variability, are often used as markers of the absence of stress and threat.

As Lester et al. (1994) explained, a multi-measurement approach is advantageous when studying stress. As threat response is intrinsically tied to stress (Bhoja et al., 2020; Mogg et al., 1990), research investigating threat responses would most likely benefit from the use of multiple measures of threat response in conjunction.

Purpose & Aims

This study aims to address several identified gaps in the current literature investigating the relationship between anxiety levels and threat response. Another aim of this study is to test a new methodology for future research in this field.

The first aim of this study is to determine the relationship between both individuals' generalised anxiety (GA) levels and social anxiety (SA) levels and multiple response measures to both social threat (ST) and non-social threat (NST). Our first hypothesis is *H1: Those with higher SA levels will show a stronger response to STs, but not to NSTs, when compared to individuals with lower SA levels*, based on the current literature (e.g. Goldin et al., 2009).

As there is a lack of research investigating GA's relationship with STs versus NSTs, this aspect of the study will be exploratory. However, based on previous research studying general threat response (e.g. Thayer et al., 2000) our second hypothesis is *H2: Those with higher GA levels will show a larger response to all threat types (i.e. both NST and ST) than those with lower GA levels.*

As previous research shows a large comorbidity between GAD and SAD (Bandelow & Michaelis, 2015), there is a possibility of a mediation effect, such that SA levels mediate the relationship between GA levels and ST response. This would mean that GA levels would only predict ST response through its positive relationship with SA levels (Bandelow & Michaelis, 2015). As there is a lack of previous research that hypothesises such a relationship, (lead to a greater understanding of the relationship between GAD and SAD, as well as a deeper insight into the influences that different anxiety types may have on each other. Therefore, *H3: SA levels will mediate the effect of GA levels on ST response.*

Due to ethical and time constraints, this thesis was conducted with a non-clinical sample. Therefore, interpretations of the tested hypotheses should be treated with caution and be considered exploratory for the benefit of future research.

The secondary aim of this study is to test new methodology. More specifically, this study will use video stimuli with an audio component instead of the pictorial or linguistic stimuli typically used in previous research (e.g. Goldin et al., 2009; Thayer et al., 2000). It can be argued that video stimuli will be more ecologically valid as they better represent natural settings. Both the effectiveness and practicality of using video stimuli will be considered and discussed. If successful, these new methods can be replicated and improved upon in future studies that hope to investigate threat in laboratory settings.

This study also utilises electrodermal activity and heart rate variability data in combination with self-report data for a multi-measurement approach to investigating threat response. Much of previous research relies on self-report measures of stress alone in response to threatening stimuli (e.g. Goldin et al., 2009). This study hopes to show that a multi-measure approach that measures both the conscious and unconscious processing of threats in the environment is beneficial for the field moving forwards.

As these new measures are experimental, with little previous research to support them, the testing of the new methodology is also exploratory. If successful with a limited sample size, future research should work to improve upon these new methods and test their reliability and validity on a larger sample.

Significance

This study aims to continue previous research which uncovers key differences between GAD and SAD (Counsell et al., 2017; Pittig et al., 2013; Turk et al., 2005), as well as a possible mediation relationship. Uncovering key differences in the symptomatology and in the perception of threat in these disorders is fundamental for the development of effective treatment. Currently, these disorders are often treated very similarly in clinical settings in countries such as the United Kingdom (e.g. National Health Service, 2018, 2020). By generalising treatments to a range of ADs, without taking key differences between different ADs into account, it is likely that current treatments are not optimised for each specific type of AD. Taking a more tailored approach, where treatments of different ADs are more specialised for the unique symptoms of each disorder, may lead to more effective treatment.

Unusual patterns of threat detection and response are key aspects of ADs that should be targeted in treatment (Cisler & Koster, 2010). Studies have found that therapies that train attention away from threat can reduce symptoms of GAD (e.g. Hazen et al., 2009; Schmidt et al., 2009) and SAD (e.g. Amir, Beard, Burns, et al., 2009; Amir, Beard, Taylor, et al., 2009; Amir et al., 2008). If high GA and high SA individuals show different patterns in threat detection and response, this would suggest that different strategies should be used to target their specific biases. One important difference could be the types of threats that elicit an exaggerated response; this study aims to investigate this. These results may be used to determine if different strategies are required to target abnormal threat detection in GAD and SAD patients.

Unusual threat detection behaviours are also a product of attentional biases (Cisler & Koster, 2010) and so can be used to study the issue of attentional biases at large, for both AD sufferers and the general population. Threat-related selective attention in AD sufferers has been found to predict treatment success (Legerstee et al., 2009); those who struggled to disengage from threatening stimuli were less likely to significantly benefit from AD treatments. This research shows that threat detection is a significant component of ADs and should be studied in more detail to gain a greater understanding of this relationship. Currently, studies have investigated key differences between ADs regarding threat response, such as activation of specific brain regions (Buff et al., 2016), but the relationship between ADs and response to different types of threat specifically has limited research in the current literature.

To summarise, studying the relationships between anxiety types, threat types, and threat response has important implications for treatment of ADs. Studying differences in threat detection in AD sufferers should aid the development of treatments for the ADs studied and improve understanding of the underlying attentional mechanisms that play a major role in ADs.

This study can also be used to advise on the most suitable methodology for threat response studies in future research. Current research uses either still images of angry faces or threat-related words to induce a threat response. This study will use real-life video footage of threatening phenomena in action which should improve the ecological validity of the findings. In addition to this, the use of psychophysiological data in conjunction with self-report data should provide valuable information for both the conscious and unconscious aspects of threat processing. This study will provide a foundation of new methodology which future research can replicate and improve upon. This will improve the methodology employed in the field and lead to more ecologically valid findings in future research investigating anxiety and threat response.

Method

Participants

A total of 30 participants (Female = 17, Male = 12, Other = 1) were selected though opportunity sampling. The vast majority of participants analysed were students at Lund University. The age range of participants was 21 to 55 years (*M* = 25.7, *SD* = 5.93). The majority of participants (21: 70%) reported at least one European nationality. Some participants reported at least one Asian (6: 20%), North American (5: 18.3%), and South American (1: 3.3%) nationality. All participants reported either one (27: 90%) or two (3: 10%) nationalities. The majority of participants (21: 70%) self-reported as non-native fluent English speakers; others reported as either native English speakers (8: 26.7%) or semi-fluent English speakers (1: 3.3%).

Participants were not compensated for their participation and were recruited on a voluntary basis. They were recruited using social media platforms including WhatsApp and Facebook, as well as word-of-mouth. Information was provided to potential participants through the social media posts and the printed information sheets provided on-site. All participants gave informed consent prior to participation. To sign up for participation, it was required that participants were 18 or older and had normal or corrected-to-normal vision. Following previous research (e.g. Goldin et al., 2009), and given the time constraints for this project, it was decided that 30 participants would be appropriate for this research. Therefore, the stopping rule for data collection was set at n = 30.

Materials

Laboratory

The data collection was conducted in Lund University's Humanities Laboratory.

BioPac Equipment

A MP150 system was used to record the electrodermal activity and electrocardiogram of participants. The GSR100C unit and ECG100C unit were used to record electrodermal activity and heart rate respectively.

Two finger electrodes TSD203 and electrode gel GEL100 were used to connect participants to the GSR100C unit. Leads 100-S and disposable electrodes EL501 were used to connect participants to the ECG100C unit.

All of the equipment described above was manufactured by BioPac systems (c).

Computers and Display Equipment

A HP EliteBook 850 G3 laptop running on Windows 10 Enterprise version 20H2 was used by the experimenter to record and analyse the electrodermal activity and heart rate data.

A computer running on Windows 10 Pro version 1909 was used to display the stimuli to participants and record their slider responses. A 22 inch 59 Hz Dell P2210 flat panel monitor with resolution 1680 x 1050 was used in conjunction with this computer. A set of Behringer HPS3000 headphones were used to provide audio to the participants. The volume of the audio was standardised at 70% for all participants.

As the computer used to present the stimuli was unable to connect to the internet, a Hp Pavilion x360 running on Windows 10 Home version 21H2 was used to record participants' questionnaire responses.

Programmes

AcqKnowledge 5.0 (BIOPAC Inc., Goleta, CA, USA) was used for the acquisition and analysis of the physiological data collected.

E-Prime 3.0 (Psychology Software Tools Inc., Pittsburgh, PA, USA) was used to automate the stimulus presentation and randomise the order of test stimuli. E-Prime 3.0 also recorded the slider response data provided by participants.

Both the sign-up form and the questionnaires presented during the experiment were created using Qualtrics XM (Qualtrics, Provo, UT, USA).

Stimuli

Trimmed clips from Our Planet's nature documentary titled "Forests", accessed through Netflix's official YouTube channel, were used during the resting periods to take baseline measurements for both electrodermal activity and electrocardiogram. A total of four clips were taken that were 5 minutes each in length, for a total of 20 minutes of footage. The clips included calm nature scenery and commentary with no apparent threat.

A total of four videos from YouTube were used for the test stimuli. Each of these videos was trimmed to be one minute in length. More information about these stimuli can be found in Table 1.

Table 1

Details and links for the 4 stimuli videos taken from YouTube

Stimuli	Video Title	Channel Title	Timestamp	Link
Non-social control	Frogs in my garden pond eating aphids from my nearby flower patch HD video with slow motion scenes	FlyingYankee59	0:20-1:20	https://www.youtube.com/watch?v=tFDXpoF8y-Y
Social control	A Friendly Conversation - Charlie White	Wendy Morgan	0:00-1:00	https://www.youtube.com/watch?v=YR6T56VonM0
Non-social experimental	Tiger Snake Biting Camera Lens	vikingtimbo	1:27-2:27	https://www.youtube.com/watch?v=9jj2VJywm4M
Social experimental	You're not getting my ID Numbnutz Unless you unlawfully arrest Me	FRICN MEDIA	7:57 – 8:57	https://www.youtube.com/watch?v=AJi0LgnoIJA

For the non-social threat conditions, "snakes" was selected as the non-social threat, using "frogs" as a control. This selection is based on limited previous research comparing social and non-social threats (LoBue et al., 2017). For the social threat conditions, "aggressive confrontation" was selected as the social threat, with "general conversation" as a control. This was based on previous research that uses images of angry vs. neutral/happy faces to convey threat with a nonthreatening control (e.g. Goldin et al., 2009), translated to a video format.

Measures

Inclusion Criteria and Methodology Testing: The Specific Phobias Questionnaire (SPQ)

This is a 29-item questionnaire created by the researcher specifically for the present study. This questionnaire is based on the Acrophobia Questionnaire (Cohen, 1977) and has been adapted for this research design. This questionnaire asks participants to rate their fears of phenomena on a 7-point Likert scale, where 1 = 'Not at all anxious; calm and relaxed' and 7 = 'Extremely anxious'. Each fear has an additional checkbox where participants can also report whether they have a phobia of the listed phenomena, separate to the 7-point Likert scale. Participants are instructed to answer “Yes” to the additional checkbox if they have been diagnosed with a specific phobia of the item, or they believe that they would be if they were to be tested. The phenomena listed included snakes, frogs, general conversation, aggressive confrontation, and the animals featured in the resting phase documentary, as well as 12 other distractor fears. The distractor fears selected are based on common fears studied in previous research (Eaton et al., 2018; Fredrikson et al., 1996; Pollard & Henderson, 1988). The order that the phenomena were listed on the questionnaire was randomised for each participant. The Acrophobia Questionnaire scale was found to have good test-retest reliability over a 3-month period; test-retest reliabilities for waiting list participants (n=13) were r = 0.86 for Anxiety and r = 0.82 for Avoidance, indicating reasonable stability in untreated participants (Baker et al., 1973).

Anxiety Measures

Generalised Anxiety Disorder Questionnaire (GAD-7). The GAD-7 is a self-report questionnaire used to evaluate an individual’s general anxiety level (Spitzer et al., 2006). The questionnaire consists of eight 4-point Likert scales. These items are designed to measure day-to-day anxiety levels. A variety of studies have endorsed the internal consistency, test-retest reliability, validity, and sensitivity to change of this questionnaire (e.g. Bischoff et al., 2020; Homans, 2012; Toussaint et al., 2020). A Cronbach’s α of .94 was found for the GAD-7 in a population of sick-listed workers in the Netherlands, with a GAD detection rate of .82 when a cut-off point of 9 was used (Homans, 2012). Participants showed a mean change to baseline of -1.14 (p = .001) after 12 weeks of treatment, and a change to baseline of -2.04 (p < .001) after 48 weeks (Toussaint et al., 2020). A test of the test-retest reliability of the GAD-7 over a period of 2-4 weeks resulted in a Pearson’s r correlation of .87 (Bischoff et al., 2020).

Social Interaction Anxiety Scale Short Form (SIAS-6) and Social Phobia Scale Short Form (SPS-6). The SIAS-6 and SPS-6 are both 6-item self-report questionnaires used to measure social anxiety levels (Peters et al., 2012). These scales combined are able to assess two distinct yet related aspects of social anxiety, namely generalised social interaction anxieties and specific social fears. Participants report how characteristic of them each statement is on a 5-point Likert scale. Previous research has shown robust utility and high internal consistency for both the SIAS-6 and SPS-6 individually (α = .84 and .87 respectively) (e.g. Carleton et al., 2014). In addition, several studies endorse the use of these scales in the form of a singular 12-item questionnaire with two factors as a measurement of SA levels (Ouyang et al., 2020; Peters et al., 2012). This 12-item questionnaire is commonly referred to as the SIAS-6/SPS-6 (Ouyang et al., 2020).

Procedure

Participants were provided with an information sheet and gave informed consent. They were given the opportunity to ask any questions and informed that they could ask questions throughout the experiment.

Participants were then instructed to complete the SPQ via Qualtrics. Their responses were checked by the researcher immediately after completion; if “snakes” was reported as a phobia, they proceeded with the ‘Social Threat Only’ condition (see below) instead of the standard experiment presentation. If any other items that were not distractor items were reported as a phobia, participants were informed that they could not proceed with the experiment. The items that, if reported as a phobia, lead to exclusion from the experiment are as follows; “Frogs”, “General Conversation”, “Aggressive Confrontation”, “Tigers”, “Small Forest Birds”, “Wild Boars”, “Monkeys”, “Hornbills”, “Lemurs”, “Fossae”, “Wild Dogs”, Rabbits”, “Foxes”, “Deer”, “Wolves”, and “Horses”, as these were all featured in the videos presented. Participants were instructed to ask the present researcher if they did not recognise any of the items and were shown google images by the researcher of these items.

Participants were then connected to the electrodermal activity module of the BioPac system. Participants were asked which hand they would prefer to use a computer mouse with; the electrodes were applied to the hand that was not selected. Electrode gel was applied to both of the TSD203 nodes. These nodes were then placed on the palmar surface of the distal phalange of the index and middle fingers of the participant. The connection was checked by instructing participants to take a deep breath; if an almost immediate electrodermal activity increase was not observed, the equipment was adjusted and tested again.

Participants were then connected to the Heart Rate module of the BioPac system. Participants were instructed to find their pulse on the left side of their neck, then to attach a disposable electrode on the area where the pulse was found. The researcher then attached a disposable electrode on each wrist, then connected the leads to the electrodes. The connection was checked; if the display did not show a clear ECG pattern, the leads were reconnected and tested again.

Participants were given an outline of the stimuli sequence by the researcher. They were instructed rest their arms palm-side up on either the armrests of the chair or on the table in front of them. They were instructed to stay as still as possible throughout the stimuli presentations, but to mark their responses on the presented sliders with the mouse when cued. The headphones were them placed on the participants and they were instructed to adjust the headphones until they were comfortable. The researcher started the BioPac recording on AcqKnowledge and instructed the participant to press the SPACE key to start the stimuli presentation when ready.

Participants were shown one of the 5-minute resting period videos. After the video had finished playing, a black screen was shown for 2 seconds before one of the 1-minute-test videos would play. Immediately after the test video, Participants were presented with a slider ranging from 0-100. They were instructed to “Please indicate how threatening you found the video shown on the scale above.” with the computer mouse before continuing with the experiment by pressing the SPACE key. This procedure was repeated four times, so that all resting period and test videos were played once each. This portion of the experiment was approximately 25 minutes in length and was verbally explained by the present researcher prior to commencement.

The four resting period videos were always played in the same order, but the order of the four test videos was randomised using a built-in E-prime function. The randomisation was independent across research sessions. The order of each occurrence can be found in Table 2.

Table 2

Number of participants viewing each video in each order position

Video	Order Position			
	First	Second	Third	Fourth
All Videos Condition (n = 28)				
“Frogs”	10	9	1	8
“Snakes”	6	4	12	8
“General Conversation”	4	8	8	8
“Aggressive Confrontation”	8	7	7	6
Social Threat Only Condition (n = 2)				
“General Confrontation"	1	1		
“Aggressive Confrontation”	1	1		

Participants' electrodermal activity and electrocardiogram data was collected, as well as their slider response values and order of the test video presentation. The start and end of each stimulus presentation was manually marked by the researcher in AcqKnowledge during data collection to be used in further analysis.

After the stimulus presentation ended, participants removed the headphones, the leads connecting to the disposable electrodes, the disposable electrodes, and the TSD203 nodes. They were directed to a sink with hand soap to wash their hands and the electrode sites.

Once they were ready, participants completed the final questionnaire, consisting of demographic questions, the GAD-7, and the SIAS-6/SPS-6, in that order.

Participants were then provided with a debrief sheet and were verbally debriefed by the researcher. They were given the opportunity to ask any questions, reminded of their participant number, and reminded of their right to withdraw their data.

Statistical Analysis

All data analysis was conducted in R version 4.2.0 (R Core Team, 2021), using packages such as "psych" (Revelle, 2022), "ggplot2" (Wickham, 2016), "lavaan" (Rosseel, 2012), semPlot (Epskamp, 2022), and "bda" (Wang, 2021).

Data processing

Questionnaire Data. A score was taken for each of the three questionnaires (SPQ, GAD-7, and SIAS-6/SPS-6) by summing the response score of each question, as the official scoring recommends for the GAD-7 and SIAS-6/SPS-6. For the GAD-7 average, only questions 1-7 were used, as the final question used a different response scale to the previous 7. A score was calculated for each of the three questionnaires separately. These scores were used for analysis.

The GAD-7 had a minimum score of 0 and a maximum score of 21, while the SIAS-6/SPS-6 together had a minimum score of 0 and a maximum score of 48. The scores were standardised; all GAD-7 scores were divided by 21 and all SIAS-6/SPS-6 scores were divided by 48, so that both scales had a minimum score of 0 and maximum score of 1. These standardised scores were used in place of the raw scores for the direct comparison of the two measures only.

Threat Rating Data. The threat rating scores for each participant were used to calculate difference scores. The rating of the non-social control video was subtracted from the threat rating of the non-social experimental video to give a NST rating difference score. The threat rating of the social control video was subtracted from the threat rating of the social experimental video to give a ST rating difference score. The NST rating difference scores and the ST rating difference scores were calculated for each participant to be used in analysis.

EDR Data. The EDR data was handled as follows. First, all recording of electrodermal activity during response to the threat rating scales was deleted. The data was then down sampled in a linear fashion from 2000 samples/second to 62.5 samples/second, which is in the recommended range of 50-100 samples/second to reduce computational load (Biopac Systems Inc., 2019). Mean value smoothing was then conducted on the signal. Through trial-and-error methods, the optimal smoothing factor was found to be 125 samples for this data; this was found to successfully remove recording errors without significantly altering the shape of the data or smoothing over skin conductance responses. Visual analysis of the data was then conducted to manually detect and remove artefacts from the signal. Finally, the phasic signal was derived from the raw data (see below). The raw EDR signal was used as an approximation of the tonic signal for further analysis.

Skin Conductance Level (SCL). Using the tonic signal, an overall mean and standard deviation score was calculated for each participant for all EDA data recorded during viewing of all resting videos and test videos. The resting score was taken for each of the 4 resting period videos, using the mean of the SCLs recorded in the final minute of each resting video. A test score was calculated for each test video by calculating the mean of SCL for the 1-minute period which the video was viewed for. All 4 resting scores and all 4 test scores were converted into standardised Z-scores using the overall mean and standard deviation of the signal recorded.

A difference Z-score was calculated for each video by subtracting the respective resting Z-score from the test Z-score. The NST SCL score for each participant was calculated by subtracting the non-social control video difference Z-score from the non-social experimental video difference Z-score. The ST SCL score for each participant was calculated by subtracting the social control video difference Z-score from the social experimental video difference Z-score. The NST SCL score and ST SCL score calculated for each participant was used in the statistical analysis.

Skin Conductance Response (SCR). The phasic signal previously derived from the raw EDR data was used. The parameters for detection of SCRs were set in AcqKnowledge according to guidelines (Braithwaite et al., 2013). The SCRs were constructed using a .05 high pass filter, a baseline window of 60 seconds, and a detection threshold = .05, with a rejection of all negative SCRs, as these are artefacts and not true SCRs. SCRs were then automatically detected by the programme.

The number of SCRs for the last minute of each resting period video and for the full test videos were calculated. The resting video SCR counts were subtracted from the respective test video SCR counts to give SCR count difference scores for each of the 4 testing videos. The NST SCR score for each participant was calculated by subtracting the non-social control video difference score from the non-social experimental video difference score. The ST SCR score for each participant was calculated by subtracting the social control video difference score from the social experimental video difference score. This NST SCR score and ST SCR score was used in the statistical analysis.

Heart Rate Variability Data. First, a band pass filter of .5 - 35Hz was used according to recommendation (Findlay & Dimov, 2016). The recommended 16000 coefficients for the 2000 samples/second sampling rate were selected. The data was then transformed using template correction: a representative ECG cycle was selected and set as a template manually, then the entire electrocardiogram signal was correlated with this template. A raw tachogram was derived from this correlation and used to manually detect and correct artefacts in the ECG signal. Errors that occurred outside the test window were “flattened”, so that the signal was replaced with a baseline of 0mV; artefacts occurring within the test windows were manually removed to recover the underlying heart rate data. The identification of ECG cycles was conducted by AcqKnowledge. The labels produced were manually checked and corrected if the programme failed to successfully identify any cycles.

RMSSD was used as a measure of the parasympathetic influence on heart rate variability. Both RMSSD and log-transformed RMSSD scores reportedly show low error of measurement; in addition, log-transformed RMSSD is not shown to be affected by breathing frequency and can capture parasympathetic activity in short time periods (e.g. Gallo-Villegas, 2020).

The RMSSD between detected heartbeats was determined for each of the 8 videos for every participant. As with the other measures of threat response, the last minute of the resting period videos and all of the test videos were used for analysis. The RMSSD is calculated by the following method: firstly, each successive time difference between heartbeats is calculated in milliseconds. Each of the values is then squared and the mean of the result is calculated before the square root of the total is determined. This calculation was conducted automatically for each video by AcqKnowledge.

The RMSSD data was then handled as follows. All RMSSD scores were first log-transformed using the natural logarithm so that the data more closely resembled a normal distribution. A difference score was calculated for each of the 4 test videos by subtracting the test video RMSSD score from the prior rest RMSSD score. The NST RMSSD score for each participant was calculated by subtracting the NST control video difference score from the NST experimental video difference score. The ST RMSSD score for each participant was calculated by subtracting the ST control video difference score from the ST experimental video difference score. The NST RMSSD score and ST RMSSD score calculated for each participant from their RMSSD data was used in further analysis. As RMSSD is a measure of parasympathetic nervous system activity, and so can be thought of as a measure of "relaxedness", a higher score indicates a lower threat response for this measure.

Statistical Tests

The statistical tests consist of 4 parts. First, both the predictor and outcome variables will be tested in regard to age and gender. Then, the 3 hypotheses stated above were tested. Next, structural equation models (SEM) were built and compared. Finally, methodology tests were conducted.

Demographics testing. Multiple *t*-tests will be conducted to compare male and female participants in their GAD-7 scores, SIAS-6/SPS-6 scores, threat ratings, mean SCL, SCR counts, and RMSSD scores. Multiple Pearson's *r* correlational tests will be conducted to correlate age with GAD-7 scores, SIAS-6/SPS-6 scores, threat ratings, mean SCL, SCR counts, and RMSSD scores.

Hypothesis Testing. To test *H1: Those with higher SA levels will show a stronger response to STs, but not to NSTs, when compared to individuals with lower SA levels*, and *H2: Those with higher GA levels will show a larger response to all threat types (i.e. both NST and ST) than those with lower GA levels*, linear regressions were conducted to test the predictive power of GA scores and SA scores on NST response and ST response for all 4 measures; threat rating, mean SCL, SCR count, and RMSSD scores.

To test *H3: SA levels will mediate the effect of GA levels on ST response*, Sobel's tests were conducted to examine whether SA scores were a significant mediator for the relationship between GA scores and ST response. This test was only conducted using threat response measures that were significantly predicted by SA levels in the previous linear regression models, as this is a prerequisite for mediation testing (Baron & Kenny, 1986)

Model Building. A total of 3 SEMs were built. A saturated baseline model with fixed parameters (model 1) were compared to a test model with no mediation (model 2) and a test model with SA levels as a mediator for the relationship between GA levels and ST response (model 3). Covariance was included between threat response measures that significantly correlate for all models. The basic structure of these models can be viewed in Figures 1, 2, and 3 (Mai et al., 2022).

Figure 1

Model 1: The saturated baseline model. Some parameters are fixed as described below

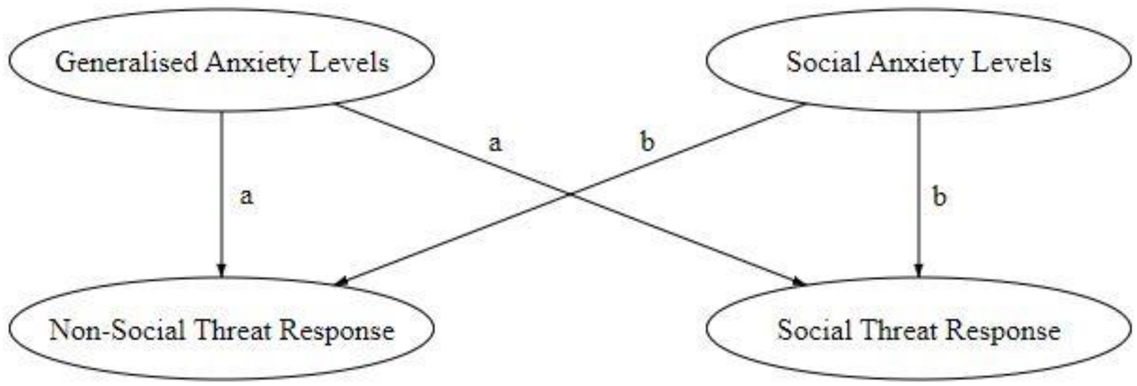


Figure 2

Model 2: The first test model. This model does not include any mediation and assumes that GA levels do not influence ST response. There are no fixed parameters in this model

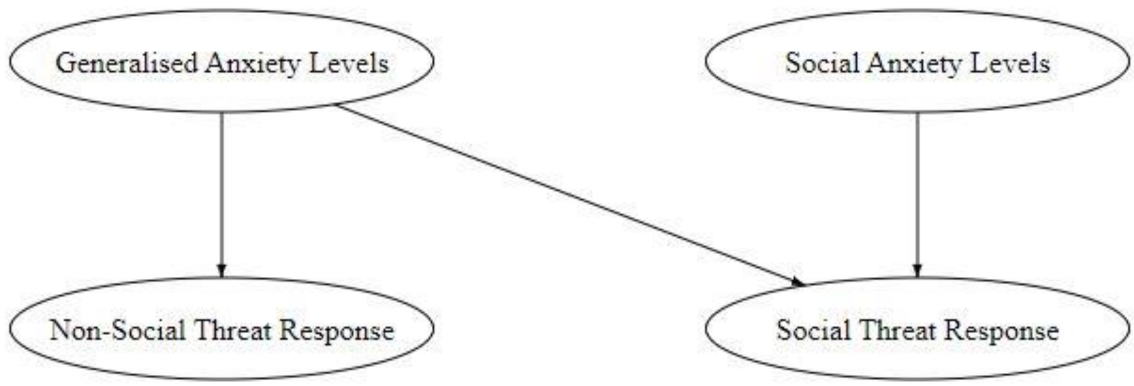
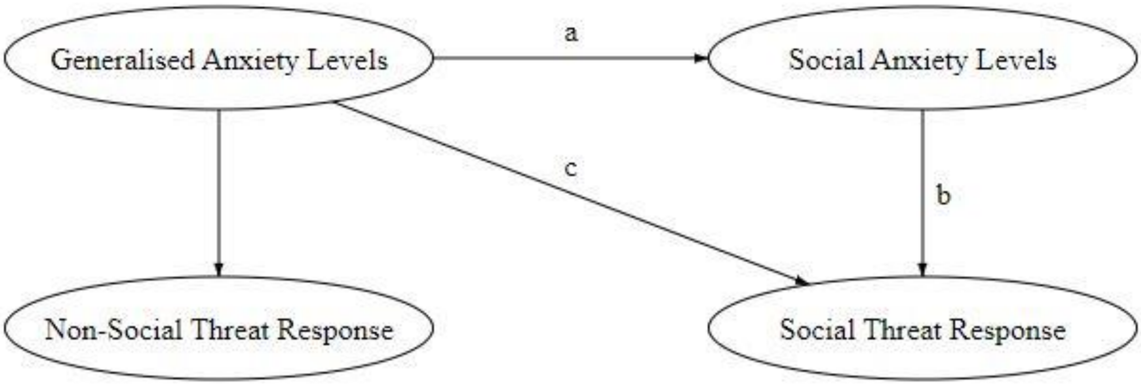


Figure 3

Model 3: The second test model. This model is similar to Model 2, but includes SA levels as a mediator for the relationship between GA and ST response. Arrow c represents the direct path for the mediation analysis, whilst arrows a and b together represent the indirect path for the mediation analysis. There are no fixed parameters in this model



The saturated baseline model with fixed parameters (model 1) suggests that GA levels exerts the same influence on NST responses and ST responses. Similarly, it also suggests that SA levels exert the same influence on both types of threat response. This model is used as a baseline as it assumes that both anxiety types influence both threat types, and that each anxiety type affects threat response in the same manner. As previous research comparing threat types is extremely limited, and usually focusses on social threat only, this is an appropriate baseline for the investigation of different influences of anxiety dependent on threat type.

The test model without mediation (model 2) suggests that GA levels influence responses to both threat types, while SA levels only influence responses to STs. This is in line with hypothesis 1 and hypothesis 2. The two key differences compared to model 1 is that SA levels solely influence ST response, and GA levels are able to influence NST and ST responses differently. This model allows for the assumptions that GA levels and SA levels influence NST and ST responses differently and that ST response in solely influenced by an individual's SA level.

The non-saturated test model with mediation (model 3) is similar to model 2 but includes SA as a mediator for the relationship between GA and ST response. This model can be used for comparison to model 2 to test for mediation stated in *H3: SA levels will mediate the effect of GA levels on ST response*.

The Akaike information criterion (AIC) values, Sample size adjusted Bayesian information criterion (Adj. BIC) values, and confidence intervals of the relationships were calculated for each model to compare model fit.

Methodology Testing. Pearson's *r* correlational tests were conducted to test the correlations between the fear ratings of the 4 test stimuli and the threat response to the respective stimuli on the SPQ. These correlational tests will be conducted separately for all 4 threat measures; threat rating, mean SCL, SCR count, and RMSSD scores. The intention of this analysis is to test the validity of the measures in portraying the intended phenomena in a threat-related context.

Two linear models were built to test GA score's and SA score's predictive power on the SPQ ratings of "Snakes" and "Aggressive Confrontation". This analysis was conducted to test the validity of the phenomena selected to portray NST and ST.

One-tailed repeated-measures *t*-tests were conducted to test that the experimental videos showed a significantly stronger threat response than the respective control video. These tests will be conducted for all 4 threat measures; threat rating, mean SCL, SCR count, and RMSSD scores.

Equivalence testing using the two one-sided tests (TOST) procedure were conducted to test the balancing of the social and non-social stimuli in regard to threat response. These tests will be conducted for all 4 threat measures; threat rating, mean SCL, SCR count, and RMSSD scores. These tests will verify whether the non-social the stimuli were perceived as equally threatening to the equivalent social threat stimuli in this sample.

A Pearson's *r* correlational test was conducted to analyse the correlation between GA levels and SA levels. This was conducted to verify that our data is in line with previous research that has found high comorbidity with GAD and SAD (e.g. American Psychiatric Association, 2013; Bandelow & Michaelis, 2015; Blair et al., 2008). A two-tailed repeated-measures *t*-test was conducted to check if the participants' mean GA levels were significantly different to their mean SA levels. The standardised scores were used for this statistical test.

Pearson's *r* correlational tests were conducted to check whether the 4 measures (threat rating, mean SCL, SCR count, and RMSSD scores) significantly correlated with one another for all 4 test videos.

Multiple Comparison Correction. When appropriate to correct for multiple comparisons, the Hochberg adjustment was used. This is preferred over the Bonferroni adjustment for this thesis as the large number of analyses combined with the limited sample size would result in large probabilities of Type II errors with the Bonferroni adjustment; the Bonferroni adjustment would likely be too conservative of a correction for this thesis (Chen et al., 2017). The Hochberg analysis is arguably the best adjustment to lower the risk of Type I errors without inflating the risk of Type II errors for the present study.

Power Analyses

Power analyses was conducted for multiple linear regression using G^*power (Faul et al., 2007, 2009). The power level was set to .9 and the alpha level was set to .05. The power analysis was conducted for a regression with 2 predictors and 1 outcome variable.

The minimum sample size required to detect an effect was calculated to be 88 participants for a medium effect size ($f^2 = .15$). A sample size of 30 participants was calculated to give a power level of .42.

Power analyses were also conducted for SEM using an online SEM power analysis calculator (Soper, 2022). The power level was set to .9, the alpha level was set to .05, and the estimated effect size was set to medium (.3). The power analysis was conducted for a SEM with 2 latent variables and 10 observed variables included in the model, based on the models analysed in this study.

The minimum sample size to detect effect was calculated to be 119 subjects for a medium effect size, with a minimum of 100 participants recommended for the proposed model structures. A sample size of 30 was calculated to give a power level of .36.

It is important to note that the lack of power in this thesis was due to practical constraints. Given the time frame for this thesis, combined with the temporary closure of the required laboratory due to COVID-19, it was decided that 30 participants would be reasonable for this project; as such, the results found should be treated with caution and viewed as exploratory as a basis for future research. This is especially true for non-significance findings that can be reasonably expected to be significant, given previous evidence.

Results

Missing Data

Two participants did not view the non-social control and non-social experimental stimuli due to a self-reported phobia of snakes. Therefore, these participants did not provide any threat response data for these videos (n = 28 for NST threat response measures, n = 30 for ST threat response measures).

Due to technical errors, all rating data was lost for one participant. All electrocardiogram data was lost for another participant due to interference during data collection (n = 29 for both threat rating data and RMSSD data).

Demographic Data

A summary of the demographic variables for the sample can be found in Table 3. As some participants reported multiple nationalities, the Nationality descriptive will use the first listed nationality only. All nationalities in the "Other" category had only 1 participant self-reporting that nationality first.

Table 3

Descriptive demographics

Category	n
Gender	
Female	17
Male	12
Other	1
Age	
Mean (*SD*)	25.70 (5.93)
Range	21-55
Nationality	
German	10
Swedish	4
US American	4
Indonesian	2
Other	10
Fluency of English	
Native	8
Fluent Non-Native	21
Semi-Fluent	1
Non-Fluent	0

Gender

The “Other” category was excluded from the gender analysis as the “Other” category contained too few participants to be included for group comparison.

A total of 6 *t*-tests were conducted to test for differences between female and male participants on all predictor and outcome measures. As previous research indicates that GA levels and SA levels are higher in female populations on average (Bandelow & Michaelis, 2015), these *t*-tests were one-tailed. All other *t*-tests were two-tailed. The results of these *t*-tests can be found in Table 4.

Table 4

Gender comparisons for all 6 measures used in the analysis

Measure	Mean		*t*	df	*p*
	Female	Male			
GAD-7	7.94	6.33	1.00	26.89	.162
SIAS-6/SPS-6	11.88	11.92	-.01	26.20	.505
Mean Threat Rating	31.13	25.88	.95	22.84	.350
Overall Mean SCL	11.92	13.98	-1.11	19.79	.282
SCR Total Count	23.18	28.83	-.86	18.87	.398
Mean RMSSD Score	38.44	40.81	-.25	19.25	.804

* p <.05, two-tailed. ** p <.01, two-tailed. *** p <.001, two-tailed. † p <.05, one-tailed. †† p <.01, one-tailed ††† p <.001, one-tailed.

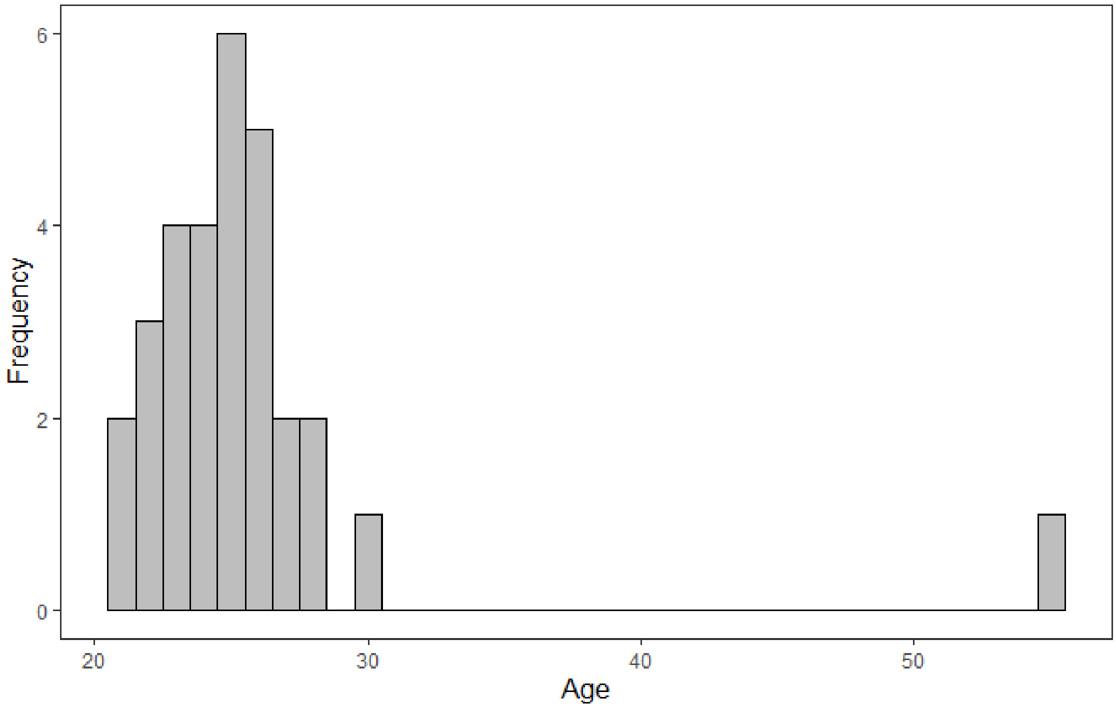
After Hochberg corrections were applied for the 6 *t*-tests, no significant differences were found between female and male participants on any of the measures used in this sample.

Age

A histogram of the participants’ ages can be viewed in Figure 4.

Figure 4

A histogram of participants' self-reported ages



A total of 6 Pearson's *r* correlational tests were conducted to test for age effects on all predictor and outcome measures. As previous research indicates that anxiety disorders generally decrease with age (e.g. Bandelow & Michaelis, 2015), the correlational tests involving the GAD-7 and SIAS-6/SPS-6 were one-tailed. All other tests were two-tailed. All of these tests used raw scores. The results of these *t*-tests can be found in Table 5.

Table 5

Correlations between anxiety and age

Measurement	*r*	df	*p*
GAD-7	-.37	28	.022†
SIAS-6/SPS-6	-.25	28	.091
Mean Threat Rating	-.12	27	.903
Overall Mean SCL	-.38	28	.037*
SCR Total Count	-.23	28	.216
Mean RMSSD Score	-.22	27	.250

* p <.05, two-tailed. ** p <.01, two-tailed. *** p <.001, two-tailed. † p <.05, one-tailed. †† p <.01, one-tailed. ††† p <.001, one-tailed.

After Hochberg corrections were applied for the 6 Pearson's *r* correlational tests, it was concluded that GAD-7 scores significantly decrease with age in this sample. It was found that the older participants were, the lower their self-reported GA levels were in this sample on average. All other measures did not significantly correlate with age after correction. Despite the outlier of the 56-year-old participant, exclusion of their data made no difference to the significance of these correlational tests after correction.

Descriptive Statistics

Descriptive statistics for the 2 predictor measures (the GAD-7 and the SIAS-6/SPS-6) and the 4 outcome measures (threat rating, mean SCL, SCR count, and RMSSD scores) can be found in Table 6.

Table 6

Descriptive statistics for the predictor and outcomes measures used in hypothesis testing

Measure	n	Mean	*SD*	Range	
				Min	Max
GAD-7	30	7.13	4.45	0	21
SIAS-6/SPS-6	30	11.53	8.23	0	48
Mean Threat Rating	27	27.34	14.56	0	100
Overall Mean SCL	28	13.99	5.62	0	NA
SCR Total Count	28	3.96	2.15	0	NA
Mean RMSSD Score	27	40.84	22.93	0	NA

Note. n = number of participants; SD = standard deviation; CI = confidence interval; LB = lower bound; UB = upper bound; Range = possible range of response; Min = lowest possible response value; Max = highest possible response value (NA indicates no predetermined upper limit). Measures of threat response included data collected during test video viewing only: participants that did not view the non-social control and experimental videos were excluded from these analyses.

Hypothesis Testing

Hypothesis 1 and Hypothesis 2

A total of 8 linear regressions were conducted to test the effect of both GA scores and SA scores on threat response for both NSTs and STs for all 4 measures. These 8 regressions used each of the 4 measures as the sole measure for NST and ST. These regressions can be found in Table 7.

Table 7

Linear regressions of GA scores and SA scores on both ST and NST response for all 4 measures. Adjusted R^2 values are provided for each of the 8 models

Measure	Coefficient	Estimate	*SE*	95% CI LB	95% CI UB	*p*	Adj. R^2
				Non-social threat			
Threat rating	Intercept	45.25	9.47	25.70	64.79	<.001***	
	GA score	-.73	1.16	-3.13	1.67	.535	
	SA score	.17	.61	-1.08	1.42	.780	-.07
Mean SCL	Intercept	.97	.43	.09	1.85	.032*	
	GA score	.05	.05	-.06	.15	.343	
	SA score	-.02	.03	-.07	.04	.577	-.04
SCR count	Intercept	2.25	1.04	.12	4.38	.040*	
	GA score	-.13	.12	-.38	.12	.305	
	SA score	.05	.07	-.09	.18	.489	-.03
RMSSD score	Intercept	-.35	.19	-.75	.06	.089	
	GA score	.04	.02	-.01	.08	.105	
	SA score	.01	.01	-.02	.03	.559	.10
				Social Threat			
Threat rating	Intercept	22.68	7.42	7.44	37.93	.005**	
	GA score	-.13	.94	-2.06	1.80	.892	
	SA score	1.16	.492	.15	2.18	.026*	.14
Mean SCL	Intercept	.44	.40	-.37	1.26	.275	
	GA score	.02	.05	-.07	.12	.618	
	SA score	-.02	.03	-.07	.04	.501	-.05
SCR count	Intercept	-.82	1.05	-2.99	1.35	.445	
	GA score	.01	.13	-.26	.27	.963	
	SA score	.07	.07	-.08	.21	.342	-.03
RMSSD score	Intercept	-.18	.16	-.50	.14	.265	
	GA score	.02	.02	-.02	.06	.328	
	SA score	.01	.01	-.01	.03	.564	.01

Note. SE = standard error; CI = confidence interval; LB = lower bound; UB = upper bound, Adj. R^2 = adjusted R^2.

As a lower RMSSD predicts a higher threat response, a negative estimate would indicate a higher threat response in those with higher GA or SA scores.

* *p* <.05, two-tailed. ** *p* <.01, two-tailed. *** *p* <.001, two-tailed.

SA levels were found to be a significant positive predictor of ST in this sample for the threat rating data. No other significant predictors were found.

Hypothesis 3

As an assumption of mediation analysis is that the mediator variable predicts the outcome variable (Baron & Kenny, 1986) (see Table 7), mediation analysis will only be conducted using the rating data. A Sobel's test will be used to examine whether SA scores were a significant mediator for the relationship between GA scores and ST response for the threat rating data.

The Sobel test found that SA score was not a significant mediator for the relationship between GA score and the rating difference score for the ST stimuli ($z = 1.72$, $p = .086$). The test shows that SA scores do not significantly mediate the relationship between GA score and the rating difference score for the ST stimuli.

Model Building and Testing

Missing Values

In this sample, one participant was missing their threat rating data, while another was missing their RMSSD data. To include these participants in the hypothesis testing, linear models were built on the sample to predict rating data from the other 3 threat response measures and predict RMSSD data from the other 3 threat response measures. These models were used to replace the missing threat rating scores and RMSSD differences scores for the respective participants. These estimated values were used in the following SEM only.

Model Comparison

A total of 3 SEM were built to examine the relationships between anxiety types and threat types in more detail. The latent variables in each model were standardised. To test for the presence of the indirect effect for model 3, bootstrapped confidence intervals were used around the estimate of the indirect effect component. The bootstrap was sampled 1000 times. These SEM included the estimated scores for the missing data points described previously.

Two participants were excluded from the SEM analysis as they did not complete the non-social threat condition (n = 28).

The GAD-7 and SIAS-6/SPS-6 were the sole measures of GA levels and SA levels respectively in this study. Therefore, GA levels and SA levels were entered into the models as observed variables, using the GAD-7 scores or SIAS-6/SPS-6 scores respectively.

The AIC and adjusted BIC values for each model can be found in Table 8.

Table 8

The AIC values and adjusted BIC values and for all 3 models. BIC values are sample size adjusted. The rank numbers indicate the best model fit (1) to worst model fit (3) ranking based on the AIC values or adjusted BIC values respectively

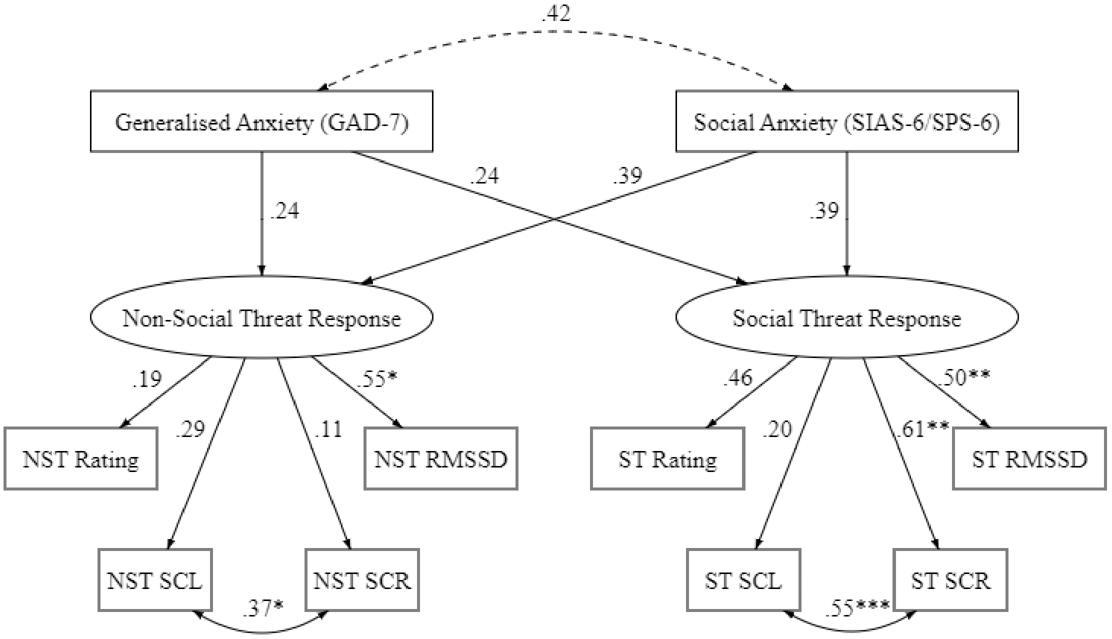
Model	AIC^{rank}	Adj. BIC^{rank}
1: Saturated baseline model	1005.993^{2}	968.679^{2}
2: Test model without mediation	1003.667^{1}	964.576^{1}
3: Test model with mediation	1200.431^{3}	1157.787^{3}

Both the AIC values and the adjusted BIC values suggest that model 3 shows a significantly poorer fit than both models 1 and 2. Both values also suggest a significant improvement in model 2 compared to model 1.

Model 1: Saturated Baseline Model. A table containing path coefficients and confidence intervals for model 1 can be found in Appendix A. A path diagram with standardised estimates for model 1 can be found in Figure 5.

Figure 5

A path diagram with standardised estimates for model 1



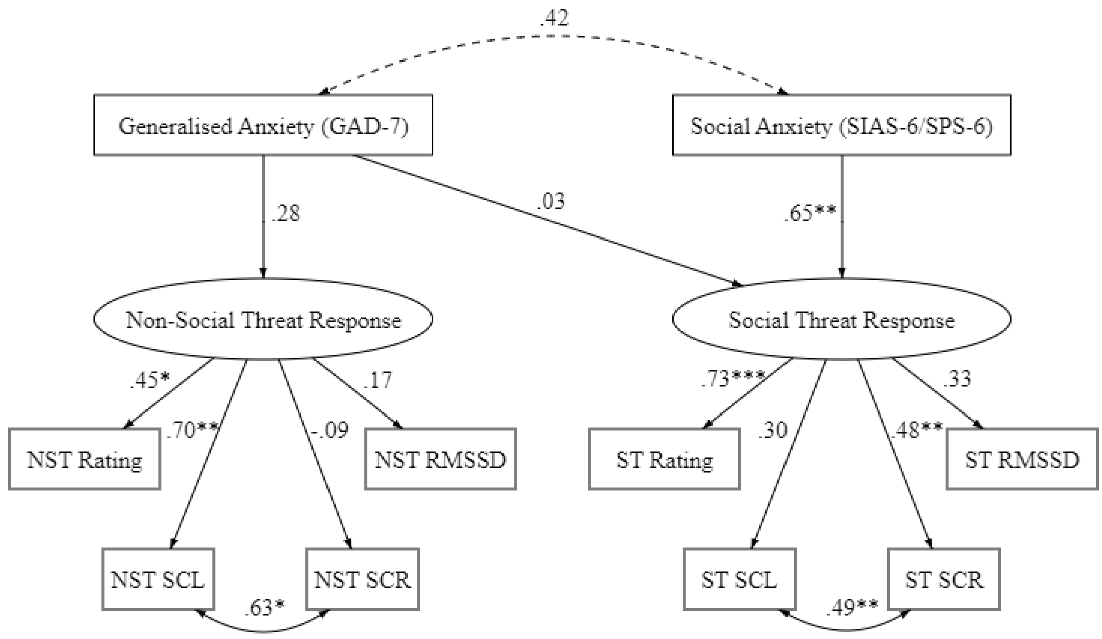
Note. Parameters were fixed such that both GA levels and SA levels each had equal effects on both threat types. Dashed lines represent covariances that were not included in significance testing.

* p <.05, ** p <.01, *** p <.001

Model 2: Test model without mediation. A table containing path coefficients and confidence intervals for model 2 can be found in Appendix B. A path diagram with standardised estimated for model 2 can be found in Figure 6.

Figure 6

A path diagram with standardised estimates for model 2



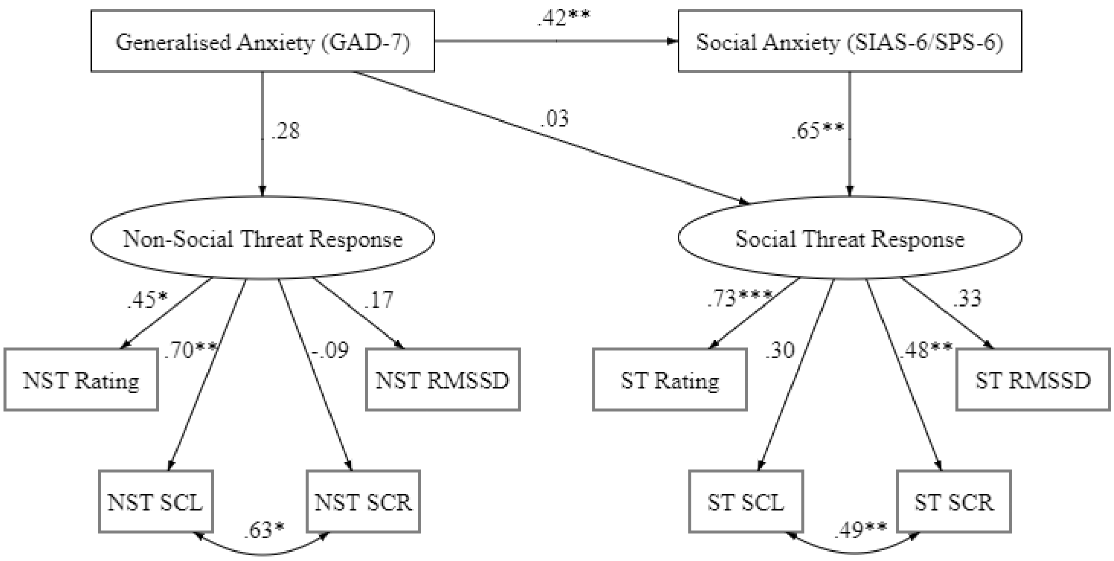
Note. Dashed lines represent covariances that were not included in significance testing.

* *p* <.05, ** *p* <.01, *** *p* <.001

Model 3: Test model with mediation. A table containing path coefficients and confidence intervals for model 3 can be found in Appendix C. A path diagram with standardised estimated for model 3 can be found in Figure 7.

Figure 7

A path diagram with standardised estimates for model 3



Note. The GA score -> SA score -> ST response path represents the indirect path for the tested mediation. The GA score -> ST response path represents the direct effect for the tested mediation.

* p <.05, ** p <.01, *** p <.001

Further examination of the potential mediation was analysed in model 3. The conclusion that SA levels is not a significant moderator for the relationship between GA levels and ST response reached as a result of the Sobel's test is supported by the linear regressions in Table 7: as SA levels predict ST response, but GA levels do not, it is unlikely that the relationship between GA levels and ST response is mediated by SA levels (Baron & Kenny, 1986).

Methodology Tests

Specific Phobias Questionnaire (SPQ)

A total of 16 one-tailed Pearson's *r* correlational tests were conducted to assess the relationship of the SPQ with threat response measurements. The threat ratings for "frogs", "snakes", "general conversation", and "aggressive confrontation" on the SPQ were correlated with the 4 threat response measures (threat rating, mean SCL, SCR count, and RMSSD scores) for the respective videos featuring these items. As a lower RMSSD value indicates a higher threat response, the RMSSD correlational test *r* values were predicted to be significantly less than 0. All other measures were predicted to show *r* values significantly greater than 0. The results of these correlational tests can be found in Table 9.

Table 9

Correlations between the SPQ threat ratings and the threat response measures for the respective video stimuli

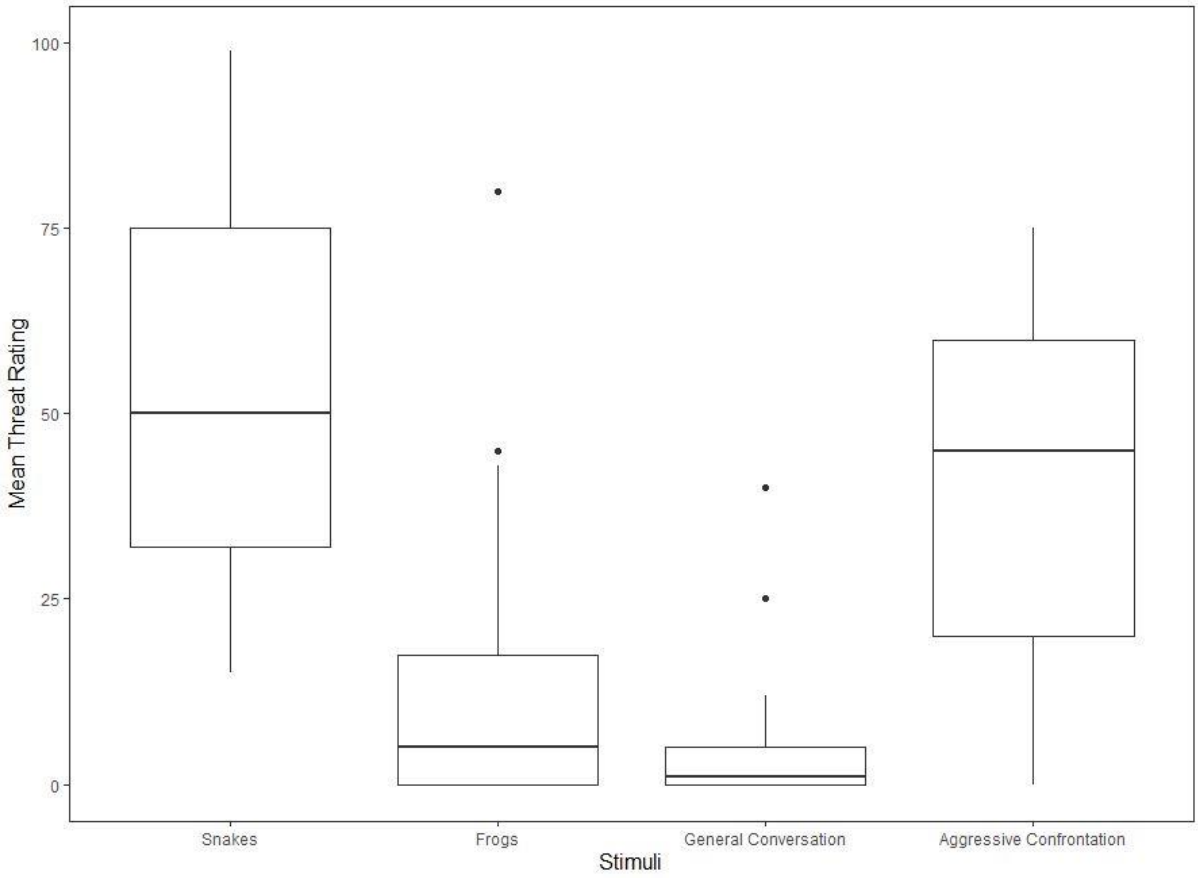
SPQ item	Threat rating			Mean SCL			SCR count			RMSSD score		
	r	df	*p*	*r*	df	*p*	*r*	df	*p*	*r*	df	*p*
Frogs	.63	25	>.001†††	-.20	26	.851	.08	26	.337	-.05	25	.412
Snakes	.50	25	.004††	.15	26	.226	-.09	26	.668	-.13	25	.255
General Conversation	.12	27	.266	-.07	28	.646	-.08	28	.671	.12	27	.735
Aggressive Confrontation	.52	27	.002††	-.25	28	.909	.09	28	.317	-.01	27	.487

† p <.05, one-tailed. †† p <.01, one-tailed. ††† p <.001, one-tailed.

After Hochberg corrections were applied for the 16 Pearson's *r* correlational tests, it was concluded that the SPQ scores for the "Frogs", "Snakes", and "Aggressive Confrontation" showed significant positive correlations with the threat rating of the respective video depicting the item. All other correlational tests were non-significant. Boxplots of the mean threat ratings of the 4 video stimuli can be found in Figure 8.

Figure 8

Boxplots of the threat ratings of all 4 test video stimuli during stimulus presentation



In addition, two linear models were built to test GA level's and SA level's predictive power on the SPQ ratings of "Snakes" and "Aggressive Confrontation". The results of these linear regressions can be found in Table 10.

Table 10

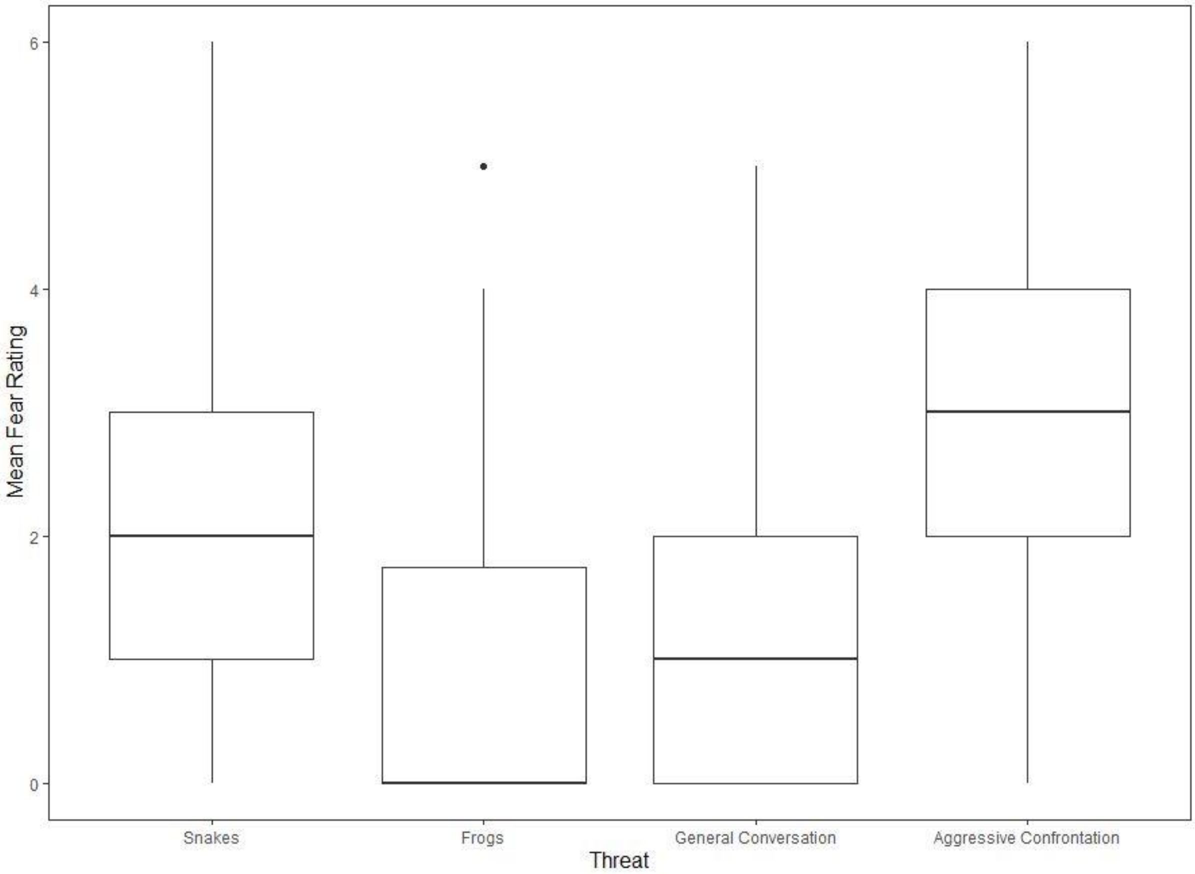
Results of linear models testing whether GA levels and SA levels predicted the self-reported fear of Snakes and Aggressive Confrontation items on the SPQ questionnaire

SPQ item	Coefficient	Estimate	*SE*	95% CI		*p*	Adj. R^2
				LB	UB		
Snakes	Intercept	1.75	.63	.45	3.05	.010*	
	GA score	.13	.08	-.03	.29	.102	
	SA score	-.02	.04	-.11	.06	.613	.03
Aggressive Confrontation	Intercept	2.25	.52	1.18	3.32	<.001***	
	GA score	-.05	.06	-.18	.08	.459	
	SA score	.09	.03	.02	.16	.013*	.16

These results show that the rating of the "Aggressive Confrontation" item on the SPQ was significantly predicted by SA scores. All other findings were non-significant. Boxplots of the fear ratings of all 4 video stimuli on the SPQ can be found in Figure 9.

Figure 9

Boxplots of the fear ratings of all 4 video stimuli on the SPQ



Note. Threat ratings ranged from a minimum score of 0 to a maximum score of 6. “Snakes” = NST experimental video, “Frogs” = NST control video, “General Conversation” = ST control video, “Aggressive Confrontation” = ST experimental video.

Manipulation Tests

A total of 8 one-tailed repeated-measures *t*-tests were conducted to test the threat response of the experimental videos in comparison to the respective control videos. The difference scores for the 2 non-social videos and the 2 social videos for all 4 measures were compared. As a lower RMSSD value indicates a higher threat response, the RMSSD *t* values were predicted to be significantly higher than 0. For all other measures, *t* values were predicted to be significantly lower than 0. The results of these t-tests can be found in Table 11.

Table 11

t-tests comparing the threat response measure scores between the experimental videos and their respective control videos

Control video	Experimental video	Threat rating			Mean SCL			SCR count			RMSSD score		
		t	df	*p*	*t*	df	*p*	*t*	df	*p*	*t*	df	*p*
Frogs	Snakes	-9.39	26	<.001†††	-5.69	27	<.001†††	-3.79	27	<.001†††	-.20	26	.580
General Conversation	Aggressive Confrontation	-8.99	28	<.001†††	-2.21	29	.018†	0.00	29	.500	-.33	28	.629

† *p* <.05, one-tailed. †† *p* <.01, one-tailed. ††† *p* <.001, one-tailed.

After Hochberg corrections were applied for the 8 *t*-tests, it was concluded that both experimental videos were given significantly higher threat ratings than their respective control video. Both mean SCL and SCR count were also significantly higher for the "Snakes" video than the "Frogs" video. All other *t*-tests were non-significant after correction.

Balancing of Conditions Tests

A total of 8 TOST were conducted to test the equivalence of threat response of the non-social videos compared to the social videos. The 2 control videos and the 2 experimental videos were compared across the 4 measurements. For the RMSSD score measure, a positive *t* value indicates that the social video showed a higher threat response than the non-social video. For all other measures, a positive *t* values indicates that the non-social video showed a higher threat response than the social video. The results of these t-tests can be found in Table 12.

Table 12

Equivalence TOST comparing the threat response measure scores between the 2 experimental videos and the 2 control videos. The equivalence bounds used a Cohen's D value of .2 for a small effect size

Outcome measure	M_{NST}	M_{ST}	*t*-test			TOST Lower			TOST Upper		
			t	df	*p*	*t*	df	*p*	*t*	df	*p*
Control Videos											
Threat rating	11.85	5.31	1.86	26	.074	2.90	26	.003**	.83	26	.791
Mean SCL	.18	.59	-3.38	27	.002**	-2.32	27	.986	-4.43	27	<.001***
SCR count	.25	1.27	-1.67	27	.106	-.62	27	.728	-2.73	27	.005**
RMSSD score	.10	-.01	1.02	26	.315	2.06	26	.025*	-.01	26	.494
Experimental Videos											
Threat rating	53.93	40.55	3.49	26	<.001***	4.53	26	.002**	2.45	26	.989
Mean SCL	1.33	1.00	2.13	27	.042*	3.19	27	.002**	1.07	27	.854
SCR count	2.11	1.27	1.49	27	.148	2.55	27	.008**	.43	27	.665
RMSSD score	.12	.02	1.24	26	.226	2.28	26	.016*	.20	26	.579

* p <.05, two-tailed. ** p <.01, two-tailed. *** p <.001, two-tailed.

It can be concluded from the above results that the null equivalence hypothesis should not be rejected for any of the 8 tests. It can also be concluded that the null significance hypothesis should be rejected for threat rating of the experimental videos, as well as the mean SCL measurements for the control videos, after Hochberg corrections have been applied.

Generalised Anxiety and Social Anxiety

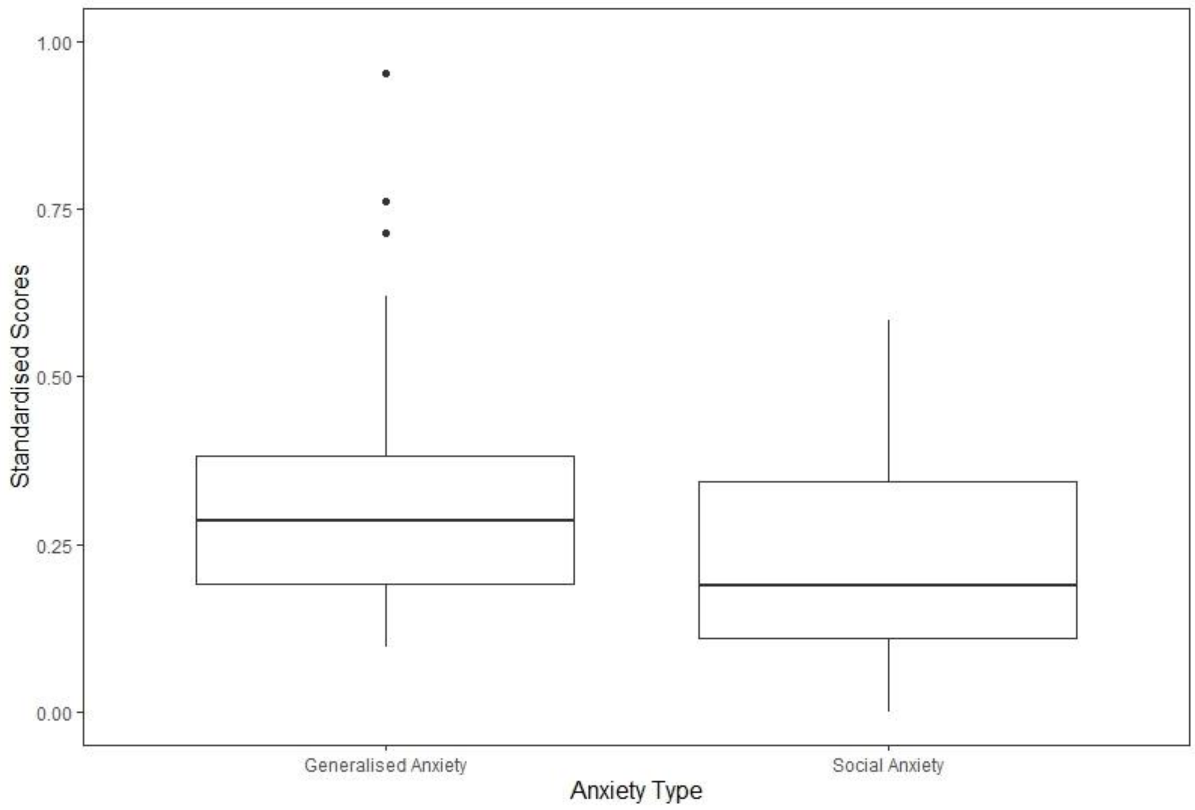
To compare the Generalised Anxiety and Social Anxiety scales, the following tests used the standardised scores as opposed to the raw scores used for all other tests.

A one-tailed Pearson's *r* correlational test found that generalised anxiety scores significantly correlated with social anxiety scores, $r(28) = .43$, $p = .009$, 95% CI [.14, 1.00]. There was a significant positive correlation between participants' standardised GA levels and standardised SA levels.

A two-tailed repeated-measures *t*-test found that participants' standardised GA levels were, on average, significantly higher than their standardised SA levels; $t(29) = 2.61$, $p = .014$, 95% CI [.02, .18], $M_{GA} = .34$, $M_{SA} = .24$. Boxplots of the standardised GA scores and SA scores can be found in Figure 10.

Figure 10

Boxplots displaying the standardised GA scores and standardised SA scores



Congruence of Measures Tests

A total of 24 one-tailed Pearson's *r* correlational tests were conducted to test the correlations between the 4 different measurements for each of the 4 video stimuli. As a lower RMSSD predicts a higher threat response, it is predicted that all correlations involving RMSSD scores will be negative, whilst all other correlations will be positive. The results of these correlational tests can be viewed in Table 13.

Table 13

Correlations between the 4 measures for each video

Outcome measure	*M*	*SD*	Threat rating			Mean SCL			SCR count		
			r	df	*p*	*r*	df	*p*	*r*	df	*p*
"Frogs" video (Non-social control condition)											
Threat rating	11.85	18.95									
Mean SCL	.18	.68	-.10	25	.689						
SCR count	.25	1.82	-.06	25	.618	.43	26	.011†			
RMSSD score	.10	.43	.05	24	.603	.22	25	.862	-.23	25	.122
"Snakes" video (Non-social experimental condition)											
Threat rating	53.93	25.86									
Mean SCL	1.33	.95	.08	25	.350						
SCR count	2.11	2.25	-.12	25	.717	.53	26	.002††			
RMSSD score	.12	.50	-.21	24	.153	-.05	25	.394	-.03	25	.436
"General Conversation" video (Social control condition)											
Threat rating	5.31	9.53									
Mean SCL	.59	.73	-.17	27	.814						
SCR count	1.27	2.12	-.09	27	.684	.32	28	.042†			
RMSSD score	-.01	.23	.10	26	.702	.27	27	.925	.28	27	.927
"Aggressive Confrontation" video (Social experimental condition)											
Threat rating	40.55	22.50									
Mean SCL	1.00	.91	.13	27	.253						
SCR count	1.27	2.10	.25	27	.094	.50	28	.002††			
RMSSD score	.02	.31	.07	26	.641	-.08	27	.335	.11	27	.717

†*p* <.05, one-tailed. ††*p* <.01, one-tailed. †††*p* <.001, one-tailed.

Prior to Hochberg corrections, the correlational *r* tests showed that the mean SCL and SCR count values correlated significantly for all 4 videos; after correction, significance was no longer reached for the "General Conversation" video. All other measure comparisons were non-significant, both prior- and post-correction.

Discussion

The first main aim of this study is to investigate the relationships between anxiety types and threat types. More specifically, this study aims to explore the relationships between both GA levels and SA levels with both NSTs and STs. Multiple structural equation models, linear regressions, and mediation analyses have been conducted to thoroughly explore these relationships.

The second main aim of this study is to test new methodology in an exploratory fashion for the purpose of use and improvement in future research. Novel stimuli were tested in conjunction with a combination of threat measures that were designed to estimate threat response on both a conscious and unconscious level.

It is important to highlight that, due to the time constraints and sample size used in this study, the research design has low statistical power and the results should be viewed as an exploratory first step in preparation for a larger scale study.

Hypothesis Testing

H1: Those with higher SA levels will show a stronger response to STs, but not to NSTs, when compared to individuals with lower SA levels.

Overall, the analyses show some support for the first hypothesis; one linear regression found SA levels, but not GA levels, is a significant predictor of ST rating score.

This finding is in line with the expectations of this thesis, given that SA is associated with fear and anxiety of social situations (American Psychiatric Association, 2013). This particular symptom of high SA may cause the significant increase in perceived threat for the social experimental video compared to the social control video. According to Schofield et al. (2012), another possible explanation for this correlation is a difficulty for high SA level individuals to disengage from STs in their environment. The lack of significance for SA levels as a predictor for NST response is also unsurprising, given the nature of SA; SA is associated with a fear of social situations in particular (American Psychiatric Association, 2013), it would not be expected that SA levels predict response to threats that do not feature social situations. Interestingly, GA levels show a negative relationship with ST rating responses in the linear regression, although this relationship was non-significant.

These regression models also show that SA levels did not significantly predict any of the psychophysiological measures of threat response (see Table 7). There are multiple potential explanations for this finding. It is likely that the SCR count and RMSSD scores were not strong enough measures of threat response to reach significance. Another likely cause of this is the low power of this study (Kivikangas et al., 2011); this is possibly the case for SCL, which was the only psychophysiological measure that was responsive to both threat types in the manipulation check analyses. A third explanation is that participants may have deduced the aim of this experiment during participation and altered their conscious threat responses accordingly, leading to only significant effects for the conscious measure of threat response (i.e. the threat ratings). This is less likely, however, as the stimuli were presented to the participants prior to the GAD-7 and SIAS-6/SPS-6 questionnaires; it seems unlikely that participant predicted that the present study was investigating GA and SA prior to completing the GAD-7 and SIAS-6/SPS-6. Overall, it can be argued that SCR count and RMSSD were not suitable measures, whilst the SCL measure was too underpowered to reach significance in the current study.

H2: Those with higher GA levels will show a larger response to all threat types (i.e. both NST and ST) than those with lower GA levels.

In sum, hypothesis 2 is not supported by the current data. None of the linear models conducted find GA levels to be a significant predictor of neither NST response nor ST response (see Table 7). This lack of significance is inconsistent with previous research (e.g. Buff et al., 2016; Thayer et al., 2000). Interestingly, GA levels show a negative relationship with NST ratings, although this relationship was not significant.

The most likely explanation for this is the lack of sufficient power in the analysis to reach significance; this is especially true for the psychophysiological measures of threat response (Kivikangas et al., 2011). However, alternative explanations must also be considered. One possible explanation is the stimuli chosen may not have been best suited to the population studied. Using snake stimuli to convey threat, coupled with frog stimuli as a baseline for comparison, was originally designed for threat response studies in young children (LoBue et al., 2017) and may not create sufficient feelings of threat in an adult sample. However, our results find that participants showed a significantly larger threat response to the “snakes” video compared to the “frogs” video in their threat ratings, mean SCLs, and SCR count data. The “snakes” video is also rated as significantly more threatening than the ST equivalent “aggressive confrontation” video, despite participants self-reporting higher fears of aggressive confrontation than snakes in the SPQ. This evidence suggests that the videos chosen for the NST conditions successfully convey a difference in threat and were not the reason for the lack of significance.

Another possible explanation is that threat conveyed by snakes is not in line with the definition of GA. High GA levels is associated with “excessive anxiety and worry about a range of concerns (e.g., world events, finances, health, appearance, activities of family members and friends, work, school)” that “is often experienced as difficult to control” (American Psychological Association, 2022a). It seems that GA is primarily associated with excessive worry over daily occurrences; snakes likely doesn’t fit into this category for the majority of the participants in this sample. However, there is an abundance of evidence to support the notion that high GA levels does indeed relate to a strong response to threat in general and is characterised by general worry about a broad range on stimuli (Goodwin et al., 2017). Therefore, issues concerning the stimuli are less likely given previous evidence.

In addition to this, the analyses show that while SA levels significantly predicted the SPQ rating of “aggressive confrontation”, GA levels did not significantly predict the SPQ fear rating of “snakes”, although this relationship was in the expected direction. It is likely that this result would reach significance with sufficient power. It could be argued that the sample size was too small to highlight the relationship between GA levels and a general heightened threat response; therefore, the threat response to the “snakes” video was not significantly predicted by GA levels. This theory is speculative, however, and would require further investigation.

H3: SA levels will mediate the effect of GA levels on ST response.

The Sobel’s tests of mediation did not find SA levels as a significant mediator for the relationship between GA levels and ST ratings. As SA levels did not significantly predict any of the psychophysiological measures, these mediations are assumed to be non-significant. Therefore, SA levels are not found to mediate the relationship between GA levels and ST response on neither a conscious nor unconscious level in the present data.

As discussed previously, this is an explorative hypothesis that has not been investigated in prior research, to the best of the author's knowledge. The lack of mediation is, however, supported by previous research that finds GAD and SAD to be separate, albeit highly correlated, disorders that show high comorbidity (e.g. American Psychiatric Association, 2013; Bandelow & Michaelis, 2015; Blair et al., 2008) and supports the categorisation of GA and SA as separate constructs. It is logical that separate constructs that merely correlate and do not influence each other would result in such a lack of mediation. Categorising GA and SA as distinct constructs further promotes the notion that specialised treatment methods for highly anxious suffers would be beneficial. This may have implications for the treatment methods currently used for sufferers of the related disorders, GAD and SAD; specialised treatments for each disorder may be preferred, although this will require thorough further investigation.

Model Comparison

Three models are compared in the present study. The saturated baseline model (model 1) assumes that GA levels exerted an equal influence on both NST and ST response; the same is assumed for SA levels. The first test model (model 2) assumes that GA levels predicted both NST and ST response, but it is not assumed that GA levels exert equal influence on the different threat types. In addition to this, SA levels are assumed to predict ST response only. The second test model (model 3) includes SA levels as a mediator for GA levels as a predictor for ST response. These three models were compared on multiple model fit statistics and individual relationships between variables were visually explored.

The model analyses find that model 3 shows significantly poorer fit than both model 1 and model 2. This in in line with the Sobel's test conducted and contradicts *H3: SA levels will mediate the effect of GA levels on ST response* when all 4 measures are included in the analyses. This finding further supports the notion that GA and SA are separate constructs with high comorbidity (Bandelow & Michaelis, 2015).

The model analyses also find that model 2 shows a significantly better fit to the present data than model 1. This result has two possible implications that correspond to the two key differences between these models. The first key difference is that model 1 contains fixed parameters, while model 2 does not. This implies that different anxiety types do not exert equal influence on NSTs and STs. This finding promotes further research into the differences between anxiety types on threat response dependent on the threat type. This finding also shows that the threat response cannot be viewed as a singular construct when applied in anxiety research, as the relationship between threat response and anxiety levels depends on the type of threat stimuli presented. This further highlights the potential issues with previous research, which often assumes that general threat response can be represented solely by STs, such as images of angry faces. The results show that ADs do not necessarily affect NSTs and STs equally, which is an important consideration when researching threat responses in the future.

The second key difference between these models is that model 1 assumes that SA levels predict both NST and ST response, while SA levels only predict ST response in model 2. This provides further support for *H1: Those with higher SA levels will show a stronger response to STs, but not to NSTs, when compared to individuals with lower SA levels*; the significant differences between these models suggest that SA levels are not a predictor of NST response. This finding is in line with the results of the linear regressions built to test H1 and H2, as well as previous research (Goldin et al., 2009). This further highlights the importance of considering threat type when addressing detrimental threat responses in highly anxious individuals.

Finally, the present model analyses may also have implications for *H2: Those with higher GA levels will show a larger response to all threat types (i.e. both NST and ST) than those with lower GA levels.* GA level's positive predictive power on NST response improves in model 2 when compared to model 1, although this relationship is not strong enough to reach statistical significance. Contrarily, GA level's predictive power on ST response considerably worsens in model 2 when compared to model 1 (see Appendix A and Appendix B for more detail). The high p value for GA level's influence on ST response in model 2 suggests that this pathway is unlikely to reach significance with a larger sample; on the other hand, it can be speculated that GA levels may become a significant positive predictor of NST response given sufficient power. However, this theory is impossible to support in the current sample and would require further research.

Methodology Testing

Specific Phobias Questionnaire (SPQ)

The results reported find that the SPQ rating of items "Frogs", "Snakes", and "Aggressive Confrontation" significantly correlate with the threat ratings of the respective stimuli intended to represent these phenomena. This suggests that the stimuli chosen successfully portray the intended phenomena, as the fear ratings of the phenomena on the SPQ reflect the threat ratings of the respective stimuli. The exception to this is "General Conversation"; this is likely due to a floor effect in the threat ratings of this particular video, as the correlation is in the expected direction (see Figure 8).

Interestingly, none of the 3 psychophysiological measures of threat response show a significant correlation with the SPQ rating of the respective stimuli. This is likely due to a very limited sample size for these types of measures (Kivikangas et al., 2011). An alternative explanation is a potential floor effect in the psychophysiological responses to the stimuli chosen, especially for the control videos. Alternatively, demand characteristics may have played a role in the threat rating measurement as ratings were reported after completion of the SPQ. Another explanation, however, is that the psychophysiological measures are somewhat de-coupled from the conscious threat rating. This is especially true for RMSSD as this primarily measures parasympathetic activity (Bhoja et al., 2020). The lack of significance between SPQ ratings and the respective mean SCL requires further investigation with a larger sample.

Manipulation Tests

The manipulation tests showed that the “Snakes” video elicits a significantly larger threat response in comparison to the “Frogs” video in the threat rating, mean SCL, and SCR count measures, but not in RMSSD scores. One potential explanation for the lack of significance of RMSSD scores is the impurity of the measure; RMSSD is viewed primarily as a measure of parasympathetic activity (Bhoja et al., 2020). It seems that using RMSSD to measure threat response as the inverse of relaxedness may not be a suitable method of quantifying threat responses for the present paradigms.

The manipulation tests also showed that the “Aggressive Confrontation” video elicits a significantly larger threat response than the “general conversation” video in the threat rating measure only. The relationship with mean SCL also moved in the expected direction, but this finding is no longer significant after correcting for multiple comparisons. Despite this, SCR count does not show the expected difference for the “Aggressive Confrontation” video, despite the close relationship between these two measures. It is possible that the “Aggressive Confrontation” video either tends to elicit a general gradual increase in SCL over the course of viewing, with few distinct spikes, or shows a large increase in SCL at the start of viewing, with a gradual return to baseline after the initial spike. This would create a high mean SCL and low SCR count for this video. Another explanation is that the “General Conversation” video tends to elicit many small spikes in SCL which have little impact on the SCL mean, but greatly increase the SCR count. These explanations could account for the incongruence of the mean SCL and SCR count data.

Balancing of Conditions Tests

These analyses show that the “Snakes” video is rated as significantly more threatening by participants than the “Aggressive Confrontation” video. This suggests that the NST experimental video chosen induces more conscious threat response, on average, than the ST experimental video in this sample. This is an interesting finding, given that the participants report a higher fear of aggressive confrontation than snakes in the SPQ. This suggests that the NST stimuli may be more effective at conveying threat than the ST stimuli. However, this does not seem to have negatively impacted the hypotheses testing, as a significant relationship between ST response and SA levels was found, but no significant relationship was found between NST response and GA levels.

Interestingly, the “General Conversation” video elicits higher mean SCL in participants than the equivalent “Frogs” video. A higher mean SCL for the “General Conversation” video suggests that this video elicits a slightly higher unconscious threat response than intended. This may contribute to the lack of significant difference in mean SCL between the “General Conversation” video and the “Aggressive Confrontation” video; it seems that the “General Conversation” video elicited too strong of an unconscious response to reach significance when compared to the “Aggressive Confrontation” video. Again, this does not seem to have negatively impacted the hypothesis testing for this study.

Congruence of Measures Tests

The analyses find that only the mean SCL and SCR count measures show a significant correlation in the present sample. The lack of significance post-correction in the "General Conversation" condition is likely due to the floor effect in threat response to this video. This theory is further supported by the *p*-values for this stimulus being generally higher than the equivalent *p*-values for the other stimuli. Strong correlations between mean SCL and SCR count are unsurprising given that both of these measures are derived from the same signal and the raw EDA data used to estimate the tonic SCL contained the SCRs.

The lack of significant correlations between all other pairs of threat response measures can be explained in multiple ways. The most obvious theory is the small sample size. Both mean SCL and SCR count measures failing to significantly correlate with the threat ratings may be due to the nature of the measurement, as the threat ratings measure conscious threat response as opposed to unconscious threat response. The lack of correlation between the skin conductance measures and the RMSSD is likely due to RMSSD's primary reflectance of the parasympathetic nervous system as previously discussed (Bhoja et al., 2020); it apparent that inverting a measure of relaxedness does not adequately capture threat response for use in the current paradigms.

General Discussion

Strengths and Limitations

The main limitation of this study is the limited sample size. This power of this study's analysis is not sufficient to consistently find underlying significant effects in the variables tested; this is especially true for more complex measures, such as electrodermal activity and heart rate variability, which have large individual differences by nature (Kivikangas et al., 2011; Ney et al., 2018). It is likely that the analyses using the psychophysiological measures are most affected by the limited sample available for this thesis. As a result, any conclusions drawn from this thesis should be interpreted with caution, especially in cases of non-significance where significance should typically and logically be expected.

Despite this, this study shows great potential as a starting point for future research in this field. Despite the low power of the sample, significant results in support for hypothesis 1 are found and all SEM showed significant differences that were consistent with the current literature and theory. This speaks to the overall strength of the new methodology that was employed in this paper; with a larger sample size, these new methods can benefit research investigating the nuances in the complex relationship between anxiety and threat response.

Although evidence supporting hypothesis 1 was found, hypothesis 2 requires further investigation with a more sufficient sample. Although this study was lacked sufficient power to draw concrete conclusions regarding hypothesis 2, the results do provide a hint at what a larger sample may reveal; these results suggest that GA levels may predict NST response, but not ST response, in a larger sample.

The main weakness of the methodology in this study is the lack of congruence between different measures of threat response. Throughout testing there are inconsistencies between rating data and the electrodermal activity measures, including the lack of correlation between these measures for each stimulus, for example. However, arguably the least consistent measure in the present study was the RMSSD measure, which failed to show correlation with all other measures throughout analysis. It seems that the SCR count and RMSSD measures are either not adequately sensitive or not valid for quantifying threat response. These results suggest that SCL is the most effective measure of unconscious threat response tested in this thesis. An additional methodological weakness of the present study is the randomisation leading to potential order effects.

However, one of the main strengths of the new methodology was the use of video stimuli with an audio component. These stimuli, for the most part, showed the expected significant differences between control and experimental conditions that implies that these videos successfully convey the intended threat to a sufficient degree. Overall, the use of video stimuli in place of linguistic or pictorial stimuli is a success in this study and can be a useful tool moving forward with research in this field.

Implications

This study has several implications. Firstly, this study highlights the need for the distinction of threat type in this field; in particular, those researching SA should focus on addressing heightened responses to STs and acknowledge that such relationships likely only apply to STs. These results suggest a risk of overgeneralisation in studies of threat response that do not acknowledge the potential importance of the threat type being investigated.

Although GA's relationship with threat type must be further investigated, there is a potential that GA levels predict NST responses only, given the findings of these analyses. This shifts the approach taken by previous research, which generally only uses socially threatening stimuli when testing threat response in relation to GA (e.g. Thayer et al., 2000). Again, these results highlight the use of STs as a representation of general threat as a potential weakness in previous research.

The lack of mediation found in this experiment further promotes the notion that GA and SA are separate constructs that do not directly influence each other, despite high positive correlation. This highlights the need for further investigation into key differences between these constructs.

Finally, these results hint that electrodermal activity measures, particularly mean SCL, may be a more effective measure of threat response than heart rate variability. This may be due to electrodermal activity pure reflectance of activity in the sympathetic nervous system, unlike heart rate variability (Bhoja et al., 2020). It may be therefore more beneficial to focus on SCL as the key psychophysiological measure of threat response in conjunction to threat rating data.

Future Research

This study creates the opportunity for an abundance of important future research. The new methodology tested in this thesis can be adjusted to be used in further study. It may be possible to use more threatening stimuli for the experimental conditions than the videos selected for this research, especially for ST. It would also be beneficial to ensure that the control conditions are well-balanced and elicit a low mean threat response, which the stimuli chosen here achieved. Future research with different video stimuli may be advised to further improve upon the methodology employed in this thesis, with the aim to induce a stronger threat response in the experimental conditions.

It is also recommended to combine mean SCL with a self-report measure of threat response to measure both conscious and unconscious levels of threat response, although it is important to note that such a study would require a large sample size. SCR count and RMSSD measures seem to be less appropriate for quantifying unconscious threat responses than mean SCL overall.

One area that requires further study with a sufficiently powered sample is the relationship between GA levels with both NST and ST response. Given the results of this study, it is recommended to adjust H2 to the following: *Those with higher GA levels will show a stronger response to NSTs, but not to STs, when compared to individuals with lower GA levels.* This hypothesis could be tested using similar methods to this study with the alterations previously suggested.

Should the hypotheses of this study be supported by replications with larger samples in a laboratory study, it would be ideal to test these findings using clinical samples of GAD and SAD sufferers in comparison to healthy controls. Confirming that the expected patterns also apply to a clinical sample is key step in using such research to further develop treatments for AD sufferers.

It may be possible to also test other common ADs using the above methods to investigate their similarities and differences in regard to threat response. Common ADs that it may be beneficial to test include panic disorder and Agoraphobia (Bandelow & Michaelis, 2015). It may also be possible to test other types of threat response in relation to anxiety, for example comparing visible threat (e.g. snakes) to an invisible, but present, threat (e.g. risk of infection).

Summary

In sum, this research accomplished its goals to test new methodology and compare anxiety types with threat types in the general population. Although this research was underpowered and some flaws in the new methodology was identified, this research has many strengths and opens many opportunities for future research. Firstly, it would be beneficial to retest the above hypotheses with a larger sample. Secondly, the above methodology, while mostly successful, could be adjusted with relative ease to elicit stronger threat responses in subjects. Overall, this study may contribute to identifying differences between anxiety types using improved methods and should prove to be an excellent starting point for reforming investigation concerning anxiety and threat response in the future.

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Appendix A

Path coefficients and confidence intervals for model 1. Parameters are fixed as described using the labels below

Path (label)	Std. Estimate	*SE*	95% CI		*p*
			LB	UB	
Regressions					
GA -> NST (a)	.24	.23	-.22	.69	.307
GA -> ST (a)	.24	.23	-.22	.69	.307
SA -> NST (b)	.39	.22	-.05	.83	.081
SA -> ST (b)	.39	.22	-.05	.83	.081
Latent Variables					
NST_Rating -> NST	.19	.23	-.25	.63	.396
NST_SCL -> NST	.29	.22	-.14	.72	.187
NST_SCR -> NST	.11	.23	-.34	.56	.624
NST_RMSSD -> NST	.55	.24	.08	1.02	.021*
ST_Rating -> ST	.46	.20	.07	.84	.019*
ST_SCL -> ST	.20	.24	-.26	.66	.399
ST_SCR -> ST	.61	.19	.24	.97	.001**
ST_RMSSD -> ST	.50	.19	.12	.87	.009**
Covariances					
NST_SCL ~ NST_SCR	.37	.17	.04	.70	.026*
ST_SCL ~ ST_SCR	.55	.16	.24	.86	<.001***

Note. SE = standardised standard error; CI = standardised confidence interval; LB = standardised lower bound; UB = standardised upper bound. GA = Generalised anxiety score, SA = Social anxiety score, NST = Non-social threat response, ST = Social threat response. Rating = Threat ratings, SCL = mean SCL, SCR = SCR count, RMSSD = RMSSD score.

* p <.05, ** p <.01, *** p <.001

Appendix B

Path coefficients and confidence intervals for model 2

Path (label)	Std. Estimate	*SE*	95% CI LB	95% CI UB	*p*
Regressions					
GA -> NST	.28	.22	-.15	.72	.203
GA -> ST	.03	.22	-.41	.47	.894
SA -> ST	.65	.19	.28	1.03	.001**
Latent Variables					
NST_Rating -> NST	.45	.21	.04	.86	.033*
NST_SCL -> NST	.70	.27	.18	1.22	.008**
NST_SCR -> NST	-.09	.29	-.66	.49	.761
NST_RMSSD -> NST	.17	.22	-.26	.60	.445
ST_Rating -> ST	.73	.16	.42	1.05	<.001***
ST_SCL -> ST	.30	.20	-.10	.70	.141
ST_SCR -> ST	.48	.18	.14	.83	.006**
ST_RMSSD -> ST	.33	.20	-.06	.71	.094
Covariances					
NST_SCL ~ NST_SCR	.63	.30	.04	1.22	.037*
ST_SCL ~ ST_SCR	.49	.15	.19	.79	.001**

Note. SE = standardised standard error; CI = standardised confidence interval; LB = standardised lower bound; UB = standardised upper bound. GA = Generalised anxiety score, SA = Social anxiety score, NST = Non-social threat response, ST = Social threat response. Rating = Threat ratings, SCL = mean SCL, SCR = SCR count, RMSSD = RMSSD score.

* *p* <.05, ** *p* <.01, *** *p* <.001

Appendix C

Path coefficients and confidence intervals for model 3. The paths labelled a and b together form the indirect path for the tested mediation. The c path represents the direct path for the tested mediation

Path (label)	Std. Estimate	*SE*	95% CI		*p*
			LB	UB	
		Regressions			
GA -> NST	.28	.22	-.15	.72	.203
GA -> SA (a)	.42	.15	.12	.71	.006**
SA -> ST (b)	.65	.19	.28	1.03	.001**
GA -> ST (c)	.03	.22	-.41	.47	.894
indirect (ab)	.27	.13	.02	.53	.038*
total (c+ab)	.30	.23	-.14	.74	.181
		Latent Variables			
NST_Rating -> NST	.45	.21	.04	.86	.033*
NST_SCL -> NST	.70	.27	.18	1.22	.008**
NST_SCR -> NST	-.09	.29	-.66	.49	.761
NST_RMSSD -> NST	.17	.22	-.26	.60	.445
ST_Rating -> ST	.73	.16	.42	1.05	<.001***
ST_SCL -> ST	.30	.20	-.10	.70	.141
ST_SCR -> ST	.48	.18	.14	.83	.006**
ST_RMSSD -> ST	.33	.20	-.06	.71	.094
		Covariances			
NST_SCL ~ NST_SCR	.63	.30	.04	1.22	.037*
ST_SCL ~ ST_SCR	.49	.15	.19	.79	.001**

Note. SE = standardised standard error; CI = standardised confidence interval; LB = standardised lower bound; UB = standardised upper bound. GA = Generalised anxiety score, SA = Social anxiety score, NST = Non-social threat response, ST = Social threat response. Rating = Threat ratings, SCL = mean SCL, SCR = SCR count, RMSSD = RMSSD score.

* $p < .05$, ** $p < .01$, *** $p < .001$