The Role of Individual Differences in Social Anxiety on Threat Extinction and Avoidance

Thesis submitted for the degree of Doctor of Philosophy

School of Psychology and Clinical Language Sciences

University of Reading

Shannon Wake

February 2021

Declaration of Original Authorship

I confirm that this is my own work and the use of all materials from other sources has been properly and fully acknowledged. In Paper 1 and Paper 3 Natalie Manningham, Josephine Arthur and Rebecca Borcsok helped me collect the data. In Paper 2 Maria Amerikanou and Ingelin Hansen assisted in coding the texts.

Shannon Wake

February 2021

Acknowledgements

I would like to thank the ESRC for funding my research throughout my PhD. Thank you to all of the participants that took part in my experiments and the masters students that have helped me along the way: Natalie Manningham, Josephine Arthur, Rebecca Borcsok, Maria Amerikanou and Ingelin Hansen.

I am beyond thankful for the training and supervision that I have received throughout my PhD. I would like to thank Dr. Jayne Morriss for your time and advice. I would also like to thank Prof. Carien van Reekum for adopting me as your PhD student. My work has benefitted massively from your supervision and I have learnt so much from you, thank you. A very special thank you goes to my first supervisor Prof. Helen Dodd. Your wisdom, support and guidance have helped me build my confidence as a researcher and I'll be forever grateful for that. I'm not sure how I would have got to this point without you. Jayne, Carien, and Helen - I feel so privileged to have had the opportunity to work with and learn from you all.

A huge thanks goes to my Mum and Dad for always supporting me. Thank you for the endless encouragement and faith in my abilities (this feels a long way from FuzzBuzz). And, finally, thank you to my best friend and my husband, Matt. Thank you for always being there for me (and for instinctively knowing when to bring snacks to my desk). I'm so grateful to have you on my side.

Table of Contents

List of Figures

List of Tables

Thesis Abstract

Social anxiety disorder is a prevalent and debilitating disorder that significantly impairs quality of life. Although Cognitive Behavioural Therapy, that incorporates exposure as a primary component, is the first-line treatment for social anxiety disorder, relapse after treatment is common. Principles of threat extinction serve as a laboratory-based model for exposure therapy. Despite this, relatively few studies have investigated the effect of social anxiety on extinction learning processes. Therefore, the primary aim of this work was to examine the relationship between individual differences in social anxiety and learning processes within Pavlovian threat extinction paradigms.

Paper 1 used two separate socially relevant threat extinction experiments to assess the relationship between social anxiety and threat extinction and retention. In Paper 2, a systematic review of the literature that has investigated the association between social anxiety and threat conditioning and extinction was conducted. The findings from Paper 1 and Paper 2 did not provide evidence that social anxiety is related to compromised extinction learning or retention. Instead, this work suggests that other maladaptive processes related to social anxiety may account for the maintenance or return of fear after exposure therapy. Thus, Paper 3 examined the effect of individual differences in social anxiety on low-cost avoidance conditioning and extinction and found that social anxiety was associated with increased avoidance behaviour to threat and safety cues after extinction learning.

Taken together, the findings suggest that maladaptive extinction of avoidance behaviour, and not extinction learning, is implicated in the maintenance or return of social anxiety related symptoms after exposure therapy. The work of this thesis points towards several suggestions for future clinical research to inform potential targets for exposure-based treatments for social anxiety disorder.

CHAPTER 1.

General Introduction to Thesis

1. General Introduction to Thesis

Social anxiety disorder (SAD) is a prevalent disorder that considerably impairs quality of life (Cooney et al., 2006; Cramer et al., 2005). Cognitive behaviour therapy (CBT) is the first-line treatment of social anxiety (Pilling et al., 2013), and typically embodies exposure therapy as a principle component (Chesham et al., 2018; Heimberg, 2002). Principles of threat extinction serve as a model for exposure therapy (Dunsmoor et al., 2015; Milad & Quirk, 2012) and extensive research has utilised Pavlovian threat extinction paradigms to examine the relationship between elevated levels of anxiety and safety learning mechanisms (for review see Lonsdorf & Merz, 2017). However, there is a limited literature that has specifically examined the effect of social anxiety on threat extinction processes. The primary aim of this thesis is to examine whether social anxiety is associated with abnormalities in threat extinction processes. Three papers are presented in the thesis in relation to this aim. In Paper 1, an experimental study examining the relationship between social anxiety and the extinction of social threat is presented. Two separate experiments are reported in this paper. Paper 2 includes a systematic review of the literature that has investigated the effect of social anxiety on threat acquisition and extinction. Finally, Paper 3 presents an experimental study that has examined the effect of social anxiety on the acquisition and extinction of low-cost avoidance behaviour. The final chapter of this thesis brings the findings of the three papers together and provides suggested directions for future research.

The following introduction first outlines the symptomology, characteristics, and theoretical models of social anxiety. Treatment approaches and outcomes are then described. Next, the theory and literature behind the use of threat extinction paradigms within anxiety-related research is discussed. The introduction concludes with a summary of the three stand-alone papers included in this thesis with an explanation of how they each contribute to the overall aim of the thesis.

1.1 Characteristics of Social Anxiety

1.1.1 Definition of Social Anxiety and Overview of Symptomology

According to the DSM-5 (American Psychiatric Association, 2013), social anxiety disorder (SAD) is characterised by marked fear or anxiety in response to social or performance situations that might expose the individual to scrutiny or negative evaluation from others. Fear in social anxiety is often expressed as severe distress in social contexts that is out of proportion compared to the actual threat posed by the social situation. Typical social situations that elicit such fear often involve interaction, observation and performance and include meeting strangers, initiating and participating in conversations within groups, talking to authority figures, eating or drinking while being observed,

going to school or work, using public toilets, and presenting information in front of others (NICE, 2013). Individuals with SAD fear that they will behave in a way that they think is humiliating or embarrassing (such as blushing, sweating, appearing anxious, boring, or incompetent) (NICE, 2013; Goldin et al., 2014) and therefore, social situations are typically avoided or suffered through. Avoidance and safety behaviours during social interaction (i.e., avoiding eye contact) are hallmark features of SAD and serve to maintain social anxiety, even though they are intended to reduce the risk of embarrassment or rejection (Clark & Wells, 1995).

SAD is prevalent (12.1%; Kessler et al., 2005), chronic (Cairney et al., 2007) and can lead to significant disability in education, employment and relationships (Stein et al., 2000). For example, individuals experiencing social anxiety are at increased risk of leaving school early with poorer attainment of qualifications (Ranta et al., 2009; van Ameringen et al., 2003), and are more likely to be bullied (Acquah et al., 2016; Ranta et al., 2009). In the workplace, Individuals with social anxiety also report poorer performance and more days absent from work (Stein et al., 1999), as well as fewer friendships across all areas of their life (Whisman et al., 2000). SAD is also associated with a variety of co-occurring conditions, including depression, generalised anxiety disorder, and substance abuse (Beesdo et al., 2007; Spence & Rapee, 2016) and unsurprisingly, is associated with lower well-being (Sherbourne et al., 2010). Although social anxiety symptoms cause the individual marked distress, the majority of individuals with SAD do not receive treatment for their social anxiety (Magee et al., 1996). Thus, social anxiety often affects individuals lives for a sustained period of time, despite the availability of effective interventions (Goldin et al., 2014).

1.1.2 The Epidemiology and Prevalence of Social Anxiety

There is evidence from research carried out in both community and clinical settings that SAD is a prevalent and disabling disorder (Stein et al., 2017). Findings from both the National Comorbidity Survey (NCS) and the National Comorbidity Survey Replication (NCS-R) carried out in the United States, demonstrate that SAD is among the most prevalent psychiatric disorders in adults with lifetime prevalence estimates of 16% and 12.1% respectively (Magee et al., 1996; Ruscio et al., 2008). Both of these surveys indicated that the typical age of onset is early and that comorbidity with other psychiatric disorders is high (Kessler, 2003; Kessler et al., 2009). Estimates of prevalence rates of paediatric SAD in the United States has ranged from 5% to 10% (Fichter et al., 2009; Schneier, 2006), and more recent epidemiological data has suggested that 9% of the US adolescent population has suffered with SAD (Burstein et al., 2011). A large study conducted in New Zealand demonstrated that 11.1% of 18-year-olds met diagnostic criteria for SAD (Feehan et al., 1994), while a German study estimated rates of 4% across 14- to 17-year-olds (Wittchen et al., 1999).

SAD typically develops during late childhood or adolescence (Beesdo et al., 2007; Detweiler et al., 2014; Wittchen & Fehm, 2003) and a gender difference in SAD-related symptoms is evident by adolescence (Detweiler et al., 2014). In the United States, more females than males receive a diagnosis of SAD (Xu et al., 2012; McNeil & Randall, 2014) and this gender difference appears to be greater in younger cohorts (Hofmann et al., 2010; Kessler et al., 2012). Further, lifetime prevalence estimates in the United States demonstrate that more women compared to men suffer with the disorder across their lifetime (Kessler et al., 2012).

To date, however, the majority of available data of the epidemiology of SAD has originated from high income countries in the West (Stein et al., 2017). European epidemiological data have typically been consistent with data generated in the United States, highlighting the high prevalence and comorbidity of SAD (Fehm et al., 2005). Nevertheless, it has been suggested that SAD may be a particularly Western construct (Dowbiggin, 2009). To address this question, Stein and colleagues (2017) analysed data from the WHO World Mental Health (WMH) Survey Initiative to investigate the epidemiology of SAD across a range of countries around the world. Findings from this study demonstrated that SAD prevalence rates were lowest in low/lower-middle income countries and in the African and Eastern Mediterranean regions, and highest in high income countries and in the Americas and Western Pacific regions. Results further demonstrated that the age of onset is early across the globe and the persistence of symptoms is highest in upper-middle income countries, Africa, and the Eastern Mediterranean. Further, across countries, SAD was associated with specific socio-demographic characteristics (i.e., younger age, female gender, unmarried status, lower education, and lower income), suggesting that similar patterns of SAD epidemiology exist across the globe. Taken together, this worldwide analysis suggests that SAD is not a uniquely Western construct and emphasises the international clinical and public health significance of SAD.

There is an increasing tendency to adopt a dimensional approach to the conceptualisation of SAD, which takes into consideration individuals experiencing sub-threshold or subclinical levels of social anxiety, and who may also experience significant impairment across different areas of their life (Crişan et al., 2016; Fehm et al., 2008; Knappe et al., 2009). Fehm et al. (2008) demonstrated that individuals with symptomatic but sub-threshold levels of social anxiety report significantly poorer life satisfaction, physical health, mental health and have more clinical complaints and disabilities over a 12-month period compared to individuals who do not exhibit symptoms of social anxiety. Therefore, the proportion of individuals suffering from social anxiety-related symptoms may in fact be higher than current estimates of disorder indicate (Jefferies & Ungar, 2020). Given the high lifetime prevalence of social anxiety, research examining the processes underlying the maintenance of social

anxiety-related symptoms is important for informing treatment and care for individuals with SAD and its related symptoms.

1.1.3 The Dimensional Approach to Social Anxiety

Human beings are inherently social and social relationships provide a functional purpose (e.g., social support) that facilitates health and survival (Young, 2008). Despite the functional nature of social relationships, some level of social anxiety is experienced by most humans and, in its trait form, social anxiety is normally distributed within populations (Brockveld et al., 2014; Crozier & Alden, 2001). Hence, social anxieties and fears manifest on a continuum of intensity (Bogels et al., 2010), ranging from useful and adaptive (i.e., remaining socially aware during uncertain social contexts) to disabling and maladaptive (i.e., being unable to initiate or maintain significant relationships despite feeling alone) (McNeil & Randall, 2014). As socialisation cannot be avoided on a consistent basis (McNeil & Randall, 2014), maladaptive emotional states (i.e., severe distress) and behaviours (i.e., safety behaviours and avoidance) associated with social interaction can have a significant and damaging impact on an individual's quality of life.

According to McNeil and Randall (2014), research examining the mechanisms associated with social anxieties and fears is best served by dimensional analyses and should be built on the concept that social anxiety exists along a continuum comprising of pathological extremes of social fears. It has been proposed that there is currently no compelling argument to suggest that trait social anxiety and SAD differ qualitatively (Jorstad-Stein & Heimberg, 2009) and this dimensional understanding of social anxiety was used to inform the updated diagnostic criteria outlined in the DSM-5 (APA, 2013). Further, studies examining whether principle characteristics of social anxiety correspond to category or dimension suggest that social anxiety is continuous, with milder traits (i.e., shyness) providing support for a dimensional approach to conceptualising SAD (Ruscio, 2010). Thus, a dimensional approach towards social anxiety has been adopted throughout the experimental work included in this thesis.

1.2 Cognitive-Behavioural Models of Social Anxiety

Since its recognition as a mental health disorder in the DSM third edition (American Psychiatric Association, 1980), several researchers have considered an array of theoretical perspectives and proposed explanatory models to better our understanding of SAD and inform approaches to treatments. The most widely cited of these models is that proposed by Clark and Wells (1995) and Rapee and Heimberg (1997), although other valuable models have been put forward (e.g., Hofmann, 2007; Heimberg et al., 2010; Wong & Rapee, 2016). These prominent models of SAD highlight key

cognitive and behavioural components that account for the maintenance of SAD and have stimulated a significant body of research that has been utilised in the development of effective interventions for the treatment of SAD. The following section summarises the preeminent cognitive-behavioural models of SAD, as well as the more recently proposed models relevant to this thesis.

1.2.1 Clark and Wells (1995): A Cognitive Model of SAD

According to Clark and Wells' (1995) cognitive model of SAD, social anxieties develop due to an interaction between life experiences and innate behavioural predispositions. In their model, Clark and Wells (1995) propose four interactive processes to describe the dysfunctional responses associated with social anxiety. The first process occurs when an individual with SAD enters a feared social situation. As stated by the model, the socially anxious individual fears that they are at risk of being negativity evaluated and use interoceptive information, such as increased heart rate or temperature, as the primary source of feedback about their social performance. Typically, their internal observations provide confirmation of their social failures and Clark and Wells refer to this attentional inward bias as a "processing of the self as a social object". The second dysfunctional process suggested by Clark and Wells (1995) refers to the "safety behaviours" that socially anxious individuals employ to prevent negative evaluation by others (i.e., avoiding eye contact). Safety behaviours, however, prevent the individual from experiencing situations that contradict their internal negative beliefs about feared consequences and thus, serve to maintain social anxieties. The third dysfunctional process reported by Clark and Wells (1995) concerns cognitive distortions in relation to the individual's behaviour. Individuals with SAD often overestimate how negatively other individuals judge their social performance and anticipate the consequences of social failures to be more catastrophic than is realistic. The final dysfunctional process described by Clark and Wells (1995) is the anticipatory and post-event processing that occurs before or after a social event is encountered. For example, many individuals with SAD experience anticipatory anxiety prior to engaging in a social event, during which negative experiences are recalled and expectations of failure are evoked. This anticipatory anxiety can result in the individual completely avoiding the situation. Further, following a social interaction, individuals with SAD often inwardly review their performance, recalling events and outcomes as more negative than they really were. This post-event processing again increases the likelihood that future feared situations will be avoided and maintains negative self-schemas.

1.2.2 Rapee and Heimberg (1997) and Heimberg, Brozovich & Rapee (2010): A Cognitive-Behavioural Model of SAD

In line with Clark and Wells (1995) model, Rapee and Heimberg (1997) also proposed that social anxiety is associated with dysfunctional cognitions, the excessive employment of attentional resources towards threat cues, as well as maladaptive avoidance behaviours. According to Rapee and Heimberg (1995), individuals with SAD typically believe that others hold extremely high standards for their social performance, fear negative evaluation and anticipate the cost of social failure to be high.

In 2010, Heimberg, Brozovich and Rapee published an updated version of Rapee and Heimberg's (1997) Cognitive-Behavioural Model of SAD to incorporate updated findings from across the field. The updated model posited that individuals with SAD not only fear negative evaluation, but any evaluation regardless of the valence. The updated Rapee-Heimberg (1997) model also highlighted the influence of negative self-imagery that is consistent with the theory that individuals with SAD hold a mental representation of the self as observed by the audience.

There are considerable similarities between Clark and Wells' (1995) and Rapee and Heimberg's (1997) models, however a subtle difference lies in the concept of attentional focus in SAD. Clark and Wells (1995) claim that attentional biases in SAD are associated with internal cues which prevent the individual from attending to the true responses of others. In contrast, Rapee and Heimberg (1997) posit that, although self-focused attention is an attribute of increased social anxiety, attention is directed externally towards forms of potential negative evaluation from others.

1.2.3 Hofmann (2007): Cognitive Factors that Maintain SAD

Hofmann's (2007) model is similar to that provided by Clark and Wells (1995), however, there are a few distinctions. Given the overlap of Hofmann's (2007) model with those outlined above, the following will focus on points of departure.

According to Hofmann (2007), the main goal for individuals with social anxiety is to meet the expectations of others, however, such individuals have difficulty setting, defining, and achieving social goals. Hofmann (2007) posits that socially anxious individuals experience problems when planning and implementing actions and behaviours that are consistent with goal attainment. The doubt that the individual can achieve the high standards set by others results in increased anxiety as they enter social situations. In line with other cognitive-behavioural models of SAD, Hofmann (2007) emphasises the role of negative self-perceptions and the perceived cost of performing poorly in social situations. However, Hofmann (2007) adds that individuals with SAD recognise themselves as

having less control over their emotions. The belief that others will witness their loss of control over their emotions results in the experience of anxiety when in the presence of other people. Hofmann (2007) states that the combination of negative self-perceptions, low perceived emotional control, high predicted social cost, and an inability to set social goals results in increased expectations of social failure and therefore, avoidance and the use of safety behaviours. The employment of such avoidance behaviours in turn prevents individuals from learning from social experiences and rectifying their maladaptive beliefs.

1.2.4 Wong and Rapee (2016): An Integrated Aetiological and Maintenance Model of SAD

In an attempt to build upon previous models that highlight the maintaining factors of SAD but do not highlight the aetiological basis for such maintaining factors, Wong and Rapee (2016) proposed an integrated aetiological and maintenance (IAM) model of SAD. The core component of the IAM model is the social-evaluative threat (SET) principle. According to Wong and Rapee (2016), the SET principle outlines the extent that social-evaluative stimuli (i.e., facial expressions, eye contact, gestures, and postures) communicate an expression of evaluation. As stated by the IAM model, the SET principle is a basic human characteristic, hence the concept of aetiology in this model refers to features that increase or decrease the threat value assigned to social-evaluative stimuli. Wong and Rapee (2016) propose that threat values may fluctuate throughout an individual's lifetime, however, suggest that greater flexibility is likely to occur earlier in life with threat values becoming more consistent beyond middle adolescence. The IAM model puts forward five aetiological factors that can each affect the threat values assigned in the SET principle, namely, inherited tendencies, parent behaviours, peer experiences, life events, and culture. In general, individuals will differ in the varying degrees of exposure to the separate aetiological factors, and so there will be individual differences in threat values assigned to social-evaluative stimuli.

The IAM model states that individuals with higher threat values assigned to social-evaluative stimuli are more likely to experience anxiety in relation to social stimuli. According to Wong and Rapee (2016), elevated threat values represented in the SET principle result in the development of maladaptive cognitive (i.e., self-focused and attentional focus to threat in the environment) and behavioural processes (i.e., avoidance of social-evaluative stimuli) that identify and remove social-evaluative threat. These processes increase the likelihood that the individual will display performance deficits and hence the elevated SET principle is maintained.

1.3 Safety-Learning in the Anxiety Disorders

The cognitive-behavioural models of social anxiety primarily highlight the role of cognitions in the development and maintenance of SAD and imply that changes in flawed cognitions will result in treatment gain. The cognitive perspective of SAD posits that biased information processing towards threat relevant information plays a causal role in SAD and emphasis is placed on the predicted consequence of public scrutiny and negative evaluation. In essence, these models outline the maintaining factors of SAD. However, with the exception of Wong and Rapee (2016), they do not describe in detail an aetiological basis for the disorder or the mechanism through which maintaining factors emerge. Although, Wong and Rapee's (2016) model addresses this gap it does not account for why some individuals with seemingly similar aetiological factors go on to develop pathological social anxiety and others do not. It has been proposed that this differential vulnerability might hinge on associative learning processes (Mineka & Oehlberg, 2008; Lonsdorf & Merz, 2017), such as heightened fear reactivity to dangerous stimuli, overgeneralisation of acquired fears to non-dangerous stimuli and/or deficits in safety-learning (Vervliet et al., 2013).

Safety-learning deficits are associated with anxiety and stress disorders (Blechert et al., 2007; Milad et al., 2008; Milad et al., 2009). For example, meta-analyses have demonstrated that individuals with an anxiety disorder continue to react fearfully to a stimulus that no longer signals danger (i.e., compromised safety learning; Duits et al., 2015). Further, impaired safety-learning has been observed in individuals at risk of developing anxiety disorders, suggesting that it may be a key aetiological factor. For instance, children of parents diagnosed with anxiety disorders have displayed slower safety-learning compared to children of parents without a diagnosis of an anxiety disorder (Craske et al., 2008). Given that safety-learning processes (i.e., threat extinction) serve as a model for exposure therapy (Dunsmoor et al., 2015; Milad & Quirk, 2012), a widely used treatment for SAD, research that examines the processes that underly safety-learning across the anxiety disorders is vital to determine how treatment outcomes can be improved.

1.4 Cognitive-Behavioural Therapy for Social Anxiety Disorder

Cognitive-behavioural models of SAD propose that strategies aimed at reframing maladaptive social beliefs and targeting avoidance behaviours may be effective at reducing social anxiety. In line with these models, cognitive-behavioural therapy (CBT) is the first-line treatment for SAD and aims to modify the negative beliefs and avoidance behaviours associated with the disorder. During CBT, patients learn to recognise and question maladaptive thoughts and participate in exposures to feared situations to evaluate the accuracy of biased beliefs (Kaplan et al., 2018).

The primary components of CBT that have been applied for the treatment of SAD include cognitive restructuring, relaxation training, social skills training, and exposure therapy (Heimberg, 2002). During cognitive restructuring, individuals are taught to recognise negative thoughts that occur before, during or after feared social situations, evaluate the accuracy of their thoughts, and acquire rational alternative explanations. Behavioural tasks are assigned to individuals during treatment that are designed to undermine the individual's maladaptive beliefs. During relaxation training, patients learn to identify and exert control over the somatic symptoms of social anxiety experienced during or in anticipation of a feared social event. Relaxation techniques assume that excessive physiological arousal hinders functioning during social situations (Gordon et al., 2014). Further, social skills training is a behavioural intervention aimed at improving the individual's verbal and nonverbal interpersonal skills by practicing social behaviours with instruction, modelling, corrective feedback, and reinforcement from a therapist. While principle evidence-based components of CBT include a variety of cognitive restructuring, relaxation training, and social skills training strategies, standard treatment almost always incorporates exposure therapy as its central component (Chesham et al., 2018; Heimberg, 2002).

Exposure therapy for social anxiety includes direct and indirect encounters with the feared social stimuli (i.e., initiating a conversation or attending a party) (McNeil et al., 2010). During exposure therapy, the therapist and the client create a hierarchy of social situations that are used during gradual in vivo or imagined exposure (Deacon & Abramowitz, 2004; Rodebaugh et al., 2004). In vivo exposure consists of direct engagement with actual feared stimuli in a real-world setting, while imagined exposure includes visualising feared situations (Olatunji et al., 2010). During exposure therapy, the client gradually faces each feared stimulus, from least to most feared. The exposure to each situation creates an opportunity for the individual to receive feedback of disconfirmatory information that challenges maladaptive social beliefs (Gordon et al., 2014). Theoretically, as the individual engages with each feared stimulus or situation, new safety learning occurs and competes with the original threat association, resulting in the decline of social anxiety (Rodebaugh et al., 2004).

Hofmann (2008) claims that exposure therapy is the most important component of efficacious treatment for a range of anxiety disorders, including SAD, and argues that the mechanisms of change during exposure therapy are mediated by changes in cognition as well as safety-learning. This suggestion is supported by meta-analyses that demonstrate minimal differences in treatment outcome between providing clients with exposure therapy alone compared to combining exposure therapy with cognitive restructuring and social skills training (Acarturk et al., 2009; Powers et al., 2008). However, methods of exposure do not reduce anxiety symptoms for all

individuals with social anxiety (Acarturk et al., 2009; Powers et al., 2008). The maintenance of treatment gains from exposure have also been questioned (Gordon et al., 2014). Despite advances in treatments for SAD, many patients remain symptomatic after initial intervention. For example, Otto et al. (2000) report that only 25% of patients with SAD met remission criteria following treatment. Further, the likelihood of experiencing a return of fear from post-treatment to follow-up is estimated to range from 19% to 62% across patients with obsessive-compulsive disorder, specific phobia, and performance anxieties (see review by Craske & Mystkowski, 2006). This conclusion demonstrates that a return of fear following successful treatment is not uncommon and highlights important questions regarding long-term effects of exposure-based interventions. The fact that so many individuals retain their diagnosis or experience a return of anxiety symptoms following treatment indicates that there is room for improvement in exposure therapy as a treatment for anxiety disorders, including SAD.

1.5 Pavlovian Threat Extinction as a Model for Exposure Therapy

1.5.1 Pavlovian Threat Conditioning and Extinction

Principles of Pavlovian threat extinction (i.e., safety-learning) serve as a model of exposure therapy (Dunsmoor et al., 2015; Foa et al., 1989; Milad & Quirk, 2012). For example, laboratory paradigms used to examine threat extinction processes approximate procedures employed clinically during exposure therapy. By bridging the gap between the laboratory and the clinic, research examining threat extinction has the potential to shed light on possible methods for improving treatments of anxiety disorders, including SAD (Carpenter et al., 2019; Raeder et al., 2020).

Classical Pavlovian conditioning occurs when a previously neutral stimulus (conditioned stimulus, CS+) is associated with an aversive stimulus (unconditioned stimulus, US) after several presentations so that the CS+ obtains the capacity to generate a defensive response when presented alone (conditioned response, CR) (Pavlov, 1927). Another neutral stimulus (CS-) is presented repeatedly which serves as the comparison condition and hence is never paired with the US. Differential threat conditioning is typically observed by an increase in self-reported (i.e., US expectancy ratings) or physiological fear-related responses (i.e., skin conductance responses) to the CS+ compared to the CS-. The reduction of the conditioned response is generally achieved through threat extinction. During threat extinction, the CS+ is repeatedly presented in the absence of the US, leading to a decline in the conditioned response as the CS+ loses its predictive value concerning the US. Threat extinction does not erase the learned threat association; instead, it involves new safety learning which inhibits the expression of the original threat association (Bouton, 1993; Milad & Quirk, 2012). Similarly, in exposure therapy, repeatedly approaching a feared situation, stimulus or memory (i.e.,

CS) enables patients to learn that their feared consequences (i.e., US) are unlikely to happen, leading to a comparable reduction in fear responses, as observed during threat extinction. The capability to model clinical treatment through simple laboratory paradigms provides researchers with the opportunity to examine processes of change and manipulations that might alter fear responses with greater control and specificity than is feasible in a clinical setting (Carpenter et al., 2019). Such paradigms therefore serve as useful translational tools for understanding the development and maintenance of maladaptive fear responses across anxiety disorders, including SAD.

1.5.2 Return of Fear

The return of fear-related symptoms after therapy highlights significant limitations on the long-term outcomes of exposure-based anxiety treatments (Vervliet et al., 2013). Clinical and experimental evidence demonstrates that upon re-exposure to a CS after extinction learning has taken place, the extinction memory does not always manifest and often a re-occurrence of conditioned responding is observed (Lonsdorf et al., 2017). The return of fear can be examined in the laboratory within Pavlovian conditioning paradigms that include an extinction retention test phase. The extinction retention test phase is a post-extinction procedure used to tap into spontaneous recovery processes of previously learned responses that may occur over the passing of time after extinction learning. Hence, spontaneous recovery refers to the relapse of the conditioned response towards CS as a consequence of time after successful extinction learning (see Lonsdorf et al., 2017). Notably, extinction-retention therefore refers to the absence of a conditioned response towards CS during a retention test phase and is explained as the successful expression of the extinction memory.

1.5.3 Pavlovian Threat Extinction and Anxiety Literature

Deficits in safety learning are deduced from differential conditioning paradigms. Typically, during the extinction phase of such paradigms, differential responding between the CS+ and CS- dissipates as the individual learns that the CS+ no longer signals threat. Previous research has demonstrated that physiological responses are higher and sustained to cues that no longer represent danger in individuals with stress and anxiety disorders. For example, a meta-analysis conducted by Duits et al. (2015) examined differences in classical fear conditioning and extinction of threat between 963 patients with stress and anxiety disorders and 1222 healthy control subjects. This study demonstrated that patients with anxiety and stress disorders indicate elevated fear responses towards the CS+ compared to healthy control participants throughout the extinction phase. Further, patients, compared to control subjects, showed persistent differentiated responding between the CS+ and CS- throughout the extinction phase, demonstrating delayed or reduced safety learning in

individuals diagnosed with stress and anxiety disorders. These findings have been replicated in individuals with subclinical levels of anxiety (i.e., individuals who score highly in self-reported measures of state, trait anxiety or neuroticism) in work that has shown that increased levels of anxiety are associated with elevated and sustained affective responses during extinction (for review see Lonsdorf & Merz, 2017).

Over recent years, research has begun to assess the role of intolerance of uncertainty in threat extinction learning and retention. Intolerance of uncertainty (IU) has been defined as "an individual's dispositional incapacity to endure the aversive response triggered by the perceived absence of salient, key, or sufficient information, and is sustained by the associated perception of uncertainty." (Carleton, 2016a, p.31). IU is recognised as a transdiagnostic factor across anxiety, stress and mood disorders (Carleton, 2016a, 2016b; Dugas et al., 2004; Grupe & Nitschke, 2013; McEvoy & Mahoney, 2012) and has been associated with compromised safety learning during threat extinction. For example, previous research has indicated that high IU predicts reduced safety-learning, indexed by increased skin conductance responding and pupil dilation to cues that no longer signal threat throughout extinction (Morriss, 2019; Morriss & van Reekum, 2019). Further work has demonstrated that individuals with higher IU are more likely to experience spontaneous recovery of learned threat. For example, higher IU has been associated with larger skin conductance responding to cues that no longer signal threat during a next day extinction retention phase (Dunsmoor et al., 2015) and during same-day extinction after reinstatement (i.e., presentation of the US alone after extinction learning; Lucas et al., 2018). Hence, in the context of threat extinction, the uncertainty surrounding the changes in contingency between stimuli (i.e., CS-US pairings) may result in the maintenance of the conditioned response in high IU individuals.

Recent work has pointed to the need to disentangle transdiagnostic and disorder-specific characteristics of emotional disorders (Shihata et al., 2016). Given the previous literature outlined above, it seems pertinent to include measures trait anxiety and IU (i.e., State-Trait Anxiety Inventory (STAI); Intolerance of Uncertainty Scale (IUS)) in research investigating the effect of specific subtypes of anxiety (i.e., social anxiety) on safety learning. Such work may have important implications for treatment, such as targeting-disorder specific or transdiagnostic processes during exposure therapy (Shihata et al., 2016).

1.5.4 The Effect of Social Anxiety on Threat Extinction

While it is widely accepted that deficits in safety learning are implicated in the maintenance of threat associations across clinical and subclinical anxiety (e.g., Duits et al., 2015), only a handful of studies have investigated the effect of social anxiety on extinction processes and these studies have

generated mixed findings. Three studies have shown that social anxiety is associated with impaired extinction. First, in a study that measured subjective US expectancy ratings, Rabinak et al. (2016) demonstrated that patients with social phobia did not show evidence of successful extinction of the CS+-US contingency, nor did they differentiate their expectation of the occurrence of the US between the CS+ and CS- during extinction learning. Further evidence of atypical extinction learning in social anxiety comes from Hermann et al. (2002), who found delayed extinction of the conditioned response in patients with generalised social phobia, indicated by a maintained differential skin conductance response throughout the extinction phase. Further, results from a two-day neuroimaging experiment carried out with healthy volunteers indicated a negative correlation between ventromedial prefrontal cortex (vmPFC) activity (in response to the CS+ compared to the CS-) and social anxiety scores during extinction retention (Pejic et al., 2013). The vmPFC is thought to play an important role during extinction retention (Maren & Quirk, 2004; Milad et al., 2005; Kalish & Robins, 2006; Quirk & Beer, 2006) by regulating fear expression through inhibition of the amygdala (Gottfried & Dolan, 2004; Phelps et al., 2004; Quirk & Beer, 2006).

In contrast, two studies did not find differences between socially anxious individuals (clinical and subclinical) and healthy control subjects in threat extinction on either psychophysiological or subjective measures (Lissek et al., 2008; Tinoco-Gonzalez et al., 2015). However, as noted by Tinoco-Gonzalez et al (2015), the extinction phase in their study was extremely short and a longer phase would have been more appropriate for the examination of extinction. Further, Lissek et al. (2008) stated that the absence of a conditioned eyeblink startle potentiation among both socially anxious and comparison subjects during the extinction sequence compromised their paradigm's capacity for measuring extinction learning.

Although the paradigms employed in the literature reviewed above model the procedural elements of exposure therapy (i.e., extinction learning), the primary characteristics of social anxiety, namely cognitive biases towards threat and avoidance behaviours, generally have not been incorporated into extinction paradigms to investigate how features of social anxiety impact extinction learning and retention. Despite the emphasis on maladaptive cognitive processes within aetiological and maintenance models of SAD, to our knowledge only one study has included a cognitive element into an extinction study. Blechert et al. (2015) demonstrated that reappraisal training resulted in a decline in conditioned negative valence in healthy and socially anxious individuals after extinction. Further, reappraisal training reduced the elevated conditioned responding observed in socially anxious participants after regular extinction. Such results suggest that reappraisal facilitates extinction learning in socially anxious individuals and supports the role of cognitive restructuring within CBT for the treatment of SAD.

Further, despite the critical role of avoidance behaviour in social anxiety, only one study has examined the effect of social anxiety on avoidance learning within an avoidance conditioning task (Ly & Roelofs, 2009). During avoidance conditioning, a simple motor response, for example pressing a button, in the presence of the CS+ prevents the presentation of the US, which can lead to the acquisition of conditioned avoidance. Ly and Roelofs (2009) found that when the opportunity to make an avoidance response was removed, elevated levels of social anxiety were associated with increased US expectancy compared lower levels of social anxiety. However, the effect of social anxiety on the extinction of avoidance behaviour has not yet been examined. As a result of the limited literature in this area, little is known about the role of cognitive processes and avoidance behaviours on safety learning and retention in individuals with elevated social anxiety. Such work is required to shed light on how these primary characteristics of social anxiety might impact the efficacy of exposure therapy for the treatment of SAD.

1.6 Aims of the Thesis and Outline of the Papers

1.6.1 Aim of the Thesis

As outlined, it is well established that extinction learning deficits are associated with anxiety and stress disorders (see Duits et al., 2015). However, comparatively little research has specifically examined the association between social anxiety and threat extinction processes. Furthermore, there are inconsistencies in the findings across the relatively limited literature in this field and where effects of social anxiety are reported, this work has not examined whether such effects are specific to social anxiety, and not the result of more general processes underlying anxiety (i.e., trait anxiety and intolerance of uncertainty). In addition, preceding work has not examined the relationship between social anxiety and the extinction of avoidance behaviour. These are important gaps in the literature as social anxiety has an estimated lifetime prevalence of 12.1 % (Ruscio et al., 2008), higher than any other anxiety disorder except specific phobia (Kessler et al., 2005), and can lead to significant disability in education, employment and relationships (Stein & Kean, 2008). Although exposure therapy is an effective and evidence-based treatment for social anxiety disorder, relapse after exposure therapy is common (Hofmann & Smits, 2008). Therefore, further examination into the association between social anxiety and safety learning, as well as filling the gap in the literature regarding the relationship between social anxiety and the extinction of avoidance behaviour will provide a better understanding of the learning mechanisms that are compromised in social anxiety. This work can be utilised to inform clinical research aimed at improving the outcome of exposure-based treatments for social anxiety disorder.

1.6.2 Overall Aim and Outline of Papers

The primary aim of this thesis was to examine whether social anxiety is associated with abnormalities in threat extinction processes. This aim was explored across three stand-alone papers. The following sections outline the research questions investigated within each paper.

1.6.3 Paper 1

The threat extinction literature has demonstrated that for individuals with increased levels of anxiety, affective responses during extinction remain elevated and sustained to cues that no longer signal threat, suggesting compromised extinction learning (see Lonsdorf & Merz, 2017). Previous work has shown that social anxiety is associated with impaired extinction, however, there are discrepancies in the findings across the literature. Several studies have demonstrated that elevated levels of social anxiety are associated with delayed extinction of the conditioned response (Hermann et al., 2002; Olsson et al., 2013; Rabinak., 2016), as well as difficulties differentiating between threat and safety cues (Ahrens et al., 2014; Hermann et al., 2002; Sachs et al., 2013). However, in contrast, a number of studies have failed to find a relationship between elevated levels of social anxiety and differences in threat extinction processes across either psychophysiological or subjective measures (Lissek al., 2008; Reichenberger et al., 2017; Tinoco-Gonzaleoz et al., 2015). Alongside the variation in findings across the literature, previous work has not examined whether reported effects are specific to social anxiety and not the results of more general processes that underpin anxiety more broadly (i.e., trait anxiety or intolerance of uncertainty).

Paper 1 aimed to examine how individual differences in social anxiety are related to threat extinction and retention, and to what extent any observed atypicalities in extinction processes related to social anxiety are robust after controlling for levels of intolerance of uncertainty and trait anxiety. Further, Paper 1 aimed to replicate previous findings of a relationship between transdiagnostic measures of anxiety (i.e., trait anxiety and IU) and extinction learning. Within this paper, findings from two separate socially relevant conditioning paradigms are reported. Both tasks consisted of a two-day threat acquisition, extinction learning and extinction retention protocol. The first experiment employed a cognitive component during threat extinction and retention. During this task, contextual information was presented with the CS+ and CS-. Participants were required to allocate attention towards and cognitively evaluate these contexts on a trial-by-trial bases in order to determine the threat level of the CS+. The second experiment removed these contexts and comprised a standard extinction paradigm with socially relevant stimuli. Skin conductance responses and subjective ratings of anxiety and US expectancy were collected across both experiments.

1.6.4 Paper 2

As outlined above, there are inconsistencies in findings across previous literature that has investigated the effect of social anxiety on threat extinction. Further, the results across both experiments reported in Paper 1 do not support the hypothesis that social anxiety is associated with compromised extinction learning. A scoping review of the literature also indicated that there is considerable variation in task design, methodology and dependent variables assessed across previous work. While a previous meta-analysis has examined differences in classical threat conditioning and extinction between patients diagnosed with anxiety disorders versus healthy control subjects (Duits et al., 2015), there has been no systematic review of the relationship between social anxiety, broadly defined to include social anxiety disorder as well as high social anxiety symptoms, and threat conditioning and extinction processes.

Paper 2 therefore aimed to systematically review research that has examined the association between social anxiety and threat conditioning and extinction. A second aim of this review was to investigate the sensitivity of various study designs and characteristics to detect social anxiety-related differences in threat conditioning and extinction. Further, the review adopted a dimensional approach and included research that examined clinical social anxiety as well as experiments that investigated individual variation in social anxiety levels. Fourteen articles were identified as relevant for inclusion in the systematic review.

1.6.5 Paper 3

In Paper 2, the review showed that there was not compelling evidence that high levels of social anxiety are associated with atypical threat conditioning and extinction. However, prior findings demonstrate that relapse after exposure therapy is common for individuals with social anxiety disorder (Craske & Mystkowski, 2006). An explanation, that aligns with cognitive models of social anxiety, might be that avoidance of social interaction and evaluation is a contributory maintaining factor of social anxiety. Excessive avoidance behaviour, in which an overt action delays or prevents an approaching event, is a defining characteristic of social anxiety. Cognitive models of social anxiety suggest that socially anxious individuals engage in various numerous 'in-situation or subtle safety behaviours', such as avoiding eye contact or joining in conversation (Clark & Wells, 1995). The employment of such safety behaviours prevents individuals with social anxiety from processing exposure accurately as the non-occurrence of feared outcomes (i.e., negative evaluation and rejection), is assigned to the safety behaviours that were engaged. Despite the crucial role of avoidance and safety behaviours in social anxiety, research aimed at improving the effectiveness of

exposure therapy and preventing relapse has largely focused on learning mechanisms, such as threat extinction.

Paper 3 addresses the lack of research in this field and aimed to examine the effect of individual differences in social anxiety on low-cost operant avoidance conditioning and extinction. An avoidance learning and extinction paradigm was employed with socially relevant CS and US. The task included five phases: threat acquisition, avoidance conditioning, threat extinction, avoidance test and a re-extinction phase. Throughout the task, skin conductance response, US expectancy ratings and behavioural avoidance responses were recorded.

1.6.6 Summary

Collectively the three papers in this thesis examine the association between social anxiety and learning processes within various Pavlovian threat extinction paradigms. Specifically, the following papers aimed to, 1) examine whether there is an association between individual differences in social anxiety and safety learning processes, 2) bring clarity to the current literature regarding the relationship between social anxiety and threat conditioning and extinction and 3) investigate the relationship between individual differences in social anxiety and low-cost avoidance conditioning and extinction. The degree to which the three papers address the aims of the thesis will be discussed in the final chapter.

References

Acarturk, C., Cuijpers, P., van Straten, A., & de Graaf, R. (2009). Psychological treatment of social anxiety disorder: a meta-analysis. In *Database of Abstracts of Reviews of Effects (DARE): Quality-assessed Reviews [Internet]*. Centre for Reviews and Dissemination (UK).

Acquah, E. O., Topalli, P. Z., Wilson, M. L., Junttila, N., & Niemi, P. M. (2016). Adolescent loneliness and social anxiety as predictors of bullying victimisation. *International Journal of Adolescence and Youth*, *21*(3), 320-331.

American Psychiatric Association (2013). Diagnostic and statistical manual of mental disorders (5th ed.). Arlington, VA: American Psychiatric Publishing.

Beesdo, K., Bittner, A., Pine, D. S., Stein, M. B., Höfler, M., Lieb, R., & Wittchen, H. U. (2007). Incidence of social anxiety disorder and the consistent risk for secondary depression in the first three decades of life. *Archives of general psychiatry*, *64*(8), 903-912.

Blechert, J., Wilhelm, F. H., Williams, H., Braams, B. R., Jou, J., & Gross, J. J. (2015). Reappraisal facilitates extinction in healthy and socially anxious individuals. *Journal of Behavior Therapy and Experimental Psychiatry*, *46*, 141–150.

Bögels, S. M., Alden, L., Beidel, D. C., Clark, L. A., Pine, D. S., Stein, M. B., & Voncken, M. (2010). Social anxiety disorder: questions and answers for the DSM-V. *Depression and anxiety*, *27*(2), 168-189.

Bouton, M. E. (1993). Context, time, and memory retrieval in the interference paradigms of Pavlovian learning. *Psychological Bulletin,* 114(1):80-99.

Brockveld, K. C., Perini, S. J., & Rapee, R. M. (2014). Social anxiety and social anxiety disorder across cultures. In *Social anxiety* (pp. 141-158). Academic Press.

Burstein, M., He, J. P., Kattan, G., Albano, A. M., Avenevoli, S., & Merikangas, K. R. (2011). Social phobia and subtypes in the National Comorbidity Survey-Adolescent Supplement: Prevalence, correlates, and comorbidity. Journal of the American Academy of Child and Adolescent Psychiatry, 50 (9), 870–880.

Cairney, J., McCabe, L., Veldhuizen, S., Corna, L. M., Streiner, D., & Herrmann, N. (2007). Epidemiology of social phobia in later life. *The American journal of geriatric psychiatry*, *15*(3), 224-233.

Carleton, R. N. (2016a). Fear of the unknown: One fear to rule them all? *Journal of Anxiety Disorders,* 41, 5–21.

Carleton, R. N. (2016b). Into the unknown: A review and synthesis of contemporary models involving uncertainty. *Journal of Anxiety Disorders,* 39, 30–43.

Carpenter, J. K., Pinaire, M., & Hofmann, S. G. (2019). From extinction learning to anxiety treatment: Mind the gap. *Brain Sciences*, *9*(7).

Clark, D. M., & Wells, A. (1995). A cognitive model of social phobia. In R. G. Heimberg, M. R. Liebowitz, D. A. Hope, & F. R. Schneier (Eds.), Social Phobia: Diagnosis, Assessment, and Treatment (69-93). New York, NY: Guilford Press.

Chesham, R. K., Malouff, J. M., & Schutte, N. S. (2018). Meta-Analysis of the Efficacy of Virtual Reality Exposure Therapy for Social Anxiety. *Behaviour Change*, *35*(3), 152–166.

Cooney, R. E., Atlas, L. Y., Joormann, J., Eugène, F., & Gotlib, I. H. (2006). Amygdala activation in the processing of neutral faces in social anxiety disorder: Is neutral really neutral? Psychiatry Research: *Neuroimaging*, *148*, 55-59.

Cramer, V., Torgersen, S., & Kringlen, E., 2005. Quality of life and anxiety disorders: a population study. *Journal of Nervous and Mental Disease, 193*, 196–202.

Craske, M. G., & Mystkowski, J. L. (2006). Exposure Therapy and Extinction: Clinical Studies.

Craske, M. G., Waters, A. M., Bergman, R. L., Naliboff, B., Lipp, O. V., Negoro, H., & Ornitz, E. M. (2008). Is aversive learning a marker of risk for anxiety disorders in children?. *Behaviour research and therapy*, *46*(8), 954-967.

Crişan, L. G., Vulturar, R., Miclea, M., & Miu, A. C. (2016). Reactivity to social stress in subclinical social anxiety: emotional experience, cognitive appraisals, behavior, and physiology. *Frontiers in Psychiatry*, *7*, 5.

Crozier, W. R., & Alden, L. E. (2001). *International Handbook of Social Anxiety. Concepts, research and interventions relating to the self and shyness*.

Deacon, B. J., & Abramowitz, J. S. (2004). Cognitive and behavioral treatments for anxiety disorders: A review of meta-analytic findings. *Journal of clinical psychology*, *60*(4), 429-441.

Detweiler, M. F., Comer, J. S., Crum, K. I., & Albano, A. M. (2014). Social anxiety in children and adolescents: Biological, developmental, and social considerations. In *Social Anxiety* (pp. 253-309). Academic Press.

Dowbiggin, I. R. (2009). High anxieties: the social construction of anxiety disorders. *The Canadian Journal of Psychiatry*, *54*(7), 429-436.

Dugas, M. J., Buhr, K., & Ladouceur, R. (2004). The role of intolerance of uncertainty in etiology and maintenance of generalised anxiety disorder. In R. G. Heimberg, C. L. Turk, & D. S. Mennin (Eds.), Generalised anxiety disorder: Advances in research and practice (pp. 143–163). New York, NY: Guilford Press

Duits, P., Cath, D. C., Lissek, S., Hox, J. J., Hamm, A. O., Engelhard, I. M., … Baas, J. M. P. (2015). Updated meta-analysis of classical fear conditioning in the anxiety disorders. *Depression and Anxiety*, *32*(4), 239–253.

Dunsmoor, J. E., Campese, V. D., Ceceli, A. O., Ledoux, J. E., & Phelps, E. A. (2015). Archival Report Novelty-Facilitated Extinction: Providing a Novel Outcome in Place of an Expected Threat Diminishes Recovery of Defensive Responses. *Biological Psychiatry*, 1–8.

Feehan, M., McGee, R., Raja, S. N., & Williams, S. M. (1994). DSM-III-R disorders in New Zealand 18-year-olds. *Australian and New Zealand Journal of Psychiatry*, *28*(1), 87-99.

Fehm, L., Beesdo, K., Jacobi, F., & Fiedler, A. (2008). Social anxiety disorder above and below the diagnostic threshold: prevalence, comorbidity and impairment in the general population. *Social psychiatry and psychiatric epidemiology*, *43*(4), 257-265.

Fehm, L., Pelissolo, A., Furmark, T., & Wittchen, H. U. (2005). Size and burden of social phobia in Europe. *European neuropsychopharmacology*, *15*(4), 453-462.

Fichter, M. M., Kohlboeck, G., Quadflieg, N., Wyschkon, A., & Esser, G. (2009). From childhood to adult age: 18-year longitudinal results and prediction of the course of mental disorders in the community. Social Psychiatry and Psychiatric Epidemiology, 44 , 792–803 .

Foa, E. B., Steketee, G., & Rothbaum, B. O. (*1989*). Behavioral/cognitive conceptualisations of post-traumatic stress disorder. *Behavior Therapy,* 20(2), 155–176.

Goldin, P. R., Jazaieri, H., & Gross, J. J. (2014). Emotion regulation in social anxiety disorder. In *Social anxiety* (pp. 511-529). Academic Press.

Goldin, P. R., Lee, I., Ziv, M., Jazaieri, H., Heimberg, R. G., & Gross, J. J. (2014). Trajectories of change in emotion regulation and social anxiety during cognitive-behavioral therapy for social anxiety disorder. *Behaviour research and therapy*, *56*, 7-15.

Gordon, D., Wong, J., & Heimberg, R. G. (2014). Cognitive-behavioral therapy for social anxiety disorder: The state of the science.

Gottfried, J. A., & Dolan, R. J. (2004). Human orbitofrontal cortex mediates extinction learning while accessing conditioned representations of value. *Nature neuroscience*, *7*(10), 1144-1152.

Grupe, D. W., & Nitschke, J. B. (2013). Uncertainty and anticipation in anxiety: An integrated neurobiological and psychological perspective. *Nature Reviews Neuroscience,* 14, 488–501.

Heimberg, R. G. (2002). Cognitive-behavioral therapy for social anxiety disorder: Current status and future directions. *Biological Psychiatry*, *51*(1), 101–108.

Heimberg, R. G., Brozovich, F. A., & Rapee, R. M. (2010). A cognitive behavioral model of social anxiety disorder: Update and extension. In *Social anxiety* (pp. 395-422). Academic Press.

Hermann, C., Ziegler, S., Birbaumer, N., & Flor, H. (2002). Psychophysiological and subjective indicators of aversive pavlovian conditioning in generalised social phobia. *Biological Psychiatry*, *52*(4), 328–337.

Hofmann, S. G. (2007). Cognitive factors that maintain social anxiety disorder: A comprehensive model and its treatment implications. *Cognitive behaviour therapy*, *36*(4), 193-209.

Hofmann, S. G., Anu Asnaani, M. A., & Hinton, D. E. (2010). Cultural aspects in social anxiety and social anxiety disorder. *Depression and anxiety*, *27*(12), 1117-1127.

Hofmann, S. G., & Smits, J. A. (2008). Cognitive-behavioral therapy for adult anxiety disorders: a meta-analysis of randomized placebo-controlled trials. *The Journal of clinical psychiatry*, *69*(4), 621.

Jefferies, P., & Ungar, M. (2020). Social anxiety in young people: A prevalence study in seven countries. *Plos one*, *15*(9), e0239133.

Jørstad-Stein, E. C., & Heimberg, R. G. (2009). Social phobia: an update on treatment. *Psychiatric Clinics*, *32*(3), 641-663.

Kalish, Y., & Robins, G. (2006). Psychological predispositions and network structure: The relationship between individual predispositions, structural holes and network closure. *Social networks*, *28*(1), 56-84.

Kaplan, S. C., Swee, M. B., & Heimberg, R. G. (2018). Psychological treatments for social anxiety disorder. In *Oxford research encyclopedia of psychology*.

Kessler, R. C. (2003). The impairments caused by social phobia in the general population: implications for intervention. *Acta Psychiatrica Scandinavica*, *108*, 19-27.

Kessler, R. C., Berglund, P., Demler, O., Jin, R., Merikangas, K. R., & Walters, E. E. (2005). Lifetime prevalence and age-of-onset distributions of DSM-IV disorders in the National Comorbidity Survey Replication. *Archives of general psychiatry*, *62*(6), 593-602.

Kessler, R. C., Petukhova, M., Sampson, N. A., Zaslavsky, A. M., & Wittchen, H. U. (2012). Twelve-month and lifetime prevalence and lifetime morbid risk of anxiety and mood disorders in the United States. *International journal of methods in psychiatric research*, *21*(3), 169-184.

Kessler, R. C., Ruscio, A. M., Shear, K., & Wittchen, H. U. (2009). Epidemiology of anxiety disorders. *Behavioral neurobiology of anxiety and its treatment*, 21-35.

Knappe, S., Beesdo, K., Fehm, L., Höfler, M., Lieb, R., & Wittchen, H. U. (2009). Do parental psychopathology and unfavorable family environment predict the persistence of social phobia?. *Journal of Anxiety Disorders*, *23*(7), 986-994.

Lissek, S., Levenson, J., Biggs, A. L., Johnson, L. L., Ameli, R., Pine, D. S., & Grillon, C. (2008). Elevated fear conditioning to socially relevant unconditioned stimuli in social anxiety disorder. *American Journal of Psychiatry*, *165*(1), 124–132.

Lonsdorf, T. B., Menz, M. M., Andreatta, M., Fullana, M. A., Golkar, A., Haaker, J., … Merz, C. J. (2017). Don't fear 'fear conditioning': Methodological considerations for the design and analysis of studies on human fear acquisition, extinction, and return of fear. *Neuroscience and Biobehavioral Reviews*, *77*, 247–285.

Lonsdorf, T. B., & Merz, C. J. (2017). More than just noise: Inter-individual differences in fear acquisition, extinction and return of fear in humans - Biological, experiential, temperamental factors, and methodological pitfalls. *Neuroscience and Biobehavioral Reviews,* 80, 703-728.

Lucas, K., Luck, C. C., & Lipp, O. V. (2018). Behaviour Research and Therapy Novelty-facilitated extinction and the reinstatement of conditional human fear. *Behaviour Research and Therapy*, *109*, 68–74.

Ly, V., & Roelofs, K. (2009). Social anxiety and cognitive expectancy of aversive outcome in avoidance conditioning. *Behaviour Research and Therapy*, *47*(10), 840-847.

Magee, W. J., Eaton, W. W., Wittchen, H. U., McGonagle, K. A., & Kessler, R. C. (1996). Agoraphobia, simple phobia, and social phobia in the National Comorbidity Survey. *Archives of general psychiatry*, *53*(2), 159-168.

Maren, S., Quirk, G.J. (2004). Neuronal signalling of fear memory. Nat Rev Neurosci, 5, 844–852.

McEvoy, P. M., & Mahoney, A. E. (2012). To be sure, to be sure: Intolerance of uncertainty mediates symptoms of various anxiety disorders and depression. *Behavior therapy*, *43*(3), 533-545.

McNeil, D. W., Lejuez, C. W., & Sorrell, J. T. (2010). Basic behavioral mechanisms and processes in social anxieties and social anxiety disorders. *Social Anxiety*, 347-372.

McNeil, D. W., & Randall, C. L. (2014). Conceptualizing and describing social anxiety and its disorders. In *Social Anxiety* (pp. 3-26). Academic Press.

Milad, M. R., Orr, S. P., Lasko, N. B., Chang, Y., Rauch, S. L., & Pitman, R. K. (2008). Presence and acquired origin of reduced recall for fear extinction in PTSD: results of a twin study. *Journal of psychiatric research*, *42*(7), 515-520.

Milad, M. R., Pitman, R. K., Ellis, C. B., Gold, A. L., Shin, L. M., Lasko, N. B., ... & Rauch, S. L. (2009). Neurobiological basis of failure to recall extinction memory in posttraumatic stress disorder. *Biological psychiatry*, *66*(12), 1075-1082.

Milad, M. R., Quinn, B. T., Pitman, R. K., Orr, S. P., Fischl, B., & Rauch, S. L. (2005). Thickness of ventromedial prefrontal cortex in humans is correlated with extinction memory. *Proceedings of the National Academy of Sciences*, *102*(30), 10706-10711.

Milad, M. R., & Quirk, G. J. (2012). Fear extinction as a model for translational neuroscience: ten years of progress. *Annual review of psychology*, *63*, 129–151.

Mineka, S., & Oehlberg, K. (2008). The relevance of recent developments in classical conditioning to understanding the etiology and maintenance of anxiety disorders. *Acta psychologica*, *127*(3), 567-580.

Morriss, J. (2019). What do I do now? Intolerance of uncertainty is associated with discrete patterns of anticipatory physiological responding to different contexts. Psychophysiology, 56(9).

Morriss, J., & van Reekum, C., M. (2019). I feel safe when I know: Contingency instruction promotes threat extinction in high intolerance of uncertainty individuals. *Behavior Research and Therapy,* 116, 111-118.

Olatunji, B. O., Cisler, J. M., & Deacon, B. J. (2010). Efficacy of cognitive behavioral therapy for anxiety disorders: a review of meta-analytic findings. *Psychiatric Clinics*, *33*(3), 557-577.

Olsson, A., Carmona, S., Downey, G., Bolger, N., & Ochsner, K. N. (2013). Learning biases underlying individual differences in sensitivity to social rejection. *Emotion*, *13*(4), 616–621.

Otto, M. W., Pollack, M. H., Gould, R. A., Worthington III, J. J., McArdle, E. T., Rosenbaum, J. F., & Heimberg, R. G. (2000). A comparison of the efficacy of clonazepam and cognitive-behavioral group therapy for the treatment of social phobia. *Journal of Anxiety Disorders*, *14*(4), 345-358.

Pavlov, I. (1927). Conditioned reflexes. New York, NY, US: Dover.

Pejic, T., Hermann, A., Vaitl, D., & Stark, R. (2013). Social anxiety modulates amygdala activation during social conditioning. *Social Cognitive and Affective Neuroscience*, *8*(3), 267–276.

Phelps, E. A., Delgado, M. R., Nearing, K. I., & LeDoux, J. E. (2004). Extinction learning in humans: role of the amygdala and vmPFC. *Neuron*, *43*(6), 897-905.

Pilling, S., Mayo-Wilson, E., Mavranezouli, I., Kew, K., Taylor, C., & Clark, D. M. (2013). Recognition, assessment and treatment of social anxiety disorder: summary of NICE guidance. *Bmj*, *346*.

Powers, M. B., & Emmelkamp, P. M. (2008). Virtual reality exposure therapy for anxiety disorders: A meta-analysis. *Journal of anxiety disorders*, *22*(3), 561-569.

Quirk, G. J., & Beer, J.S. (2006). Prefrontal involvement in the regulation of emotion: convergence of rat and human studies. Current Opinion in Neurobiology, 16, 723–27.

Rabinak, C. A., Mori, S., Lyons, M., Milad, M. R., & Phan, K. L. (2016). Acquisition of CS-US contingencies during Pavlovian fear conditioning and extinction in social anxiety disorder and posttraumatic stress disorder. *Journal of Affective Disorders*, *207*(June 2016), 76–85.

Raeder, F., Merz, C. J., Margraf, J., & Zlomuzica, A. (2020). The association between fear extinction, the ability to accomplish exposure and exposure therapy outcome in specific phobia. *Scientific reports*, *10*(1), 1-11.

Ranta, K., Kaltiala-Heino, R., Pelkonen, M., & Marttunen, M. (2009). Associations between peer victimization, self-reported depression and social phobia among adolescents: the role of comorbidity. *Journal of adolescence*, *32*(1), 77-93.

Rapee, R. M., & Heimberg, R. G. (1997). A cognitive-behavioral model of anxiety in social phobia. *Behaviour Research and Therapy*, *35*(8), 741–756.

Reichenberger, J., Porsch, S., Wittmann, J., Zimmermann, V., & Shiban, Y. (2017). Social fear conditioning paradigm in virtual reality: Social vs. electrical aversive conditioning. *Frontiers in Psychology*, *8*(NOV), 1–15.

Rodebaugh, T. L., Holaway, R. M., & Heimberg, R. G. (2004). The treatment of social anxiety disorder. *Clinical Psychology Review*, *24*(7), 883-908.

Ruscio, A. M. (2010). The latent structure of social anxiety disorder: consequences of shifting to a dimensional diagnosis. *Journal of Abnormal Psychology*, *119*(4), 662.

Ruscio, A. M., Brown, T. A., Chiu, W. T., Sareen, J., Stein, M. B., & Kessler, R. C. (2008). Social fears and social phobia in the United States: results from the National Comorbidity Survey Replication. *Psychological medicine*, *38*(1), 15.

Schneier, F. R. (2006). Clinical practice. Social anxiety disorder. New England Journal of Medicine , 355 , 1029–1036 .

Sherbourne, C., Sullivan, G., Craske, M. G., Roy-Byrne, P., Golinelli, D., Rose, R. D., ... & Stein, M. B. (2010). Functioning and Disability Levels in Primary Care Outpatients with One or More Anxiety Disorders (PM# 8021). *Psychological Medicine*, *40*(12), 2059.

Shihata, S., McEvoy, P. M., Mullan, B. A., & Carleton, R. N. (2016). Intolerance of uncertainty in emotional disorders: What uncertainties remain? *Journal of Anxiety Disorders*, *41*, 115–124.

Spence, S. H., & Rapee, R. M. (2016). The etiology of social anxiety disorder: An evidence-based model. *Behaviour Research and Therapy*, *86*, 50–67.

Stein, D. J., Lim, C. C. W., Roest, A. M., de Jonge, P., Aguilar-Gaxiola, S., Al-Hamzawi, A., … Williams, D. R. (2017). The cross-national epidemiology of social anxiety disorder: Data from the World Mental Health Survey Initiative. *BMC Medicine*, *15*(1), 1–21.

Stein, M. B., & Kean, Y. M. (2000). Disability and quality of life in social phobia: epidemiologic findings. *American Journal of Psychiatry*, *157*(10), 1606-1613

Stein, M. B., McQuiad, J. R., Laffaye, C., & McCahill, M. E. (1999). Social phobia in the primary care medical setting. *Journal of Family Practice*, *48*(7), 514-514.

Tinoco-González, D., Fullana, M. A., Torrents-Rodas, D., Bonillo, A., Vervliet, B., Pailhez, G., … Torrubia, R. (2015). Conditioned Subjective Responses to Socially Relevant Stimuli in Social Anxiety Disorder and Subclinical Social Anxiety. *Clinical Psychology and Psychotherapy*, *22*(3), 221–231.

van Ameringen, M., Mancini, C., & Farvolden, P. (2003). The impact of anxiety disorders on educational achievement. *Journal of anxiety disorders*, *17*(5), 561-571.

Vervliet, B., Craske, M. G., and Hermans, D. (2013). Fear extinction and relapse: state of the art. Annu. Rev. Clin. Psychol. 9, 215–248.

Whisman, M. A., Sheldon, C. T., & Goering, P. (2000). Psychiatric disorders and dissatisfaction with social relationships: Does type of relationship matter?. *Journal of abnormal psychology*, *109*(4), 803.

Wittchen, H. U., & Fehm, L. (2003). Epidemiology and natural course of social fears and social phobia. *Acta Psychiatrica Scandinavica*, *108*, 4-18.

Wittchen, H. U., Stein, M. B., & Kessler, R. C. (1999). Social fears and social phobia in a community sample of adolescents and young adults: prevalence, risk factors and co-morbidity. *Psychological medicine*, *29*(2), 309-323.

Wong, Q. J. J., & Rapee, R. M. (2016). The aetiology and maintenance of social anxiety disorder: A synthesis of complimentary theoretical models and formulation of a new integrated model. *Journal of Affective Disorders*, *203*, 84–100.

Xu, Y., Schneier, F., Heimberg, R. G., Princisvalle, K., Liebowitz, M. R., Wang, S., & Blanco, C. (2012). Gender differences in social anxiety disorder: Results from the national epidemiologic sample on alcohol and related conditions. *Journal of anxiety disorders*, *26*(1), 12-19.

Young, I. M. (2008). Responsibility and global justice: A social connection model. *Handbook of research on global corporate citizenship*, 137-165.

CHAPTER 2.

Paper 1: Intolerance of uncertainty, and not social anxiety, is associated with compromised extinction of social threat

This paper has been accepted for publication in the Journal *Behaviour, Research and Therapy*.

Wake, S., Morriss, J., Johnstone, T., van Reekum., C. M., & Dodd, H. Intolerance of uncertainty, and not social anxiety, is associated with compromised extinction of social threat. Journal *Behaviour Research and Therapy.* (Accepted January 2021).

Author Contributions:

S.W., C.v.R., T.J. & H.D. designed the studies. S.W. collected the data, conducted the analysis and interpretation and wrote the manuscript draft. J.M. helped with physio data extraction protocols/scripts and statistics for analysis. J.M., C.v.R., and H.D. contributed to interpretation, critical manuscript revision and approval of final manuscript. T.J. edited and approved the final manuscript.

Abstract

Extinction-resistant threat is regarded as a central hallmark of pathological anxiety. However, it remains relatively under-studied in social anxiety. Here we sought to determine whether self-reported trait social anxiety is associated with compromised threat extinction learning and retention. We tested this hypothesis within two separate, socially relevant conditioning studies. In the first experiment, a Selective Extinction Through Cognitive Evaluation (SECE) paradigm was used, which included a cognitive component during the extinction phase, while experiment 2 used a traditional threat extinction paradigm. Skin conductance responses and subjective ratings of anxiety (experiment 1 and 2) and expectancy (experiment 2) were collected across both experiments. The findings of both studies demonstrated no effect of social anxiety on extinction learning or retention. Instead, results from experiment 1 indicated that individual differences in Intolerance of Uncertainty (IU) were associated with the ability to use contextual cues to decrease a conditioned response during SECE. However, during extinction retention, high IU predicted greater generalisation across context cues. Findings of experiment 2 revealed that higher IU was associated with impaired extinction learning and retention. The results from both studies suggest that compromised threat extinction is likely to be a characteristic of high levels of IU and not social anxiety.

Keywords: Threat Acquisition, Extinction Learning, Extinction Retention, Social Anxiety, Intolerance of Uncertainty, Skin Conductance

1. General Introduction

Social anxiety disorder (SAD) is characterised by the persistent and intense fear of social or performance situations in which the individual is exposed to potential scrutiny and negative evaluation from others (American Psychiatric Association, [APA], 2013). Fear in social anxiety is often expressed as severe distress in social contexts and the avoidance of situations in which there is a perceived social threat (APA, 2013). Previous models have noted that social anxiety exists along a severity continuum, with many individuals experiencing severe symptoms without meeting the threshold for clinical diagnosis of SAD (Bögels et al., 2010; Spence & Rapee, 2016; Stein et al., 2000). The UK's National Institute for Health and Care Excellence (NICE) guidelines indicate that graduated exposure can be used in the treatment of SAD. Although exposure is an effective and evidence-based treatment for SAD (Jorstad-Stein & Heimberg, 2009; Ponniah & Hollon, 2008), relapse after exposure therapy is common (Craske et al., 2014; Graham & Milad, 2011; Hofmann & Smits, 2008), and can affect as many as 33-50% of successfully treated individuals (Craske & Rachman, 1987; Smith et al., 2009).

Principles of threat extinction serve as a model for exposure therapy (Dunsmoor et al., 2015; Foa et al., 1989; Milad & Quirk, 2012). Classical conditioning occurs when a previously neutral stimulus (conditioned stimulus, CS+) is associated with an aversive stimulus (unconditioned stimulus, US) so that the CS+ acquires the ability to elicit a defensive response when presented alone (conditioned response, CR) (Pavlov, 1927). The reduction of the conditioned response is typically achieved through threat extinction. During threat extinction, the CS+ is repeatedly presented in the absence of the US, leading to a decline in the conditioned response, as the CS+ loses its predictive value concerning the US. Threat extinction does not erase the learned threat association; instead, it involves new safety learning which inhibits the expression of the original threat association (Bouton, 1993; Milad & Quirk, 2012). Exposure-based therapies use the threat extinction principle to oppose flawed associations between intrinsically safe situations (CS) and imagined dangerous outcomes (US), by repeatedly exposing the patient to the objects or situations that generate fear (Vervliet et al., 2013).

Across threat conditioning and extinction research, anxiety is generally defined broadly, and studies have included dimensional assessments of individual differences in trait anxiety as well as comparisons across clinical and non-clinical samples. This broad definition of anxiety is consistent with The National Institute of Mental Health Research Domain Criteria (RDoc; National Institute of Mental Health, 2011) and theory regarding the relationship between trait anxiety and anxiety disorders (e.g., Raymond et al., 2017). The threat extinction literature has shown that for individuals with elevated levels of anxiety, affective responses during extinction remain elevated and sustained

to cues that no longer signal threat, suggesting impaired threat extinction (See Lonsdorf & Merz, 2017, for a recent review). As relapse after exposure therapy is common in SAD, further research examining the circumstances under which extinction learning and retention is compromised in socially anxious individuals is of value to inform clinical avenues aimed at improving the efficacy of exposure-based treatments for social anxiety.

Previous work has reported that social anxiety is associated with compromised extinction of the conditioned response, however, there are discrepancies in findings across the literature. A study that measured US expectancy ratings found that patients with SAD did not show evidence of successful extinction of the CS+ and US contingency (Rabinak et al., 2016). Two studies have further demonstrated that elevated levels of social anxiety are associated with delayed extinction of the conditioned response, indicated by a maintained differential skin conductance response throughout the extinction phase, in both patients with SAD (Hermann et al., 2002), and participants with elevated self-reported levels of rejection sensitivity (Olsson et al., 2013). In contrast, several studies have failed to find a relationship between elevated levels of social anxiety and differences in threat extinction processes across either psychophysiological or subjective measures, in both clinical and analogue samples (Lissek et al., 2008; Reichenberger et al., 2017; Tinoco-Gonzalez et al., 2015).

One explanation for this discrepancy across findings in the literature may be that the aforementioned studies did not investigate whether the reported effects were related to social anxiety specifically and not the result of more general or transdiagnostic processes that underpin anxiety more broadly (i.e., trait anxiety and intolerance of uncertainty). This is an important limitation because it is well-established that social anxiety is related to transdiagnostic traits such as trait anxiety and Intolerance of Uncertainty (IU) (Boelen & Reijntjes, 2009; Carleton, Collimore & Asmundson, 2007; McEvoy et al., 2019; Mogg & Bradley, 2002; Whiting et al., 2014), and these same trait variables are associated with compromised threat extinction learning and retention.

Intolerance of uncertainty (IU) has been defined as "an individual's dispositional incapacity to endure the aversive response triggered by the perceived absence of salient, key, or sufficient information, and is sustained by the associated perception of uncertainty." (Carleton, 2016a, p.31). IU is recognised as an important component of anxiety and stress disorders (Carleton, 2016a, 2016b; Dugas et al., 2004; Grupe & Nitschke, 2013). A series of recent experiments have revealed that higher IU is associated with reduced safety-learning indicated by greater skin conductance responding and pupil dilation to cues that no longer signal threat throughout extinction (Morriss et al., 2015, 2016; Morriss & van Reekum, 2019). Previous research has also shown that individuals with higher IU demonstrate impaired extinction retention of learned threat (Dunsmoor et al., 2015; Lucas et al., 2018). Similarly, high levels of self-reported trait anxiety have also been associated with

compromised threat extinction learning and retention (Barrett & Armony, 2009; Gazendam et al., 2013; Haaker et al., 2015). Hence, the inconsistencies in findings across the social anxiety and threat extinction literature may be the consequence of variance in dispositional traits, such as IU and trait anxiety, that have not been accounted for in previous work across the field. For example, levels of IU or trait anxiety may have been high across participants recruited in studies reporting an association between social anxiety and compromised threat extinction, but low in studies that do not find the same effect. As a result, there is a need to disentangle the transdiagnostic and disorder specific vulnerabilities associated with social anxiety when examining its effect on threat extinction processes (Shihata et al., 2016). Such an approach would provide the field with a starting point for understanding the contribution of transdiagnostic and specific components of social anxiety on extinction learning and retention, which will have relevance for targets of exposure-based treatments for social anxiety.

A further limitation of the existing literature on extinction learning and retention in social anxiety is that, despite relapse after exposure therapy being common for individuals with social anxiety (Craske & Mystkowski, 2006), research examining extinction retention in social anxiety is extremely sparse. It could be argued that social anxiety is unique in terms of the amount of exposure to the feared stimulus the individual experiences in their daily life. It is almost impossible to avoid social interactions entirely, but despite exposure, social anxiety is maintained. To our knowledge, only two studies have investigated the relationship between social anxiety and extinction retention within discriminative learning paradigms and both studies have recruited relatively small sample sizes (Pejic et al., 2013; Rabinak et al., 2017). Therefore, further examination of the relationship between social anxiety and extinction retention processes is warranted to inform new approaches to exposure-based therapies that promote the retention of the extinction memory.

Therefore, the current research aimed to address a number of limitations in the existing literature on social anxiety and extinction learning and retention, across two studies. The primary research questions were: 1) Are individual differences in social anxiety related to compromised threat extinction and retention?; 2) Are previous findings of a relationship between transdiagnostic measures of anxiety (i.e., trait anxiety and IU) and extinction learning and retention replicated?; 3) Are any effects of social anxiety on extinction learning and retention robust after controlling for transdiagnostic features of anxiety (i.e., trait anxiety and IU)? To examine these questions, we carried out two separate socially relevant conditioning experiments designed to target extinction learning and extinction retention processes. The first experiment employed a cognitive component during extinction, while the second experiment comprised a standard extinction paradigm.

2. Introduction Experiment 1

Cognitive mechanisms play a vital role in the development and maintenance of social anxiety (Clark & Wells, 1995; Heimberg et al., 2014; Hirsch & Clark, 2004; Hofmann, 2007). The cognitive model assumes that socially anxious individuals allocate attentional resources towards detecting social threat in the environment and there is increasing evidence that such attentional biases towards threat play a causal role in the maintenance of social anxiety (Heimberg et al., 2014; Hofmann, 2007).

Across the conditioning literature, previous studies have found that highly socially anxious individuals demonstrate difficulties differentiating between threat and safety cues (Ahrens et al., 2014; Hermann et al., 2002; Sachs et al., 2003). These findings suggest that compromised discrimination learning may be a characteristic of elevated social anxiety and imply an increased tendency in socially anxious individuals to generalise conditioned fear across safe cues (Ahrens et al., 2016).

In experiment 1, we used a Selective Extinction through Cognitive Evaluation (SECE) task (development of task outlined in Macdonald et al., 2020), that adds additional cognitive load into an extinction study. Within this task, contextual information was presented with the CS+ and CS- during the extinction phase. Participants were required to allocate attention towards and cognitively evaluate these contexts on a trial-by-trial basis to determine the threat level of the CS+. Therefore, as in a real-life situation, participants were required to assess all the information presented to predict whether the US is likely to occur. If socially anxious individuals exhibit attentional biases towards threat during extinction, we might predict that such individuals will have difficulty using contextual "safety" information to determine the threat level of a stimulus previously associated with an aversive event.

Therefore, in this study, we hypothesised that high social anxiety, relative to low social anxiety, would be associated with larger conditioned responding to the CS+ associated with a safe context during the late part of SECE learning (day 1) and the early part of the SECE retention (day 2), as demonstrated by greater skin conductance responsivity. We also hypothesised that ratings of anxiety would be higher toward the CS+ relative to the CS- throughout the experiment for high socially anxious participants compared to low socially anxious participants. Following previous research, we hypothesised that trait anxiety and IU would have these same effects on extinction learning and retention. Further, we aimed to explore whether any effects of social anxiety would be consistent over and above IU and trait anxiety (Dunsmoor et al., 2015; Lucas et al., 2018; Morriss et al., 2015, 2016; Morriss & van Reekum, 2019).

3. Method Experiment 1

3.1 Participants

The sample consisted of 83 female students (age *M* = 19.61, *SD* = 1.39; Ethnicity: 66 White, 9 Asian/Pacific Islander, 4 Black, 4 Multi-ethnic). Participants were recruited if they were female, aged 18 to 35, and not currently receiving treatment for a psychiatric disorder, including medication. Females were recruited due to the consistently higher prevalence of social anxiety in females compared to males (Remes et al., 2016). Females also demonstrate higher levels of social anxiety when using a dimensional approach (Sosic et al., 2008). Further, female faces and voices were used as conditioned and unconditioned stimuli, and it was thought that a female voice administering critical statements would have a different threat value to male participants compared to female participants. All participants had normal or corrected to normal vision. Participants provided written informed consent and received £15 or course credit for their participation.

There were two participants that did not return to the laboratory for the SECE retention phase. Further, six participants were missing ratings data due to incorrect button presses that were not recorded. Therefore, 81 participants were included in SCR analyses, and 75 participants were included in the analyses of anxiety ratings.

The power analyses suggested a sample size of 67 participants for this experiment based on an effect size of *d* = 0.89. This effect size was taken from the original SECE experiment that reported a main effect of context (CS+ dangerous vs CS- dangerous) for SCR magnitude during SECE learning (Macdonald et al., 2020). The following parameters were used: *f* = 0.45 (converted from *d* = 0.89), α error probability = 0.05, Power (1-β error probability) = 0.95, number of groups = 4 (CS: CS+, CS-; Context: Dangerous, Safe), numerator *df* = 1, number of covariates = 3 (SPIN, IU, Trait Anxiety). We oversampled by 14 participants for SCR analyses and 8 participants for analyses of ratings data[1].

The procedure was approved by the University of Reading Research Ethics Committee.

3.2 Procedure

Upon arrival on day 1, participants were informed about the experimental procedures and were provided with a verbal description of the SECE task (Macdonald et al., 2020). They were then asked to complete a consent form and a series of questionnaires (see 'Questionnaires' below). Participants were seated in a testing booth, and physiological sensors were placed on the participant's index, middle and ring finger. The stimulator electrode was placed on the little finger of

[1] We oversampled in experiment 1 as an initial power analysis, conducted before data collection, used an estimated effect size due to the lack of published research using the SECE task. The power analysis has since been updated to use the most appropriate effect size from the original SECE experiment (Macdonald et al., 2020).

the left hand. The shock level for each participant was set following procedures outlined in Delgado et al (2008) (See 'Shock Build-Up Procedure' in Supplementary Materials). Participants were asked whether they had any questions and were instructed to respond to the ratings using the number keys on the keyboard with their right hand. They were asked to stay as still as possible. At this point, the SECE task (see 'SECE Task' below for details) was presented on a computer screen while skin conductance response (SCR), pulse, and behavioural ratings were recorded.

On the second day (24 hours later), participants were provided with similar instructions of the SECE task (see 'SECE Instructions' below). The same physiological setup was used as above. Each session took approximately 45 minutes in total.

3.3 SECE Instructions

The instructions provided for the SECE task were adapted from those administered in Macdonald et al's (2020) experiment. Participants were told that they would see two female identities during the first phase and that one identity would be associated with the risk of electric shock and negative statement. Participants were informed that, after a break, the identities would again be presented, but an image of a 'place' would also be briefly displayed. Most of the places would belong to two distinct categories: houses or skyscrapers. Participants were instructed that one of these categories was "safe", meaning that regardless of the identity presented they would not receive the shock or statement. They were asked to determine which place category was safe during this phase and to keep the contingencies in mind throughout. Participants were also asked to focus on whether or not they were likely to receive the shock and statement during each trial. Finally, participants were asked to press the space bar on the rare occasion that they saw an image that did not belong to one of the two place categories (i.e., distractor trials).

Participants were provided with the same instructions on day 2. They were informed that they would not see the identities alone, but always alongside the 'place' images. Participants were not instructed that the contingencies between the identity and context images would be the same as on day 1.

3.4 SECE Task

The SECE task was designed using Matlab 2016b software (Mathworks, Ltd) and was presented using Psychtoolbox-3 (Kleiner et al., 2007). Visual stimuli were presented using a screen resolution of 800 X 600 with a 60 Hertz refresh rate. Participants sat approximately 60 cm from the computer screen. Visual stimuli included two photographs of neutral expressions of two white female identities taken from the Chicago Face Database (Ma et al., 2015). Actors were chosen from a

set of 37 white female faces based on normative data collected from over 90 individuals (96 raters for identity 1 and 91 raters for identity 2). The two identities were chosen based on having comparable subjective ratings of age and expressions of happiness, anger, and disgust presented in the neutral expression rated on a 7-point Likert scale. One was brunette, the other blonde. Aversive Statements were delivered throughout headphones by a female voice and were taken from previous studies carried out by Ahrens et al (2014), Lissek et al (2008) and Wiggert et al (2017). The volume of the statements was standardised across participants by using fixed volume settings on the presentation computer.

The paradigm comprised 3 phases, threat acquisition, Selective Extinction through Cognitive Evaluation (SECE) learning, and SECE retention. Acquisition and SECE learning took place on day 1, and SECE retention took place 24 hours later on day 2. During acquisition, one of the female identities (blonde or brunette) was paired with the electric shock and negative statement 50% of the time (CS+). In contrast, the other identity (brunette or blonde) was always presented alone (CS-). The 50% pairing rate was designed to maximise the unpredictability of the CS+/US contingency (Grady et al., 2016; Jenkins & Stanley, 1950; Leonard, 1975). Conditioning contingencies were counterbalanced across subjects. Following acquisition, the SECE learning phase took place during which participants were presented with both identities (CS+ and CS-). However, one of two 'context' stimuli (houses or skyscrapers) was also presented for a period of the trial. Context stimuli consisted of 12 different images of houses and 12 different images of skyscrapers that were randomly presented alongside the CS. One context category represented a dangerous trial, i.e., when the dangerous context was paired with the CS+, participants received the US in 50% of trials. The other context category represented a safe trial, i.e., when the safe context was paired with the CS+, there was not a risk of receiving the US. Dangerous and safe context categories were counterbalanced across participants. The SECE procedure was repeated when participants returned on day 2.

The acquisition phase comprised 40 trials (10 CS+ reinforced, 10 CS+ non-reinforced, 20 CS-). The SECE learning and SECE retention phases both consisted of 84 trials; 16 CS+ dangerous reinforced, 16 CS+ dangerous non-reinforced, 16 CS+ safe, 16 CS- dangerous, 16 CS- safe and 4 distractor trials (2 CS+ and 2 CS-). We included one trial of each condition as orientation trials (CS+/CS-; dangerous/safe), none of which were reinforced, at the start of each SECE phase. The fifth trial of SECE was always a reinforced CS+ dangerous trial to inform participants of the CS/context contingencies.

Early SECE learning and SECE retention was defined as the first seven trials (after orientation) of each trial type, and late SECE learning and SECE retention was defined as the last eight trials of each trial type. Two distractor trials (i.e., 1 CS+ and 1 CS-) were presented during early

SECE learning and SECE retention, and two distractor trials were presented during late SECE learning and SECE retention. Distractor trials were included to ensure that participants were paying attention to the CS with context contingencies throughout the task. These trials were not included in analyses.

Experimental trials were pseudo-randomised. Two separate pseudo-randomised trial sequences were generated for acquisition, SECE learning and SECE retention before data collection. The task was programmed so that a maximum of 3 trials of the same trial type would be presented in a row and sequences were counterbalanced across participants.

During acquisition, the CS was presented on the screen for 4000 ms. During reinforced trials, the statement was presented 3000 ms after CS onset and co-terminated with the trial. The electric shock lasted for 200 ms and also co-terminated with the trial. Trials during the SECE learning and SECE retention phases had a duration of 5500 ms. The identity was presented alone for 1000 ms; the context was presented on the screen below the CS for a duration of 500 ms before disappearing. The identity then remained on screen alone for a further 4000 ms. During reinforced CS+ dangerous trials, the negative statement was presented 4500 ms into the trial, and the onset of the statement was followed by the electric shock that lasted for 200 ms and co-terminated with the trial. A jittered ITI, ranging between 6000ms and 8000ms, consisted of a black screen and followed each stimulus presentation throughout the task.

During acquisition, blocks were made up of 20 trials, and during SECE learning and SECE retention blocks were made up of 42 trials. Participants were given a break between blocks in each phase. At certain time points throughout the task (Day 1: before acquisition, after acquisition and after SECE learning; Day 2: before SECE retention and after SECE retention) participants were asked to rate how anxious each identity made them feel on a scale ranging from 1 ("not at all") to 9 ("extremely").

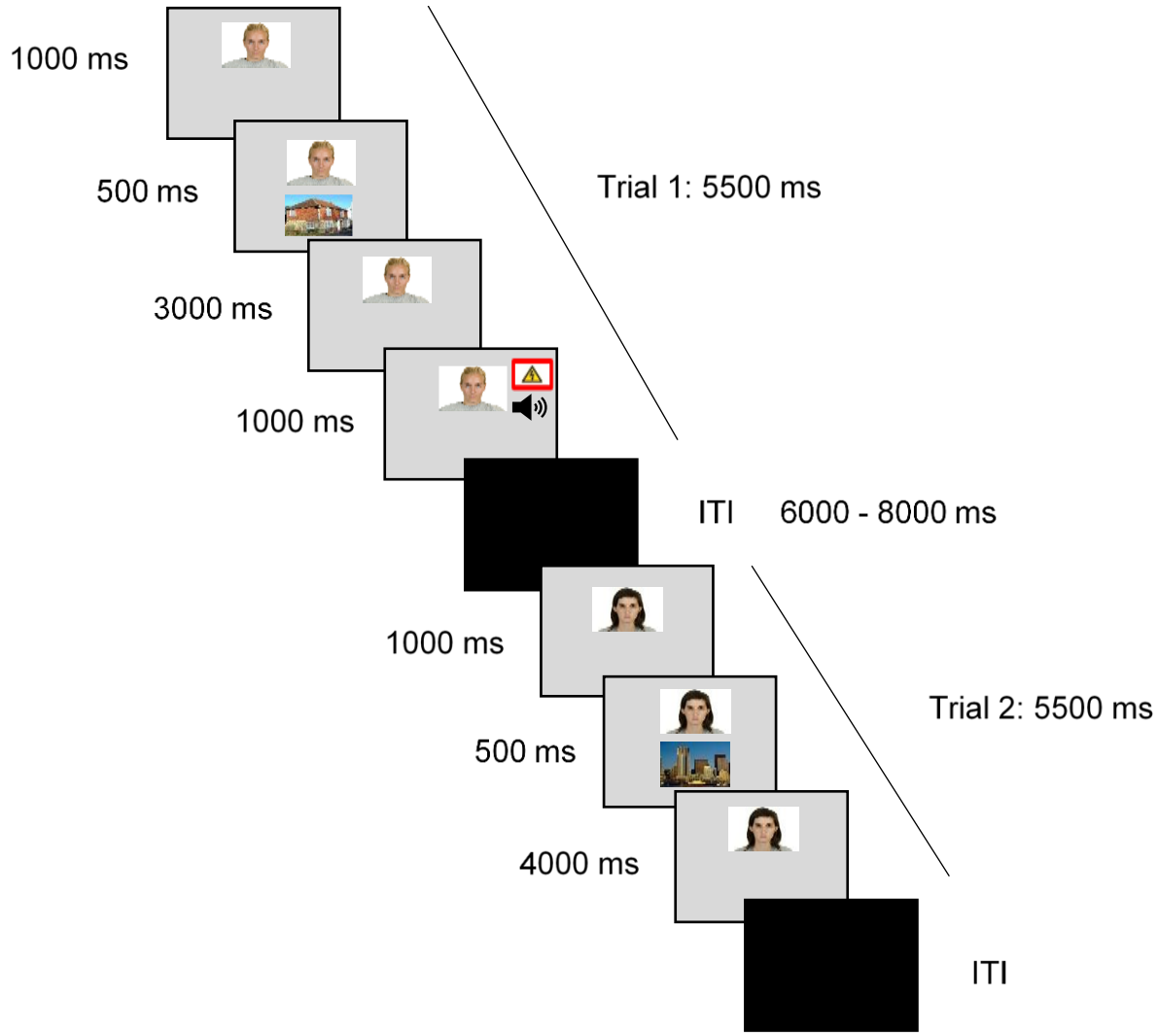


Figure 1. Example of SECE sequence of trials in experiment 1. Trial 1, CS+ dangerous. Trial 2, CS- safe.

3.5 Questionnaires

To assess social anxiety, we administered the Social Phobia Inventory (SPIN) (Connor et al., 2000), which consists of 17 items that are rated on a 5-point Likert scale[2]. We also administered the Intolerance of Uncertainty Scale (Freeston et al., 1994), which includes 27 items that are rated on a 5-point Likert scale, and the State-Trait Anxiety Inventory (STAI) (Spielberger et al., 1983), which is made up of 20 State items and 20 Trait items rated on a 4-point Likert scale. Although collected, state anxiety scores were not included in the analysis as not deemed relevant to the research questions (See Appendices for Questionnaire measures). Scores to all questionnaires were mean-centred before being entered into the analyses. Cronbach's alphas for all scales were >.9. Means and distributions were as follows, SPIN (*M* = 20.61; *SD* = 11.50; Range = 0 - 58), IU (*M* = 61.55; *SD* = 18.68; Range = 29 - 106) and trait anxiety (*M* = 41.12; *SD* = 11.10; Range = 22 - 68) (See Supplementary Materials for the distribution of questionnaire scores).

3.6 Skin Conductance Acquisition and Scoring

Physiological recordings were obtained using AD Instruments (AD Instruments Ltd, Chalgrove, Oxfordshire) hardware and software. Electrodermal activity was measured with dry MLT118F stainless steel bipolar finger electrodes that were attached to the distal phalanges of the index and middle fingers of the non-dominant hand. A low constant-voltage AC excitation of 22 mVrms at 75 Hz was passed through the electrodes, which were connected to a PowerLab 8/35, and converted to DC before being digitised and stored. The electrodermal signal was converted from volts to microSiemens using AD Instruments software (AD Instruments Ltd, Chalgrove, Oxfordshire).

We used a similar scoring procedure to previous studies (Morriss, 2019; Morriss et al., 2019). Skin conductance responses were marked using AD Instruments software (AD Instruments Ltd, Chalgrove, Oxfordshire) and extracted using Matlab R2017a software (The MathWorks, Inc., Natick, Massachusetts, United States). Skin conductance responses (SCR) were scored when there was an increase in skin conductance level exceeding 0.03 microsiemens (Dawson et al., 2000). The amplitude of each response was scored as the difference between the onset and the maximum deflection before the signal flattened out or decreased. SCR onsets and respective peaks were counted if the SCR onset was within 0.5-3.5 seconds (CS response) following CS onset during

[2] The SPIN was initially designed to establish threshold scores that might best differentiate between individuals with and without pathological social anxiety, such that the scale could act as a useful screening instrument within the assessment of SAD (Connor et al., 2000). Further, the SPIN has been used to examine individual differences in social anxiety on extinction learning in previous work (Pejic et al., 2013; Reichenberger et al., 2017; Shiban et al., 2015).

acquisition and 0.5-5 seconds (CS response) following CS onset during SECE learning and SECE retention. Trials with no discernible SCRs were scored as zero. SCR magnitudes were square-root transformed to reduce skew and z-scored (across trials for each participant) to control for interindividual differences in skin conductance responsiveness (Ben-Shakhar, 1985). CS+ non-reinforced and CS- trials were included in the analysis, but CS+ reinforced trials were discarded to avoid confounds from the sound and electric shock. Orientation trials were also discarded from analyses as participants were not yet aware of the Stimulus/Context contingencies. SCR magnitudes were calculated from remaining trials by averaging SCR-transformed values for each condition. Non-responders were defined as those who responded to 10% or less of the CS+ unpaired and CS- trials (Morriss et al., 2018; Xia et al., 2017). Eight non-responders were identified in this experiment. As excluding the non-responders did not alter the pattern or significance of SCR findings, for completeness non-responders were included in the analysis of the SCR data. There were five participants that did not learn the association between the neutral cue and the US (see 'Learning Assessment Criteria' in Supplementary Materials). Again, as removing these participants did not change the results reported, for completeness, these participants were included in the analyses.

3.7 SCR and Ratings Analysis

The analyses were conducted using the mixed procedure in SPSS 25.0 (SPSS, Inc; Chicago, Illinois). We conducted separate MLMs for SCR magnitude and subjective ratings during threat acquisition, SECE learning and SECE retention. For SCR magnitude and ratings during the acquisition phase, we entered Stimulus (CS+, CS-) at level 1 and individual subjects at level 2. For SCR magnitude and ratings during SECE learning and SECE retention, we entered Stimulus (CS+, CS-), Context (Dangerous, Safe), and Time (Early, Late) at level 1 and individual subjects at level 2. SPIN, IU and STAI-T scores were included as individual difference predictor variables in MLMs examining SCR magnitude and ratings during SECE learning and SECE retention. Separate MLMs were carried out to investigate the effect of each individual difference variable on dependent variables (i.e., separate models for each predictor; SPIN, IU and STAI-T score)[3].

Fixed effects included Stimulus, Context and Time. A diagonal covariance matrix for level 1 was used in all models. A random intercept for each participant was included as random effects, where a variance components covariance structure was used. We used a maximum likelihood estimator for the MLMs and corrected post-hoc tests for multiple comparisons using the Benjamini-Hochberg False Discovery Rate procedure (Benjamini & Hochberg, 1995). Level 1 variables were

[3] As there was not an effect of social anxiety on SCR magnitude or self-report measures of anxiety or US expectancy in either experiment 1 or experiment 2, we did not run additional MLM analyses to examine whether effects of social anxiety were robust when controlling for IU and STAI-T scores.

categorical and therefore contrast coded. Further, separate models were carried out for the three-way interactions between Stimulus, Context and Time that examined the effects of the task (i.e., section 4.2) and the four-way interactions that include individual differences variables (i.e., sections 4.3 and 4.4).

Where an interaction with an individual difference variable (SPIN, IU, STAI-T) was observed, follow-up pairwise comparisons were performed on the estimated marginal means of the relevant conditions at specific values of + or – 1 SD of the mean individual difference score. These values are estimated from the multilevel model of the complete sample, not unlike performing a simple slopes analysis in a multiple regression analysis. Similar analyses have been published elsewhere (Morriss et al., 2016; Morriss et al., 2020).

4. Results Experiment 1

4.1 Self-reported reactions to Unconditioned Stimuli

Participants reported that the electric shock (*M* = 5.6, *SD* = 1.88) and negative statement (*M* = 4.78, *SD* = 2.42) made them feel anxious (where 1 = “not at all” and 9 = “extremely”), after SECE learning on day 1. Participants rated the electric shock as significantly more anxiety-provoking compared to the negative vocal statements, $t(80) = 3.56$, $p = .001$. Individual differences in trait social anxiety were not significantly correlated with ratings of anxiety elicited by the socially relevant negative statements, $r(81) = -0.02$, $p = .89$.

4.2 Effects of the task

4.2.1 Acquisition

SCR magnitude was significantly greater towards the CS+ compared to the CS- during the acquisition phase [Stimulus, $F(1, 132.95) = 8.47$, $p = .004$, see Table 1].

There was not a significant difference in anxiety ratings towards the CS+ and CS- before acquisition, however, after the acquisition phase, anxiety ratings were significantly higher towards the CS+ compared to the CS- [Stimulus, $F(1, 163.77) = 116.77$, $p < .001$; Time, $F(1, 163.77) = 65.78$, $p < .001$; Stimulus x Time, $F(1, 163.77) = 160.78$, $p < .001$, see Table 2].

These findings indicate that conditioning was effective during the acquisition phase.

4.2.2 SECE Learning

There was a significant stimulus x context x time interaction for SCR during SECE learning [Stimulus x Context x Time, $F(1, 503.72) = 4.53$, $p = .03$, see Table 1]. SCR was significantly greater towards the CS+ dangerous compared to the CS- dangerous during early SECE learning, $p = .03$. However, SCR significantly reduced towards the CS+ dangerous between early SECE learning and late SECE learning, $p = .01$. Further, SCR declined towards the CS- safe between early SECE learning and late SECE learning, $p = .02$.

During SECE learning, anxiety ratings were significantly higher towards the CS+ compared to the CS-, $p < .001$ [Stimulus, $F(1, 161.85) = 384.45$, $p < .001$]. There was not a main effect of time or a significant stimulus x time interaction for anxiety ratings towards the CS+ and CS- across the SECE learning phase [Time, $F(1, 162.01) = 0.06$, $p = .8$; Stimulus x Time, $F(1, 161.85) = 1.15$, $p = .29$, see table 2].

4.2.3 SECE Retention

There was not a significant stimulus x context x time interaction for SCR during SECE retention [Stimulus x Context x Time, $F(1, 613.2) = 0.01$, $p = .91$, see Table 1]. There was a main effect of stimulus, $p = .04$ [Stimulus, $F(1, 613.2) = 4.46$, $p = .04$], indicating significant differential responding between CS+ (dangerous and safe, early and late) and CS- (dangerous and safe, early and late) trials throughout SECE retention.

During SECE retention, participants demonstrated significantly higher anxiety ratings towards the CS+ compared to the CS-, $p < .001$ [Stimulus, $F(1, 168.52) = 292.58$, $p < .001$]. Further, ratings of anxiety towards the CS+ increased marginally over time, $p = .056$, while there was a decline at trend for ratings of anxiety towards the CS- over time, $p = .088$ [Time, $F(1, 168.52) = 1.98$, $p = .16$; Stimulus x Time, $F(1, 168.52) = 5.32$, $p = .02$, see Table 2].

Table 1

Summary of means (SD) for SCR as a function of Stimulus (CS+ and CS-) and context (Dangerous and Safe), separately for acquisition, early and late extinction learning and extinction retention during experiment 1.

Measure	Day 1										Day 2							
	Acquisition		Early Extinction Learning				Late Extinction Learning				Early Extinction Retention				Late Extinction Retention			
	CS+	CS-	CS+		CS-		CS+		CS-		CS+		CS-		CS+		CS-	
			Dang	Safe	Dang	Safe	Dang	Safe	Dang	Safe	Dang	Safe	Dang	Safe	Dang	Safe	Dang	Safe
Square root transformed and z-scores SCR magnitude (√µs)	.189	.046	.088	.066	.058	.068	.053	.057	.055	.037	.054	.001	-.064	-.065	.012	-.067	-.033	-.048
	(.38)	(.23)	(.13)	(.09)	(.1)	(.12)	(.01)	(.12)	(.1)	(.06)	(.38)	(.34)	(.28)	(.31)	(.32)	(.25)	(.33)	(.34)

Note: SCR magnitude (√µS), square root transformed and z-scored skin conductance magnitude measured in microSiemens.

Table 2

Summary of means (SD) for anxiety ratings as a function of stimulus (CS+ and CS-), separately for acquisition, and early and late extinction learning and retention during experiment 1.

Measure	Day 1						Day 2			
	Pre-Acquisition		Early Extinction Learning		Late Extinction Learning		Early Extinction Retention		Late Extinction Retention	
	CS+	CS-	CS+	CS-	CS+	CS-	CS+	CS-	CS+	CS-
Anxiety Rating (1-9)	1.92	2.18	4.84	1.56	4.99	1.31	3.88	1.4	4.51	1.25
	1.22	1.42	1.99	1.01	2.28	0.59	2.11	0.84	2.17	0.63

4.3 Aim 1: The effect of social anxiety on SECE learning and SECE retention

4.3.1 SCR Magnitude

Contrary to hypotheses, individual differences in social anxiety were not related to SCR during SECE learning, [Stimulus x Context x Time x SPIN, $F(1, 639.28) = 0.74$, $p = .39$]. There were no other significant interactions between social anxiety and stimulus, context or time in this analysis, max $F = 0.74$.

Further, there was not a significant relationship between individual differences in social anxiety and SCR during SECE retention, [Stimulus x Context x Time x SPIN, $F(1, 639.83) = 0.35$, $p = .56$]. There were no other significant interactions between social anxiety, stimulus, context or time in this analysis, max $F = 1.42$.

4.3.2 Self-reported anxiety elicited by Conditioned Stimuli

There was not a significant relationship between individual differences in social anxiety and anxiety ratings towards the CS+ and CS- across the SECE learning phase, [Stimulus x Time x SPIN, $F(1, 161.82) = 0.01$, $p = .92$]. There were no other significant interactions between social anxiety, stimulus or time in this analysis, max $F = 0.68$.

Again, during SECE retention, there was not a significant relationship between individual differences in social anxiety and anxiety ratings towards the CS+ and CS-, [Stimulus x Time x SPIN, $F(1, 160.23) = 0.001$, $p = .97$]. There were no other significant interactions between social anxiety, stimulus and time in this analysis, max $F = 0.01$.

4.4 Aim 2: Replication of previous literature – The effect of IU and trait anxiety on SECE learning and SECE retention

4.4.1 IU and SCR magnitude

Individual differences in IU were marginally related to SCR magnitude during the SECE learning phase, [Stimulus x Context x Time x IU, $F(1, 639.34) = 3.43$, $p = .06$, see Figure 2]. There were not any significant or marginal interactions between stimulus, context and time at lower IU, $p > .11$. However, higher IU scores were associated with significantly increased SCR towards the CS+ dangerous compared to the CS- dangerous during early SECE learning, $p = .02$. Further, higher IU was marginally associated with increased SCR towards the CS+ dangerous compared to the CS+ safe during early SECE learning, $p = .08$. SCR magnitude towards the CS+ dangerous decreased at trend between early and late SECE at higher IU, p .07.

Individual differences in IU were also related to SCR magnitude during SECE retention, [Stimulus x IU, $F(1, 609.27) = 5.42$, $p = .02$; Stimulus x Context, $F(1, 609.27) = 4.90$, $p = .03$, see Figure 2]. Lower IU scores were associated with increased SCR magnitude towards CS+ dangerous compared to CS+ safe trials throughout the SECE retention phase, $p = .004$. Further, there was no discernible difference in SCR between CS- dangerous and CS- safe trials throughout SECE retention at low IU, $p = .45$. However, higher IU scores were not affected by context during SECE retention, $p = .57$, as higher IU scores were associated with significantly increased SCR magnitude during CS+ (dangerous and safe) compared to CS- (dangerous and safe) trials throughout the extinction retention phase, $p = .002$.

4.4.2 IU and self-reported anxiety elicited by Conditioned Stimuli

Individual differences in IU were related to ratings of anxiety elicited by the CS+ and CS- during SECE learning, [Stimulus x IU, $F(1, 162.42) = 11.38$, $p = .001$, see Figure 3]. Parameter estimates indicated that higher IU compared to lower IU was associated with significantly higher ratings of anxiety towards the CS+ both before, $p = .001$, and after, $p = .004$, the SECE learning phase. This effect was present for anxiety ratings toward the CS- pre-SECE learning, $p = .01$, but not post-SECE learning, $p = .23$).

There was also a significant relationship between individual differences in IU and ratings of anxiety towards the CS during SECE retention [Stimulus x IU, $F(1, 165.2) = 30.63$, $p < .001$, see Figure 3]. Parameter estimates demonstrated that higher IU compared to lower IU predicted higher ratings of anxiety towards the CS+ both before, $p = .003$, and after, $p = .002$, the SECE retention phase. This effect was not present for anxiety ratings toward the CS- (pre-SECE retention, $p = .38$, post-SECE retention, $p = .5$).

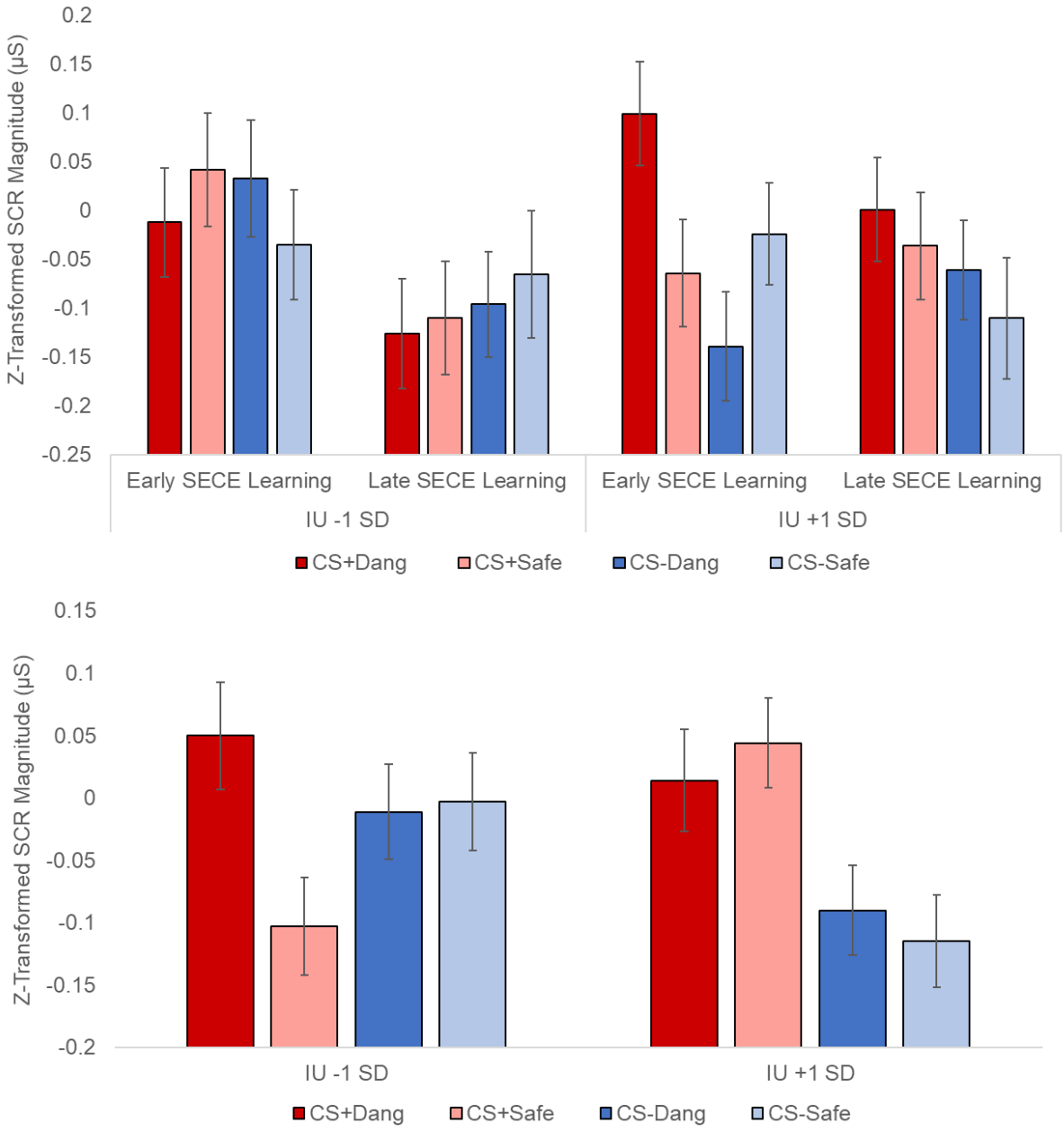


Figure 2. Bar graph depicting mean SCR magnitude during early and late SECE Learning (A) and across the SECE Retention phase (B) for IU estimated at specific values of + or – 1 SD of the mean IU score. Square root transformed and Z-transformed SCR magnitude (µS). Skin conductance magnitude is measured in microSiemens. During early SECE Learning (A), SCR was significantly greater during CS+ Dangerous trials compared to CS+ safe trials for individuals with higher IU. During SECE retention (B), lower IU scores were associated with higher SCR during CS+ Dangerous compared to CS+ Safe trials, however, higher IU scores were associated with increased SCR in CS+ trials (Dangerous and Safe) compared to CS- trials (Dangerous and Safe). Error bars represent standard error.

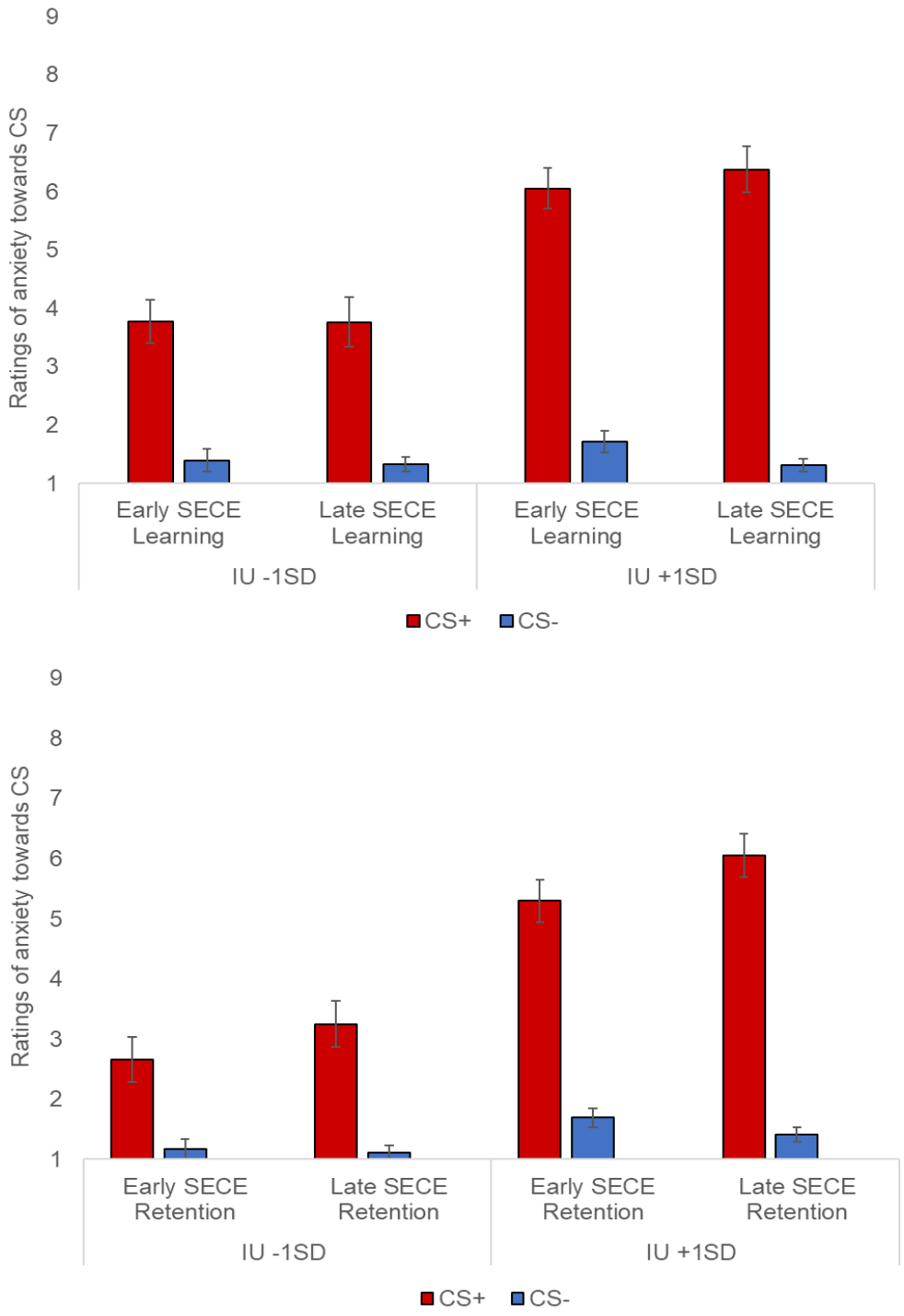


Figure 3. Bar graph depicting ratings of self-reported anxiety elicited by the CS during SECE Learning (A) and SECE Retention (B) for IU estimated at the specific values of + and – 1 SD of the mean IU score. Participants were asked to rate how anxious each identity made them feel on a scale of 1 ("not at all") to 9 ("extremely"). Throughout SECE (A) and extinction retention (B), high IU, compared to low IU was associated with higher anxiety ratings towards the CS+. Error bars represent standard error.

4.4.3 Trait Anxiety and SCR

There was not a significant relationship between individual differences in trait anxiety and SCR during SECE learning, [Stimulus x Context x Time x STAI-T, $F(1, 639.28) = 0.48$, $p = .49$]. There were no other significant interactions between social anxiety and stimulus, context and time in this analysis, max $F = 1.41$.

Further, there was not a significant relationship between individual differences in trait anxiety and SCR during SECE retention, [Stimulus x Context x Time x STAI-T, $F(1, 611.72) = 0.81$, $p = .37$]. There were no other significant interactions between trait anxiety, stimulus, context and time in this analysis, max $F = 1.46$.

3.4.4 Trait Anxiety and self-reported anxiety elicited by Conditioned Stimuli

There was not a significant relationship between trait anxiety scores and anxiety ratings towards the CS+ and CS- across the SECE learning phase, [Stimulus x Time x STAI-T, $F(1, 162.51) = 0.03$, $p = .86$]. There were no other significant interactions between trait anxiety, stimulus and time in this analysis, max $F = 0.27$.

Again, during SECE retention, there was not a significant relationship between individual differences in trait anxiety and anxiety ratings towards the CS+ and CS-, [Stimulus x Time x STAI-T, $F(1, 204.28) = 0.43$, $p = .52$]. There were no other significant interactions between trait anxiety, stimulus and time in this analysis, max $F = 0.43$.

4.5 Aim 3: The effect of social anxiety on SECE learning and SECE retention when controlling for IU and trait anxiety

As we did not find any significant effects of social anxiety on SCR magnitude or self-reported reactions to the CS during extinction learning or retention when carrying out analyses to examine Aim 1, we did not conduct follow up analyses to investigate whether effects of social anxiety were robust when controlling for IU and trait anxiety scores within a single model.

5. Conclusion Experiment 1

Contrary to hypotheses, the results from experiment 1 suggest that social anxiety does not play a role in the maintenance of learned threat during SECE learning or SECE retention. Further, we did not replicate findings from the previous literature (Barrett & Armony, 2009; Gazendam et al., 2013; Haaker et al., 2015) that demonstrated that trait anxiety is associated with compromised extinction processes. Instead, SCR magnitude results and findings across anxiety ratings indicate that IU is associated with extinction processes during SECE learning and retention. During the early part of

SECE learning, higher IU was marginally associated with the adaptive use of contextual cures to update a conditioned response to a learnt threat cue, as indexed by larger differential SCR magnitude responding during CS+ dangerous trials compared to CS+ safe trials, suggesting that participants with higher IU can successfully decrease their emotional arousal to the CS+ when they identify, based on the context presented, that there is no risk of receiving the US. In contrast, during SECE retention, higher IU was associated with increased SCR magnitude to CS+ compared to CS- trials, with no effect of context. Such a result suggests that higher IU predicted the generalisation of threat cues across contexts in the presence of the CS+ during SECE retention. These findings support previous research that suggests compromised extinction processes are related to broader and transdiagnostic features of anxiety, such as IU (Dunsmoor et al., 2015; Lucas et al., 2018; Morriss et al., 2015, 2016; Morriss & van Reekum, 2019), and build upon this work through the use of a socially relevant paradigm that includes a partial instruction and a cognitive component.

6. Introduction Experiment 2

The results of study 1 suggest that individual differences in IU and not social anxiety are associated with the maintenance of learned threat in a socially relevant extinction task that incorporates a cognitive component. However, it is possible that features of the SECE task masked an effect of social anxiety on extinction learning and retention in experiment 1. For instance, there were a high number of trials during the SECE learning and retention phases that could have led to fatigue and habituation of the US. Further, partial instruction regarding the contingencies between CS and contexts might have played a role in the absence of social anxiety related findings.

Previous work has demonstrated that when instructed to refrain from using safety behaviours, socially anxious individuals were less negative in judgements of their performance and rated the likelihood of a negative outcome as less than those who were not instructed (Taylor & Alden, 2010). A further study demonstrated that when instructed to direct their attention to components of the external environment, socially anxious individuals reported lower anxiety and less negative beliefs (Wells & Papageorgiou, 1998). It may be that individuals with elevated levels of social anxiety can use instructions to reduce anxiety during extinction learning and retention, resulting in successful extinction of the conditioned response in experiment 1. This may not be the case at high levels of IU, where the partial instruction might have induced uncertainty during the SECE retention phase. Before SECE retention in experiment 1, participants were not explicitly instructed that the CS with context contingencies would be the same as during day 1, perhaps resulting in the perception of missing information in individuals with high IU. This perceived uncertainty may have resulted in generalisation across safe and dangerous contexts for individuals with higher IU during extinction retention. Therefore, during experiment 2, we removed possibly

confounding task features and employed a standard threat extinction paradigm with socially relevant stimuli.

Experiment 2 aimed to further examine whether individual differences in social anxiety are related to impaired extinction learning and retention as well as to follow up on the effects of IU that were found during experiment 1. We hypothesised that high socially anxious participants, compared to low socially anxious participants, would demonstrate sustained skin conductance responding to the CS+ relative to the CS- during late extinction learning (day 1) and early extinction retention (day 2). We further expected that high social anxiety, relative to low social anxiety, would be associated with higher ratings of anxiety as well as higher US expectancy ratings towards the CS+ compared to the CS- throughout the experiment. Given that the findings of experiment 1 suggest that IU plays a role in the maintenance of conditioned threat within a socially relevant paradigm, and in line with prior work on IU and trait anxiety, we examined whether the hypothesised effects outlined above could also be true of IU and trait anxiety. Hence, in this simplified social extinction study, we expected that any effect of social anxiety would not be specific to social anxiety, but that IU would also be associated with deficits in extinction learning and retention.

7. Method Experiment 2

The method was identical to experiment 1, except as follows.

7.1 Participants

The sample consisted of 92 female students (*M* age = 19.66, SD = 1.38; Ethnicity: 67 White, 14 Asian/Pacific Islander, 7 Black, 3 Multi-ethnic, 1 Middle Eastern/Arab) recruited from the University of Reading. Participants were not eligible to participate if they had taken part in Study 1. Participants provided written informed consent and received course credit for their participation.

There were six participants that did not return to the laboratory for the extinction retention phase, and there were software errors for two participants. Therefore, 84 participants were included in the analysis of SCR and ratings data.

The power analysis is based on an average effect size (η2p = 0.16) taken from the Stimulus x Time x IU interaction for SCR magnitude from five published experiments using highly similar experimental designs as the current experiment (4/5 experiments reported significant effects of IU) (Morriss et al., 2015; 2016; Morriss & van Reekum, 2019). The following parameters were used: *f* = 0.43 (converted from η2p = 0.16), α error probability = 0.05, Power (1-β error probability) = 0.95, number of groups = 2 (CS: CS+, CS), numerator df = 1, number of covariates = 3 (SPIN, IU, Trait

Anxiety). The suggested sample size was 73 participants. Based on the updated power analysis, we oversampled by 10 participants.[4]

The procedure was approved by the University of Reading Research Ethics Committee.

7.2 Procedure

Experiment 2 used a standard extinction paradigm. The same stimuli, experimental parameters and physiological setup were used as in Experiment 1. However, context images were not presented in the extinction learning and extinction retention phase, and participants were not given any verbal instructions about what to expect during the task.

7.3 Conditioning Paradigm

The paradigm was comprised of three phases: acquisition, extinction learning, and extinction retention. Following acquisition, extinction learning took place during which both identities (CS+ and CS-) were presented in the absence of the shock and negative statement (US). During the extinction retention phase on day 2, participants were again presented with both identities in the absence of the US.

The acquisition phase consisted of 24 trials (6 CS+ paired, 6 CS+ unpaired, and 12 CS-). The extinction learning phase was comprised of 32 trials (16 CS+ unpaired and 16 CS-), where early extinction learning was defined as the first 8 CS+/ CS- trials and late extinction learning was defined as the last 8 CS+/CS- trials. The extinction retention phase included of 32 trials (16 CS+ unpaired and 16 CS-), again where early extinction retention was defined as the first 8 CS+/CS- trials and late extinction retention was defined as the last 8 CS+/CS- trials.

The identities were presented on the screen for a total of 4000 ms during all phases of the task. During reinforced trials, the negative statement was presented after 3000 ms, and the electric shock lasted for 200 ms. Both US co-terminated with the trial. A jittered ITI of between 6000 ms and 8000 ms occurred between trials and consisted of a black screen.

Blocks of trials in acquisition were made up of 12 trials and in extinction learning and extinction retention blocks included 16 trials. Participants were asked to rate how anxious each identity made them feel before acquisition, after acquisition, after extinction learning on day 1, and before extinction retention and after extinction retention on day 2. The scale ranged from 1 ("not at all") to 9 ("extremely"). Participants were also asked to rate whether they expected to receive

[4] We have oversampled in experiment 2 as the initial power analysis, conducted prior to data collection, included an effect size of $f = 0.22$, reported in Morriss et al (2016). We have updated the power analysis to include a more reliable effect size averaged across five similar experiments.

negative stimuli in the presence of each identity at the above time points throughout the experiment. The scale also ranged from 1 ("do not expect") to 9 ("do expect").

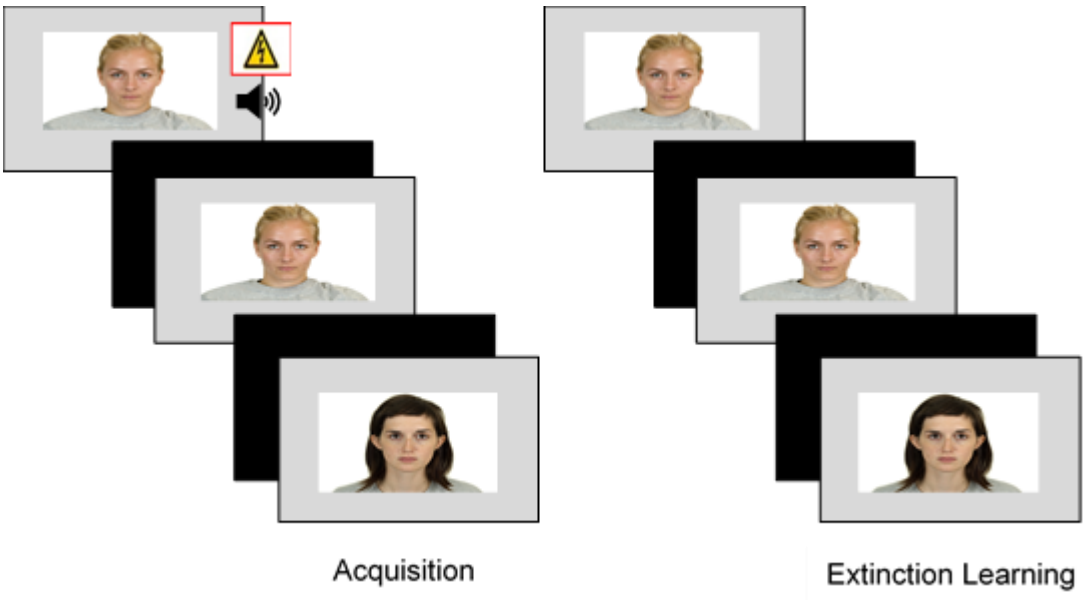


Figure 4. Example of task design during acquisition and extinction learning in experiment 2.

7.4 Questionnaires

Means and distributions for the anxiety measures were as follows, SPIN (*M* = 22.85; *SD* = 11.75; Range = 2 - 49), IU (*M* = 64.68; *SD* = 17.91; Range = 35 - 113) and trait anxiety (*M*= 44.63; *SD* = 10.87; Range = 22 - 73). Cronbach's alphas for all scales were >.9.

7.5 Skin Conductance Acquisition and Scoring

SCR onsets and respective peaks were included if the SCR onset was within 0.5-3.5 seconds (CS response) following CS onset (Morriss et al., 2018) in all three phases. As excluding non-responders (N=14) did not alter the pattern or significance of SCR findings, for completeness non-responders were included in the analysis of the SCR data. No participants were identified as non-learners in this experiment (see 'Learning Assessment Criteria' in Supplementary Materials).

7.6 SCR and Ratings Analysis

The procedure of data analysis was the same in experiment 2 as in experiment 1, apart from the following: context was not included as a variable in the model at level 1 and MLMs were also conducted for expectancy ratings during acquisition, extinction learning and extinction retention. Further, we did not expect specificity for SPIN but also expected to observe significant interactions with IU.

8. Results Experiment 2

8.1 Self-reported reactions to Unconditioned Stimuli

Participants rated the electric shock (*M* = 5.61, *SD* = 1.67) and negative statements (*M* = 4.46, *SD* = 2.15) as making them feel anxious (where 1 = "not at all", 9 = "extremely") after extinction learning on day 1. The electric shock was rated as more anxiety-provoking compared to the negative vocal statements, $t(82) = 5.48$, $p < .001$, Cohen's $d = 0.59$. Individual differences in social anxiety were not significantly correlated with ratings of anxiety elicited by the socially relevant negative statements, $r(83) = 0.08$, $p = .46$. There was missing stimulus rating data from one participant.

8.2 Effects of the task

8.2.1 Acquisition

SCR was significantly greater towards the CS+ compared to the CS- during the acquisition phase [$F(1, 84) = 10.13$, $p = .002$, see Table 3].

There was no significant difference in anxiety ratings between the CS+ and CS- before acquisition, however, after acquisition anxiety ratings were significantly higher towards the CS+

versus the CS- [Stimulus, $F(1, 191.72) = 165.44$, $p < .001$, Time, $F(1, 191.72) = 132.03$, $p < .001$, Stimulus x Time, $F(1, 191.72) = 161.06$, $p < .001$, see Table 3].

Further, US expectancy ratings were significantly greater towards the CS+ compared to the CS- after acquisition [$F(1, 167.39) = 590.08$, $p < .001$, see Table 3].

These findings indicate that conditioning was effective during the acquisition phase.

8.2.2 Extinction Learning

During extinction learning, SCR was significantly higher to the CS+ compared to the CS- [Stimulus, $F(1, 247.91) = 7.54$, $p = .006$]. There was no effect of time and no stimulus x time interaction for SCR during extinction learning [Time, $F(1, 247.91) = 0.37$, $p = .55$; Stimulus x Time, $F(1, 247.91) = 0.16$, $p = .67$, see Table 3].

Participants rated the CS+ as more anxiety provoking compared to the CS-, $p < .001$. Anxiety ratings towards the CS+ significantly decreased across the extinction phase, $p < .001$ [Stimulus, $F(1, 185.16) = 357.01$, $p < .001$; Time, $F(1, 185.16) = 41.28$, $p < .001$; Stimulus x Time, $F(1, 185.16) = 14.17$, $p < .001$, see Table 3].

During the extinction learning phase, participants demonstrated significantly higher US expectancy ratings towards the CS+ compared to the CS-, $p < .001$. Further, expectancy ratings towards the CS+ significantly reduced over time, $p < .001$ [Stimulus, $F(1, 219.42) = 505.09$, $p < .001$; Time, $F(1, 219.42) = 85.09$, $p < .001$; Stimulus x Time, $F(1, 219.42) = 89.83$, $p < .001$, see Table 3].

8.2.3 Extinction Retention

SCR magnitude during extinction retention was significantly greater for the CS+ compared to the CS-, $p < .001$ [Stimulus, $F(1, 325.97) = 20.52$, $p < .001$, see table 3]. Further, SCR towards the CS+ and CS- dropped across the extinction retention phase [Time, $F(1, 325.97) = 5.25$, $p = .02$]. The interaction between stimulus x time was not significant [Stimulus x Time, $F(1, 325.97) = 0.51$, $p = .48$, see Table 3].

During extinction retention, anxiety ratings were significantly higher towards the CS+ compared to the CS-, $p < .001$ [Stimulus, $F(1, 204.15) = 132.52$, $p < .001$, see Table 3]. There was no main effect of time and the stimulus x time interaction was not significant for anxiety ratings towards the CS+ and CS- [Time, $F(1, 204.15) = 2.39$, $p = .12$; Stimulus x Time, $F(1, 204.15) = 2.66$, $p = .1$, see Table 3].

During the extinction retention phase, participants demonstrated significantly higher US expectancy ratings towards the CS+ compared to the CS-, $p < .001$. Further, expectancy ratings

towards the CS+ significantly reduced over time, $p < .001$ [Stimulus, $F(1, 179.85) = 307.61$, $p < .001$; Time, $F(1, 179.85) = 77.22$, $p < .001$; Stimulus x Time, $F(1, 179.85) = 77.22$, $p < .001$, see Table 3].

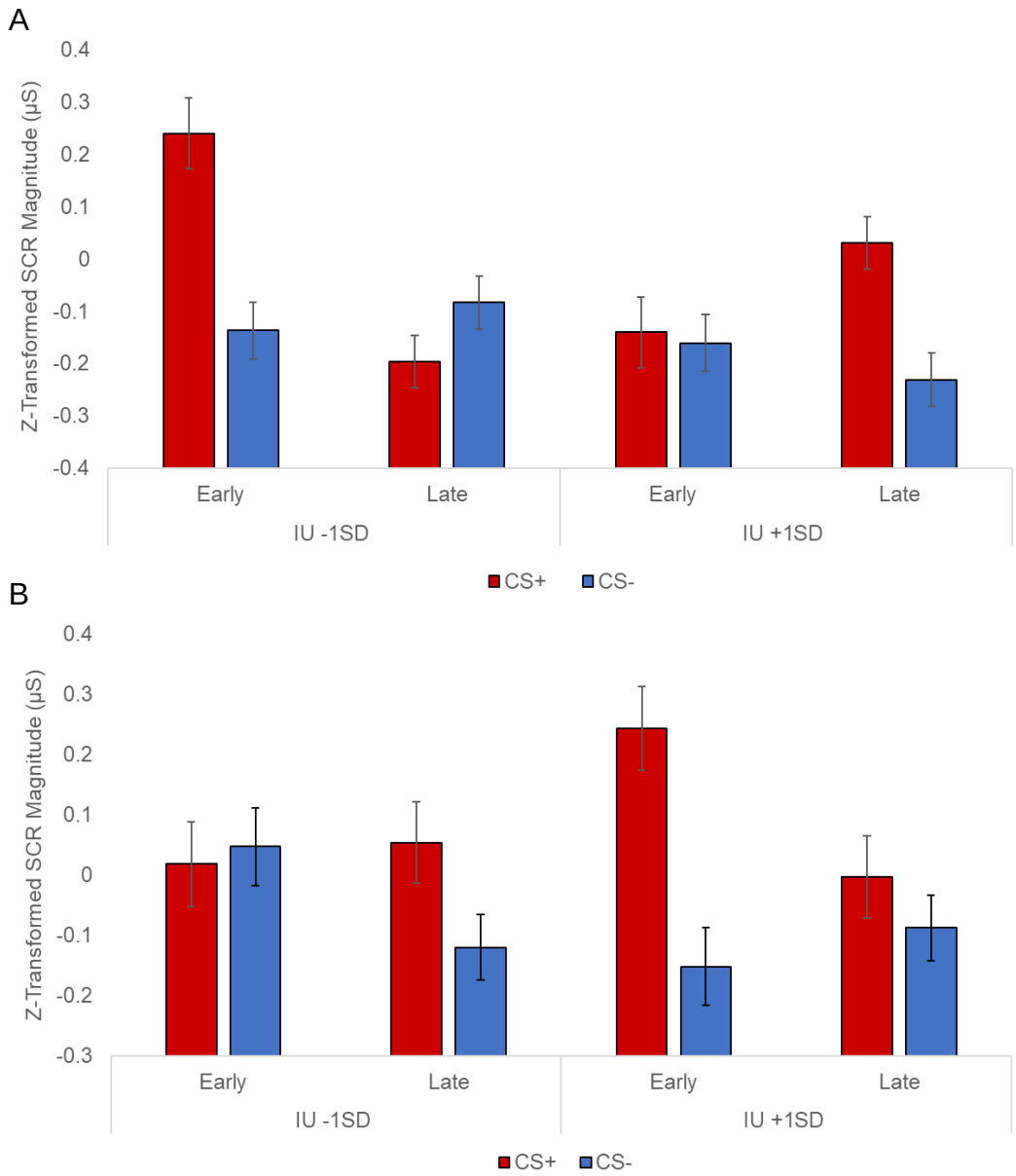


Figure 5. Bar graph depicting mean SCR magnitude during extinction learning (A) and extinction retention (B) for IU estimated at specific values of + or – 1 SD of mean IU. Square root transformed and Z-transformed SCR magnitude (µS). Skin conductance magnitude is measured in microSiemens. During extinction learning (A) low IU was associated with differential SCR between the CS+ and CS- during early extinction learning but not during late extinction learning, where high IU was associated with differential SCR between CS+ and CS- trials during late extinction learning only. During extinction retention (B), high IU was associated with increased SCR during CS+ trials during early extinction retention, but this effect dissipated over time. Error bars represent standard error.

Table 3

Summary of means (SD) for each dependent variable as a function of condition (CS+ and CS-), separately for acquisition, early and late extinction learning and retention during experiment 2.

Measure	Day 1						Day 2					
	Pre-Acquisition		Acquisition		Early Extinction Learning		Late Extinction Learning		Early Extinction Retention		Late Extinction Retention	
	CS+	CS-	CS+	CS-	CS+	CS-	CS+	CS-	CS+	CS-	CS+	CS-
Square root transformed and z-scores SCR magnitude (√µs)			.275	.08	-.059	-.153	-.084	-.155	.125	-.043	.024	-.105
			(.47)	(.3)	(.33)	(.26)	(.25)	(.25)	(.34)	(.32)	(.33)	(.27)
Anxiety Rating (1-9)	1.99	1.96			5.35	1.8	3.75	1.38	3.32	1.5	2.88	1.51
	(1.44)	(1.3)			(1.99)	(1.18)	(2.1)	(0.83)	(1.94)	(1.08)	(1.81)	(1.3)
US Expectancy Rating (1-9)					7.74	1.74	4.23	1.79	5.94	1.65	3.1	1.61
					(1.66)	(1.56)	(2.27)	(1.7)	(2.38)	(1.27)	(1.94)	(1.37)

Note: SCR magnitude (√µS), square root transformed and z-scored skin conductance magnitude measured in microSiemens.

8.3 Aim 1: The effect of social anxiety on extinction learning and extinction retention

8.3.1 SCR Magnitude

During extinction learning, individual differences in social anxiety were not related to SCR magnitude towards the CS+ and CS-, [Stimulus x Time x SPIN, $F(1, 313.75) = 0.14$, $p = .71$]. There were no other significant interactions between social anxiety, stimulus and time in this analysis, max $F = 0.14$.

Further, there was not a significant relationship between individual differences in social anxiety and SCR towards the CS+ and CS- during extinction retention, [Stimulus x Time x SPIN, $F(1, 326.04) = 0.40$, $p = .53$]. There were no other significant interactions between social anxiety, stimulus and time in this analysis, max $F = 1.24$.

8.3.2 Self-reported reactions toward Conditioned Stimuli

8.3.2.1 Anxiety ratings

There was not a significant relationship between individual difference in social anxiety and anxiety ratings towards the CS+ and CS- across the extinction learning phase, [Stimulus x Time x SPIN, $F(1, 184.91) = 0.29$, $p = .59$]. There were no other significant interactions between social anxiety, stimulus and time in this analysis, max $F = 0.29$.

Again, during extinction retention, there was not a significant relationship between individual differences in social anxiety and anxiety ratings towards the CS+ and CS-, [Stimulus x Time x SPIN, $F(1, 204.17) = 0.43$, $p = .51$]. There were no other significant interactions between social anxiety, stimulus and time in this analysis, max $F = 0.63$.

8.3.2.2 US Expectancy ratings

There was not a significant relationship between individual difference in social anxiety and US expectancy ratings towards the CS+ and CS- across the extinction learning phase, [Stimulus x Time x SPIN, $F(1, 219.76) = 2.31$, $p = .13$]. There were no other significant interactions between social anxiety, stimulus and time in this analysis, max $F = 2.31$.

Further, there was an interaction at trend between individual differences in social anxiety and US expectancy ratings towards the CS+ and CS- across the extinction retention phase, [Stimulus x Time x SPIN, $F(1, 180.84) = 3.03$, $p = .08$]. However, parameter estimates did not demonstrate that there was a significant difference in US expectancy ratings towards the CS+ and CS- at high social

anxiety compared to low social anxiety before extinction retention or after the extinction retention phase, $p > .11$.

8.4 Aim 2: Replication of previous literature – The effect of IU and trait anxiety on extinction learning and extinction retention

8.4.1 IU and SCR magnitude

Individual difference in IU were marginally related to SCR magnitude during the extinction learning phase in the expected direction [Stimulus x Time x IU, $F(1, 247.39) = 2.71$, $p = .09$, see Figure 5]. Participants with lower IU scores showed increased SCR to the CS+ compared to the CS- during early extinction learning, $p = .06$. In contrast, higher IU scores were not associated with a significant difference in SCR magnitude towards the CS+ and CS- during early extinction learning, $p = .31$. But, during late extinction learning, higher IU was associated with significant differential SCR between the CS+ and CS-, $p = .01$.

Individual differences in IU were also related to SCR magnitude towards the CS+ and CS- in the expected direction during extinction retention [Stimulus x IU, $F(1, 326.62) = 3.18$, $p = .07$, see Figure 5]. Lower IU scores were not associated with differential SCR between the CS+ and CS- during early extinction learning, $p = .33$. During late extinction retention, there was a marginal differential SCR between the CS+ and CS- for participants with lower IU scores, $p = .06$. During early extinction retention, higher IU was associated with increased SCR towards the CS+ versus the CS-, $p < .001$, and this effect remained present during late extinction retention, $p = .04$. However, higher IU was associated with significant reduction in SCR towards the CS+ across the extinction retention phase, $p = .02$.

8.4.2 IU and self-reported reactions to Conditioned Stimuli during extinction learning and extinction retention

8.4.2.1 IU and Anxiety ratings

There was not a significant relationship between individual differences in IU and anxiety ratings towards the CS+ and CS- across the extinction learning phase, [Stimulus x Time x IU, $F(1, 185.38) = 0.54$, $p = .46$]. There were no other significant interactions between IU, stimulus and time, max $F = 2.00$.

There was not a significant relationship between individual difference in IU and anxiety ratings towards the CS+ and CS- across the extinction retention phase, [Stimulus x Time x IU, $F(1,$

204.38) = 0.17, *p* =.68]. There were no other significant interactions between IU, stimulus and time, max *F* = 0.47.

8.4.2.2 IU and US Expectancy ratings

There was not a significant relationship between individual differences in IU and US expectancy ratings towards the CS+ and CS- across the extinction learning phase, [Stimulus x Time x IU, *F*(1, 219.46) = 1.26, *p* =.26]. There were no other significant interactions between IU, stimulus, and time, max *F* = 1.26.

There was a significant relationship between IU and US expectancy ratings during the extinction retention phase [Stimulus x IU, *F*(1, 179.16) = 3.94, *p* = .049. Parameter estimates demonstrated that higher IU was associated with increased US expectancy ratings towards the CS- before extinction retention, *p* = .05.

8.4.3 Trait anxiety and SCR

There was not a significant relationship between individual differences in trait anxiety and SCR during extinction learning, [Stimulus x Time x STAI-T, $F(1, 314.78) = 0.01$, $p = .91$]. There were no other significant interactions between trait anxiety and stimulus, and time in this analysis, max $F = 0.58$.

Further, there was not a significant relationship between individual differences in trait anxiety and SCR during extinction retention, [Stimulus x Time x STAI-T, $F(1, 325.60) = 0.04$, $p = .85$]. There were no other significant interactions between trait anxiety, stimulus, and time, max $F = 0.88$.

8.4.4 Trait anxiety and self-reported reactions to Conditioned Stimuli during extinction learning and extinction retention

8.4.4.1 Trait anxiety and Anxiety ratings

There was not a significant relationship between individual differences in trait anxiety and anxiety ratings towards the CS+ and CS- across the extinction learning phase, [Stimulus x Time x STAI-T, $F(1, 185.59) = 0.63$, $p = .43$]. There were no other significant interactions between trait anxiety, stimulus, and time, max $F = 2.05$.

There was also not a significant relationship between individual differences in trait anxiety and anxiety ratings towards the CS+ and CS- across the extinction retention phase, [Stimulus x Time x STAI-T, $F(1, 204.28) = 0.43$, $p = .52$]. There were no other significant interactions between trait anxiety, stimulus, and time in this analysis, max $F = 0.43$.

8.4.4.2 Trait anxiety and US Expectancy ratings

There was an interaction at trend between individual difference in trait anxiety and US expectancy ratings towards the CS+ and CS- across the extinction learning phase, [Stimulus x Time x STAI-T, $F(1, 220.06) = 3.26$, $p = .07$]. However, parameter estimates did not demonstrate that there was a significant difference in US expectancy ratings towards the CS+ or CS- at high trait anxiety compared to low trait anxiety before extinction learning or after the extinction learning phase, $p > .12$.

There was not a significant relationship between trait anxiety and US expectancy ratings during extinction retention, [Stimulus x Time x STAI-T, $F(1, 179.19) = 0.96$, $p = .33$]. There were no other significant interactions between trait anxiety, stimulus and time in this analysis, max $F = 0.96$.

8.5 Aim 3: The effect of social anxiety on extinction learning and extinction retention when controlling for IU and trait anxiety

As we did not find any significant effects of social anxiety on SCR magnitude or self-reported reactions to the CS during extinction learning or retention when carrying out analyses to examine Aim 1, we did not conduct follow up analyses to investigate whether effects of social anxiety were robust when controlling for IU and trait anxiety scores within a single model.

9. Conclusion Experiment 2

The findings from experiment 2 further suggest that individual differences in social anxiety do not affect extinction learning or retention, despite the use of socially relevant CS and US within a threat conditioning task. Further, as with experiment 1, we did not replicate findings of previous literature that demonstrates a relationship between trait anxiety levels and compromised extinction processes. Instead, the SCR magnitude results from experiment 2 support the findings from experiment 1 and suggest that compromised and delayed extinction are more likely to be characteristic of high levels of IU and not social anxiety.

10. General Discussion

We employed a social conditioning paradigm using a socially relevant CS and US to study the effect of social anxiety on extinction learning and retention in two separate experiments. Contrary to hypotheses, we did not find evidence that social anxiety is associated with delayed or impaired safety learning during threat extinction or retention. Instead, the findings across both studies suggest that IU-related mechanisms disrupt threat extinction processes, even during a socially relevant conditioning task.

The results of both experiments are somewhat surprising, given that previous research has demonstrated a relationship between social anxiety and IU (e.g. Boelen & Reijntjes, 2009; Carleton et al., 2010). The original purpose of including IU and trait anxiety in this research was to assess the specificity of any effect of social anxiety on extinction learning and retention, over and above other individual difference measures found to be associated with compromised threat extinction processes. Instead, we observed effects of IU, but no effect of social anxiety on extinction learning or retention across both psychophysiological and self-report measures. Hence, the results support and extend previous findings regarding the role of IU in extinction processes but do not provide support for the hypothesis that deficits in safety learning and retention are associated with elevated levels of social anxiety. This research therefore suggests that safety-learning processes might be modified by

features related to broader negative affect (i.e., IU) that underly anxiety, rather than by features specific to individual anxiety subtypes.

Despite this conclusion, prior findings have demonstrated that relapse after exposure therapy is common for individuals with anxiety disorders, including social anxiety (Craske et al., 2014; Graham & Milad, 2011; Hofmann & Smits, 2008). Across the numerous maintenance models of SAD, it is proposed that individuals with social anxiety engage in maladaptive cognitive and behavioural processes including anticipatory and post-event processing, avoidance and safety behaviours, performance deficits, and attentional biases (including self-focused and external threat-focused)(Clark & Wells, 1995; Heimberg et al., 2014; Hofmann, 2007; Rapee & Heimberg, 1997; Wong & Rapee, 2016). Such cognitive and behavioural processes may be particularly resistant to modification during exposure therapy because, in contrast to other fears and phobias, social cognitions are mostly inaccessible to disconfirmation (Craske, 2003; Foa et al, 1996), in that individuals with social anxiety are reliant on estimates of what they believe others think of their behaviour. Therefore, given that exposure alone cannot challenge these cognitions, our results align with the idea that relapse after exposure treatment might be explained, not by deficits in safety learning, but by the enduring negative cognitions that underpin social anxiety.

Further, the pattern of results might be explained to some extent by the nature of the research context. It is unlikely that threat extinction paradigms, carried out in the laboratory, elicit levels of social threat comparable to social evaluation experienced in the real world. Hence, it is probable that laboratory tasks, such as those used in the current experiments, are unable to capture compromised cognitive processes specifically related to social anxiety. Threat extinction tasks are, however, uncertain by nature. The omission of the US could, in some individuals, trigger a sense of future threat uncertainty (Dunsmoor et al., 2015). For this reason, threat extinction paradigms might be more aligned with IU, rather than social anxiety-related mechanisms.

Several limitations need to be considered when interpreting the results of the reported studies. In line with the previous literature that has highlighted the strengths of using socially relevant stimuli when investigating the role of social anxiety on conditioning processes (Lissek et al., 2008; Pejic et al., 2013), we presented participants with neutral facial expressions as CS and negative verbal feedback as US. Alongside the verbal feedback, we employed a second socially irrelevant US and administered an electric shock in both experiments. The shock was included due to previous research that indicated that habituation to derogatory statements during acquisition resulted in the conditioned response not lasting into the extinction phase (Lissek et al., 2008). Considering that the primary focus across both experiments was on the effect of social anxiety on threat extinction and

retention, all participants, regardless of their level of social anxiety, were required to maintain a conditioned response towards the CS+ into the extinction learning phase. Therefore, we chose to include the shock alongside the statements to ensure that the US was sufficiently threatening. However, participants rated the electric shock as significantly more anxiety-provoking than the verbal feedback across both studies. It is possible that the electric shock was perceived as largely aversive and masked the ability of the socially relevant verbal feedback to elicit the expected effects for individuals with higher social anxiety specifically.

Further, both experiments recruited young, female, university students which may limit the generalisability of the results. Females were specifically recruited in these experiments due to social anxiety being more prevalent in females compared to males (Remes et al., 2016; Sosic et al., 2008), as well as the female identities and voices used as CS and US within both tasks. It is important to note, therefore, that the findings from these experiments can only be interpreted in relation to females and we cannot draw any conclusions about the relationship between individual differences in IU and extinction processes in males. However, while the majority of previous studies that have examined the role of IU in threat extinction have recruited samples of both males and females, the number of female participants generally outweighs the number of male participants in these studies (Dunsmoor et al., 2015; Lucas et al., 2018; Morriss et al., 2015; 2016; 2020; Morriss & van Reekum, 2019). It could, therefore, be argued that across the literature, the effect of IU on extinction processes is being driven by women. Future work should examine whether there are gender differences in the effect of IU on extinction learning and retention.

The majority of previous research investigating the effect of social anxiety on extinction processes has examined between-group differences. However, we adopted a dimensional approach in this research. We measured social anxiety as a continuous variable due to the push, backed up by strong empirical support, towards a dimensional approach to psychopathology (Shear et al., 2007). While we recruited appropriately large sample sizes in both experiments to support the use of this approach, we cannot rule out that effects of social anxiety may have been observed had we compared clinically diagnosed group with a control group.

In conclusion, individual differences in IU, and not social anxiety, predicted threat expression during extinction learning and extinction retention within two separate social conditioning experiments. These results provide insight into how IU modulates threat and safe associations in the presence and absence of threat; however, social anxiety does not seem to be related to compromised safety learning in this context. The current work supports the need to disentangle transdiagnostic and disorder-specific vulnerabilities in emotional disorders (Shihata et al., 2016), and

further work in this area should examine how compromised cognitive processes, specifically related to social anxiety, affect the efficacy of exposure therapy for the treatment of SAD.

Acknowledgements

The authors wish to thank participants for taking part in these experiments, Josephine Arthur and Natalie Manningham for their assistance collecting data. This research was funded by an Economic and Social Research Council (ESRC) Doctoral Studentship awarded to Shannon Wake (1791652). Furthermore, this research was supported by: (1) a NARSAD Young Investigator Grant from the Brain & Behavior Research Foundation (27567) and an ESRC New Investigator Grant (ES/R01145/1) awarded to Jayne Morriss.

Author Contributions

S.W., C.v.R., T.J. & HD designed the studies. SW collected the data, conducted the analysis and interpretation and wrote the manuscript draft. JM helped with physio data extraction protocols/scripts and statistics for analysis. J.M., C.v.R., and HD contributed to interpretation, critical manuscript revision and approval of final manuscript. T.J. edited and approved the final manuscript.

Data Transparency and Conflicts of Interest Statements

The dataset reported here is not part of any published or currently in press works. The authors have no competing interests to declare.

References

Ahrens, L. M., Mühlberger, A., Pauli, P., & Wieser, M. J. (2014). Impaired visuocortical discrimination learning of socially conditioned stimuli in social anxiety. *Social Cognitive and Affective Neuroscience*, *10*(7), 929–937.

Ahrens, L. M., Pauli, P., Reif, A., Mühlberger, A., Langs, G., Aalderink, T., & Wieser, M. J. (2016). Fear conditioning and stimulus generalisation in patients with social anxiety disorder. *Journal of Anxiety Disorders*, *44*, 36–46.

American Psychiatric Association (2013). Diagnostic and statistical manual of mental disorders (5th ed.). Arlington, VA: American Psychiatric Publishing.

Barrett, J., & Armony, J. (2009). Influence of trait anxiety on brain activity during the acquisition and extinction of aversive conditioning. *Psychological Medicine, 39*(2), 255-265.

Benjamini, Y., & Hochberg, Y. (1995). Controlling the false discovery rate: a practical and powerful approach to multiple testing. Journal of the Royal Statistical Society: Series B (Methodological), 57(1), 289–300.

Ben-Shakhar, G. Standardization within individuals: A simple method to neutralise individual differences in skin conductance. *Psychophysiology*, 22, 292–299 (1985).

Boelen, P. A., & Reijntjes, A. (2009). Intolerance of uncertainty and social anxiety. Journal of Anxiety Disorders, 23, 130-135.

Bögels, S. M., Alden, L., Beidel, D. C., Clark, L. A., Pine, D. S., Stein, M. B., & Voncken, M. (2010). Social anxiety disorder: questions and answers for the DSM-V. Depression and anxiety, 27(2), 168-189.

Bouton, M. E. (1993). Context, time, and memory retrieval in the interference paradigms of Pavlovian learning. *Psychological Bulletin,* 114(1):80-99.

Buhr, K., & Dugas, M. J. (2002). The intolerance of uncertainty scale: Psychometric properties of the English version. *Behaviour Research and Therapy*, *40*(8), 931–945.

Carleton, R. N., et al. (2010). "It's not just the judgements - it's that I don't know": Intolerance of uncertainty as a predictor of social anxiety. Journal of Anxiety Disorders, 24, 189-195.

Carleton, R. N. (2016a). Fear of the unknown: One fear to rule them all? *Journal of Anxiety Disorders,* 41, 5–21.

Carleton, R. N. (2016b). Into the unknown: A review and synthesis of contemporary models involving uncertainty. *Journal of Anxiety Disorders,* 39, 30–43.

Clark, D. M., & Wells, A. (1995). A cognitive model of social phobia. In R. G. Heimberg, M. R. Liebowitz, D. A. Hope, & F. R. Schneier (Eds.), Social Phobia: Diagnosis, Assessment, and Treatment (69-93). New York, NY: Guilford Press.

Connor, K., Davidson, J., Churchill, L., Sherwood, A., Weisler, R., & Foa, E. (2000). Psychometric properties of the Social Phobia Inventory (SPIN): New self-rating scale. *British Journal of Psychiatry, 176*(4), 379-386. doi:10.1192/bjp.176.4.379

Craske, M. G. (2003). *Origins of Phobias and Anxiety Disorders: Why More Women Than Men?* California, USA: Elsevier.

Craske, M. G., & Rachman, S. J. (1987). Return of fear: Perceived skill and heart rate responsivity. *British Journal Clinical Psychiatry*, 26:187-200.

Craske, M. G., Treanor, M., Conway, C. C., Zbozinek, T., & Vervliet, B. (2014). Maximising exposure therapy: An inhibitory learning approach. *Behaviour Research and Therapy*, *58*, 10–23.

Dawson, M. E., Schell, A. M., Hazlett, E. A., Nuechterlein, K. H., & Filion, D. L. (2000). On the clinical and cognitive meaning of impaired sensorimotor gating in schizophrenia. *Psychiatry Research*, *96*(3), 187–197.

Delgado, M. R., Nearing, K. I., LeDoux, J. E., & Phelps, E. A. (2008). Neural Circuitry Underlying the Regulation of Conditioned Fear and Its Relation to Extinction. *Neuron*, *59*(5), 829–838.

Dugas, M. J., Buhr, K., & Ladouceur, R. (2004). The role of intolerance of uncertainty in etiology and maintenance of generalised anxiety disorder. In R. G. Heimberg, C. L. Turk, & D. S. Mennin (Eds.), Generalised anxiety disorder: Advances in research and practice (pp. 143–163). New York, NY: Guilford Press

Dunsmoor, J. E., Campese, V. D., Ceceli, A. O., LeDoux, J. E., & Phelps, E. A. (2015). Novelty-Facilitated Extinction: Providing a Novel Outcome in Place of an Expected Threat Diminshes Recovery of Defensive Responses. *Biological Psychiatry*, *78*(3), 203–209.

Foa, E., Franklin, M., Perry, K., & Herbert, J. (1996). Cognitive biases in generalised social phobia. *Journal of abnormal psychology*, *105*(3), 433-439.

Foa, E. B., Steketee, G., & Rothbaum, B. O. (*1989*). Behavioral/cognitive conceptualisations of post-traumatic stress disorder. *Behavior Therapy,* 20(2), 155–176.

Freeston, M. H., Rhéaume, J., Letarte, H., Dugas, M. J., & Ladouceur, R. (1994). Why do people worry? *Personality and Individual Differences, 17*(6), 791-802.

Gazendam, F. J., Kamphuis, J. H., & Kindt, M. (2013). Deficient safety learning characterises high trait anxious individuals. *Biological Psychology, 92*(2), 342–352.

Grady, A. K., Bowen, K. H., Hyde, A. T., Totsch, S. K., & Knight, D. C. (2016). Effect of continuous and partial reinforcement on the acquisition and extinction of human conditioned fear. *Behavioral Neuroscience*, 130(36).

Graham, B. M., & Milad, M. R. (2011). The study of fear extinction: implications for anxiety disorders. *The American journal of psychiatry*, *168*(12), 1255–1265.

Grupe, D. W., & Nitschke, J. B. (2013). Uncertainty and anticipation in anxiety: An integrated neurobiological and psychological perspective. *Nature Reviews Neuroscience,* 14, 488–501.

Haaker, J., Lonsdorf, T. B., Schümann, D., Menz, M., Brassen, S., Bunzeck, N., Gamer, M., & Kalisch, R. (2015). Deficient inhibitory processing in trait anxiety: Evidence from context-dependent fear learning, extinction recall and renewal. *Biological Psychology, 111,* 65 -72.

Heimberg, R. G., Brozovich, F. A., & Rapee, R. M. (2014). A Cognitive-Behavioural Model of Social Anxiety Disorder. In *Social Anxiety* (Third Edit).

Hermann, C., Ziegler, S., Birbaumer, N., & Flor, H. (2002). Psychophysiological and subjective indicators of aversive pavlovian conditioning in generalised social phobia. *Biological Psychiatry*, *52*(4), 328–337.

Hirsch, C. R., & Clark, D. M. (2004). Information-processing bias in social phobia. *Clinical Psychology Review*, *24*(7), 799–825.

Hofmann, S.G., Smits, J.A., 2008. Cognitive-behavioral therapy for adult anxiety disorders: a meta-analysis of randomised placebo-controlled trials. *Journal Clinical Psychiatry,* 69(4).

Hofmann, S. G. (2007). Cognitive factors that maintain social anxiety disorder: A comprehensive model and its treatment implications. *Cognitive Behaviour Therapy*, *36*(4), 193–209.

Jenkins, W. O., & Stanley, J. C., Jr. (1950). Partial reinforcement: A review and critique. *Psychological Bulletin*, 47, 193.

Jorstad-Stein, E.C., & Heimberg, R.G. (2009). Social phobia: an update on treatment. *Psychiatric Clinics of North America,* 32(3), 641-663.

Kleiner, M., Brainard, D., Pelli, D., Ingling, A., Murray, R., & Broussard, C. (2007). What's new in psychtoolbox-3. *Perception*, *36*(14), 1-16.

Leonard, D. W. (1975). Partial reinforcement effects in classical aversive conditioning in rabbits and human beings. *Journal of Comparative and Physiological Psychology,* 88, 596.

Lissek, S., Levenson, J., Biggs, A. L., Johnson, L. L., Ameli, R., Pine, D. S., & Grillon, C. (2008). Elevated fear conditioning to socially relevant unconditioned stimuli in social anxiety disorder. *American Journal of Psychiatry*, *165*(1), 124–132.

Lonsdorf, T. B., & Merz, C. J. (2017). More than just noise: Inter-individual differences in fear acquisition, extinction and return of fear in humans - Biological, experiential, temperamental factors, and methodological pitfalls. *Neuroscience and Biobehavioral Reviews,* 80, 703-728.

Lucas, K., Luck, C. C., & Lipp, O. V. (2018). Behaviour Research and Therapy Novelty-facilitated extinction and the reinstatement of conditional human fear. *Behaviour Research and Therapy*, *109*, 68–74.

Ma, D.S., Correll, J. & Wittenbrink, B. Behav Res (2015) 47: 1122. The Chicago face database: A free stimulus set of faces and norming data.

Macdonald, B., Wake, S., & Johnstone, T. (2020). Selective Extinction Through Cognitive Evaluation: Linking Emotion Regulation and Extinction. *European Journal Neuroscience.* Accepted Author Manuscript.

Milad, M. R., & Quirk, G. J. (2012). Fear extinction as a model for translational neuroscience: ten years of progress. *Annual review of psychology*, *63*, 129–151.

Morriss, J. (2019). What do I do now? Intolerance of uncertainty is associated with discrete patterns of anticipatory physiological responding to different contexts. Psychophysiology, 56(9).

Morriss, J., Chapman, C., Tomlinson, S., & van Reekum, C. M. (2018). Escape the bear and fall to the lion: The impact of avoidance availability on threat acquisition and extinction. *Biological Psychology*, *138*(August), 73–80.

Morriss, J., Hoare, S., & Reekum, C. M. van Reekum. (2018). It's time: A commentary on fear extinction in the human brain using fMRI. *Neuroscience and Biobehavioral Reviews*, *94*(May), 321–322.

Morriss, J., Christakou, A., & van Reekum, C. M. (2015). Intolerance of uncertainty predicts fear extinction in amygdala-ventromedial prefrontal cortical circuitry. *Biology of Mood and Anxiety Disorders*, *5*(1).

Morriss, J., Christakou, A., & van Reekum, C. M. (2016). Nothing is safe: Intolerance of uncertainty is associated with compromised fear extinction learning. *Biological Psychology*, *121*, 187–193.

Morriss, J., Christakou, A., & van Reekum, C. M. (2019). Multimodal evidence for delayed fear extinction in adolescence and young adulthood. *Scientific Reports*, *9*(7748).

Morriss, J., Macdonald, B., & Van Reekum, C. M. (2016). What is going on around here? Intolerance of uncertainty predicts threat generalisation. *PLoS ONE*, *11*(5).

Morriss, J., Saldarini, F., & Van Reekum, C. M. (2019). The role of threat level and intolerance of uncertainty in extinction. International Journal of Psychophysiology, 142, 1-9.

Morriss, J., & van Reekum, C., M. (2019). I feel safe when I know: Contingency instruction promotes threat extinction in high intolerance of uncertainty individuals. *Behavior Research and Therapy,* 116, 111-118.

Morriss, J., Wake, S., Lindner, M., McSorley, E., & Dodd, H. (2020). How many times do I need to see to believe? The impact of intolerance of uncertainty and exposure experience on safety-learning and retention in young adults. *International Journal of Psychophysiology*.

Olsson, A., Carmona, S., Downey, G., Bolger, N., & Ochsner, K. N. (2013). Learning biases underlying individual differences in sensitivity to social rejection. *Emotion*, *13*(4), 616–621.

Pavlov, I. (1927). Conditioned reflexes. New York, NY, US: Dover.

Pejic, T., Hermann, A., Vaitl, D., & Stark, R. (2013). Social anxiety modulates amygdala activation during social conditioning. *Social Cognitive and Affective Neuroscience*, *8*(3), 267–276.

Ponniah, K., & Hollon, S.D., (2008). Empirically supported psychological interventions for social phobia in adults: a qualitative review of randomised controlled trials. *Psychological Medicine,* 38, 3-14.

Rabinak, C. A., Mori, S., Lyons, M., Milad, M. R., & Phan, K. L. (2016). Acquisition of CS-US contingencies during Pavlovian fear conditioning and extinction in social anxiety disorder and posttraumatic stress disorder. *Journal of Affective Disorders*, *207*(June 2016), 76–85.

Rapee, R. M., & Heimberg, R. G. (1997). A cognitive-behavioral model of anxiety in social phobia. *Behaviour Research and Therapy*, *35*(8), 741–756.

Raymond, J. G., Steele, J. D., & Seriès, P. (2017). Modeling Trait Anxiety: From Computational Processes to Personality. *Frontiers in Psychiatry*, *8*, 1-1.

Reichenberger, J., Porsch, S., Wittmann, J., Zimmermann, V., & Shiban, Y. (2017). Social fear conditioning paradigm in virtual reality: Social vs. electrical aversive conditioning. *Frontiers in Psychology*, *8*(NOV), 1–15.

Remes, O., Brayne, C., van, d. L. R., & Lafortune, L. (2016). A systematic review of reviews on the prevalence of anxiety disorders in adult populations. *Brain and Behavior*.

Sachs, G., Anderer, P., Doby, D., Saletu, B., & Dantendorfer, K. (2003). Impaired conditional discrimination learning in social phobia. Neuropsychobiology, *47*, 66–72.

Shear, M. K., Bjelland, I., Beesdo, K., Gloster, A. T., & Wittchen, H. U. (2007). Supplementary dimensional assessment in anxiety disorders. International Journal of Methods in Psychiatric Research, 16(S1), S52-S64.

Shiban, Y., Reichenberger, J., Neumann, I. D., & Mühlberger, A. (2015). Social conditioning and extinction paradigm: A translational study in virtual reality. *Frontiers in Psychology*, *6*.

Shihata, S., McEvoy, P. M., Mullan, B. A., & Carleton, R. N. (2016). Intolerance of uncertainty in emotional disorders: What uncertainties remain? *Journal of Anxiety Disorders*, *41*, 115–124.

Smith, I., Landesman, S., & Failure, M. T. (2009). Relapse of successfully treated anxiety and fear: theoretical issues and recommendations for clinical practice. *Australian and New Zealand Journal of Psychiatry*, *43*(2), 89–100.

Sosic, Z., Gieler, U., & Stangier, U. (2008). Screening for social phobia in medical in-and outpatients with the German version of the Social Phobia Inventory (SPIN). *Journal of Anxiety Disorders*, *22*(5), 849-859.

Spence, S. H., & Rapee, R. M. (2016). The etiology of social anxiety disorder: An evidence-based model. *Behaviour Research and Therapy*, *86*, 50–67.

Spielberger, C. D., Gorsuch, R. L., Lushene, R., Vagg, P. R., & Jacobs, G. A. (1983). *Manual for the State-Trait Anxiety Inventory*. Palo Alto, CA: Consulting Psychologists Press.

Stein, M. B., Torgrud, L. J., & Walker, J. R. (2000). Social phobia symptoms, subtypes, and severity: findings from a community survey. Archives of general psychiatry, 57(11), 1046-1052.

Taylor, C. T., & Alden, L. E. (2010). Safety behaviors and judgmental biases in social anxiety dis-order. Behaviour Research and Therapy, 48, 226–237.

Tinoco-González, D., Fullana, M. A., Torrents-Rodas, D., Bonillo, A., Vervliet, B., Pailhez, G., … Torrubia, R. (2015). Conditioned Subjective Responses to Socially Relevant Stimuli in Social Anxiety Disorder and Subclinical Social Anxiety. *Clinical Psychology and Psychotherapy*, *22*(3), 221–231.

Vervliet, B., Craske, M. G., and Hermans, D. (2013). Fear extinction and relapse: state of the art. Annu. Rev. Clin. Psychol. 9, 215–248.

Vervliet, B., & Indekeu, E. (2015). Low-Cost Avoidance Behaviors are Resistant to Fear Extinction in Humans. *Frontiers in Behavioral Neuroscience*, *9*, 1–12.

Wells, A., & Papageorgiou, C. (1998). Social phobia: effects of external attention on anxiety, negative beliefs, and perspective taking. Behavior Therapy, *29,* 357–370.

Wiggert, N., Wilhelm, F. H., Boger, S., Georgii, C., Klimesch, W., & Blechert, J. (2017). Social Pavlovian conditioning: Short- and long-term effects and the role of anxiety and depressive symptoms. *Social Cognitive and Affective Neuroscience*, *12*(2), 329–339.

Wong, Q. J. J., & Rapee, R. M. (2016). The aetiology and maintenance of social anxiety disorder: A synthesis of complimentary theoretical models and formulation of a new integrated model. *Journal of Affective Disorders*, *203*, 84–100.

Xia, W., Dymond, S., Lloyd, K., & Vervliet, B. (2017). Partial reinforcement of avoidance and resistance to extinction in humans. *Behaviour Research and Therapy*, *96*, 79–89.

Supplementary Materials

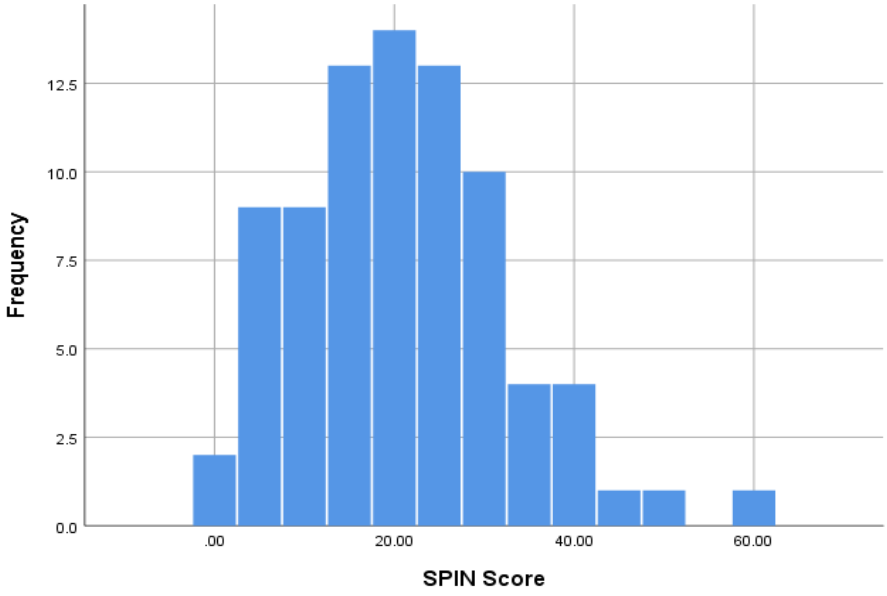
Methods

Shock Build-Up Procedure

An initial shock was delivered at a very low level (0.5 mV) and gradually increased in steps of 0.5 mV. Participants rated the sensation of each shock on a scale of 1 ("not painful at all") to 10 ("extremely painful"). When a rating of "8" was reached, the experimenter reduced the shock intensity by 1 step and participants were informed that the intensity of shock would not change for the duration of the experiment.

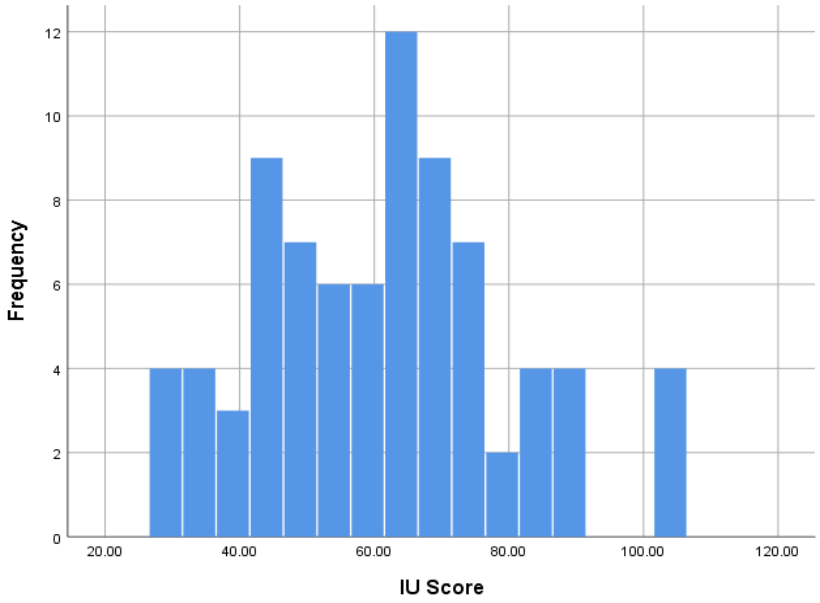
Experiment 1

Distributions of Individual Differences Scores

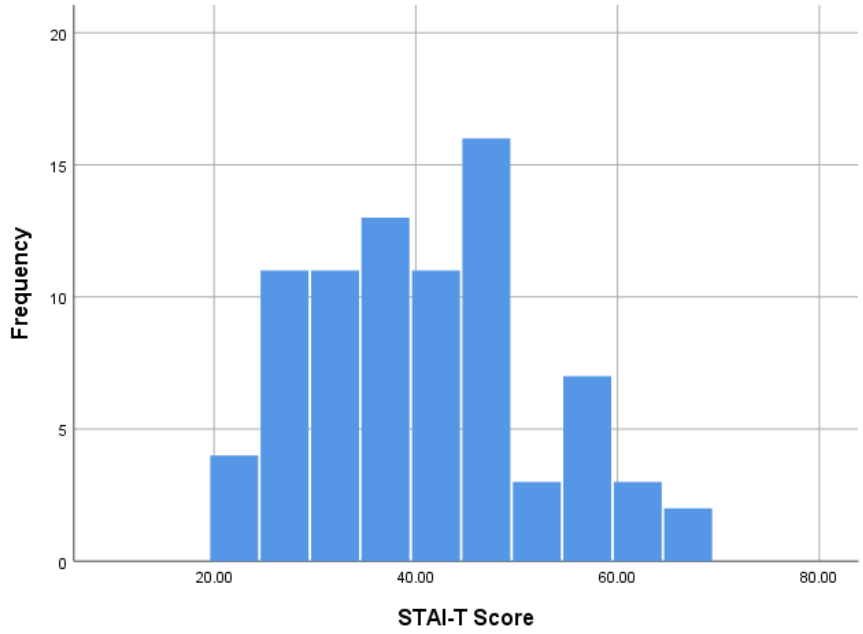


Supplementary Fig 1. Histogram of SPIN scores in experiment 1.

Previous research indicates that a cut-off score of 19 should be used to distinguish between individuals with pathological levels of social anxiety and those without. A SPIN score > 40 is considered severe social anxiety.



Supplementary Fig 2. Histogram of IU scores in experiment 1.



Supplementary Fig 3. Histogram of trait anxiety (STAI-T) scores in experiment 1.

Correlations between anxiety measures

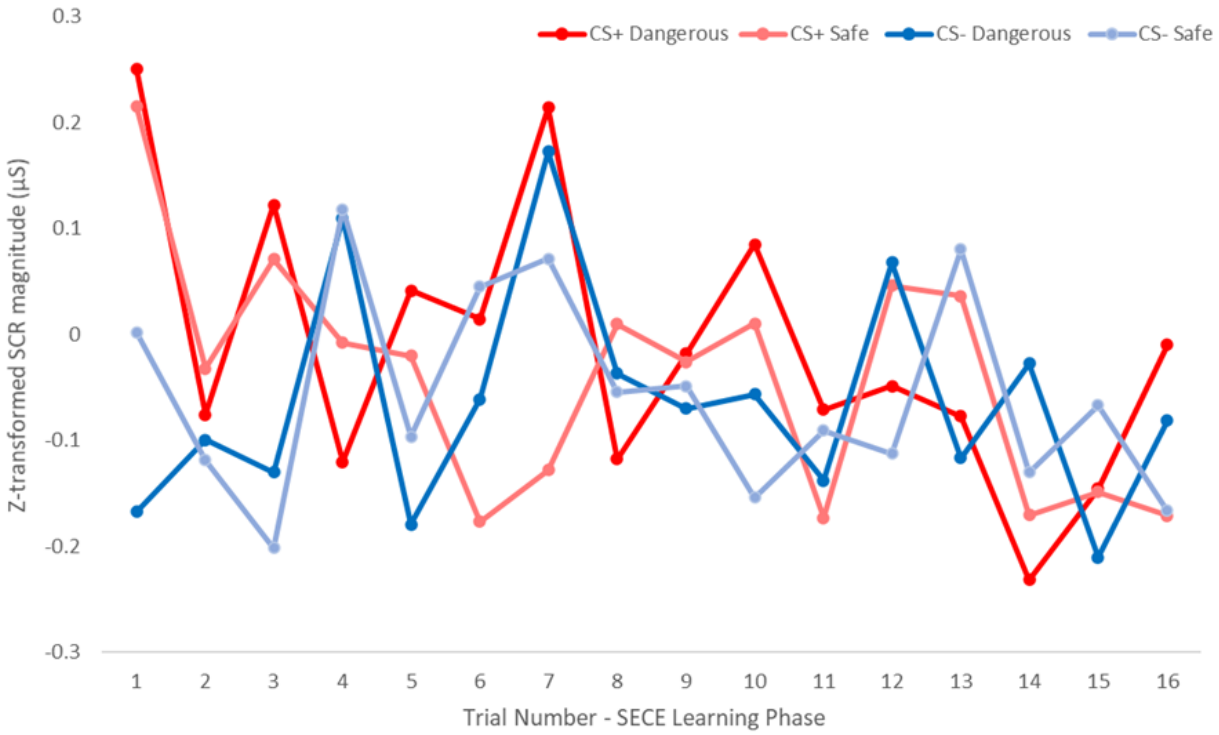
Social anxiety, IU, and trait anxiety measures were significantly positively correlated to one another, with the smallest correlation between trait anxiety and IU, $r(81) = .58$, and the largest

correlation between social anxiety and IU, $r(81) = .61$. The correlation between social anxiety and trait anxiety was $r(81) = .59$. All correlations were at the $p < 0.001$ level.

Learning Assessment

To assess whether participants had learnt the association between the neutral cue and the US , we calculated separate conditioned response scores for subjective ratings of anxiety and SCR magnitude during acquisition and the orientation trials of SECE (i.e., the mean CS+ value minus the mean CS- value for ratings of anxiety and SCR magnitude during acquisition and the average of the first 2 CS+ trials (safe + dangerous) minus the average of the first 2 CS- trials (safe + dangerous) during the orientation trials of the SECE). This assessment is similar to previous work that has examined conditioned responses in extinction (Milad et al., 2009; Morriss, Christakou & van Reekum, 2016). A positive differential response score indicated a larger response to the CS+ relative to the CS-, demonstrating a conditioned response. Based on these criteria, five participants were identified as non-learners As removing these participants did not change the results reported, for completeness, these participants were included in the analysis.

Trial-by-Trial SCR Magnitudes during SECE Learning and SECE Retention



Supplementary Fig 4. Mean SCR magnitude toward the CS+ Dangerous, CS+ Safe, CS- Dangerous and CS- Safe for each trial across the SECE Learning Phase. Square root transformed and Z-transformed SCR magnitude (µS). Skin conductance magnitude is measured in microSiemens.

Supplementary Fig 5. Mean SCR magnitude toward the CS+ Dangerous, CS+ Safe, CS- Dangerous and CS- Safe for each trial across the SECE Retention Phase. Square root transformed and Z-transformed SCR magnitude (µS). Skin conductance magnitude is measured in microSiemens.

The relationship between IU-12 and SCR

When IU-12 scores were entered into the MLM instead of IUS scores, there was still a stimulus x context x time x IU interaction at trend for SCR during the SECE phase, $F(1, 639.38) = 2.83$, $p = .09$.

The stimulus x IU interaction remained significant when IU-12 scores were entered into the MLM in place of IUS scores for SCR during extinction retention, $F(1, 609.83) = 2.83$, $p = .009$.

The relationship between IU-12 and anxiety ratings towards CS

When IU-12 scores were entered into the MLM instead of IUS scores, the stimulus x IU interaction remained significant for ratings of anxiety towards the CS during SECE, $F(1, 158.74) = 26.55$, $p < .001$.

This was also true when IU-12 scores were entered into the MLM in place of IUS scores for rating ratings of anxiety towards the CS during extinction retention, $F(1, 164.31) = 29.98$, $p < .001$.

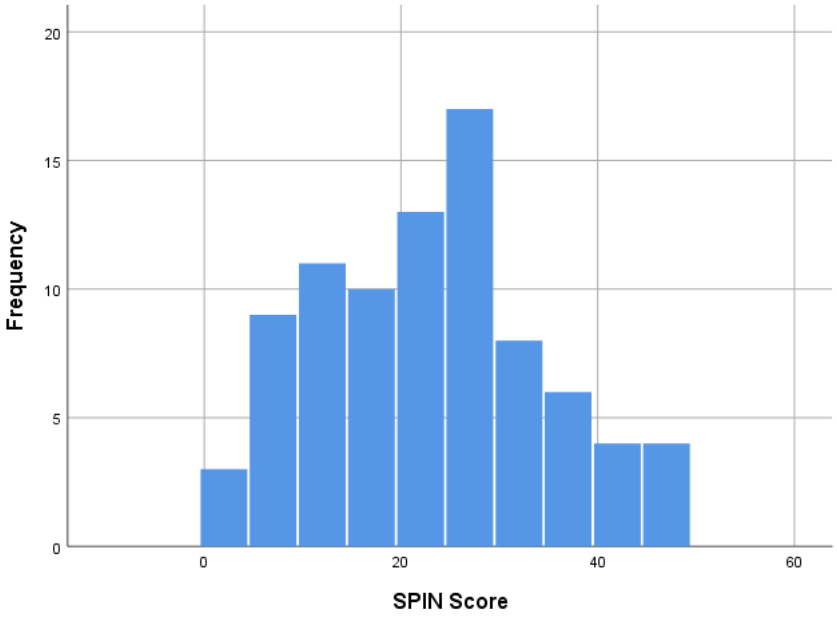
Contingency Awareness Check

At the end of the experimental session on both day 1 and day 2, participants were asked to complete a contingency awareness check questionnaire on paper. The questionnaire was comprised of four questions (i.e., eight questions across both experimental sessions). Participants were presented with an image of each of the identities (CS+ and CS-) and were asked "Was this identity 'safe' or 'dangerous'? Please circle the correct response (safe/dangerous)". Further, participants were asked, "Which 'place' was dangerous? Please circle the correct response (Houses/Skyscrapers)" and "Which 'place' was safe? Please circle the correct response (Houses/Skyscrapers)".

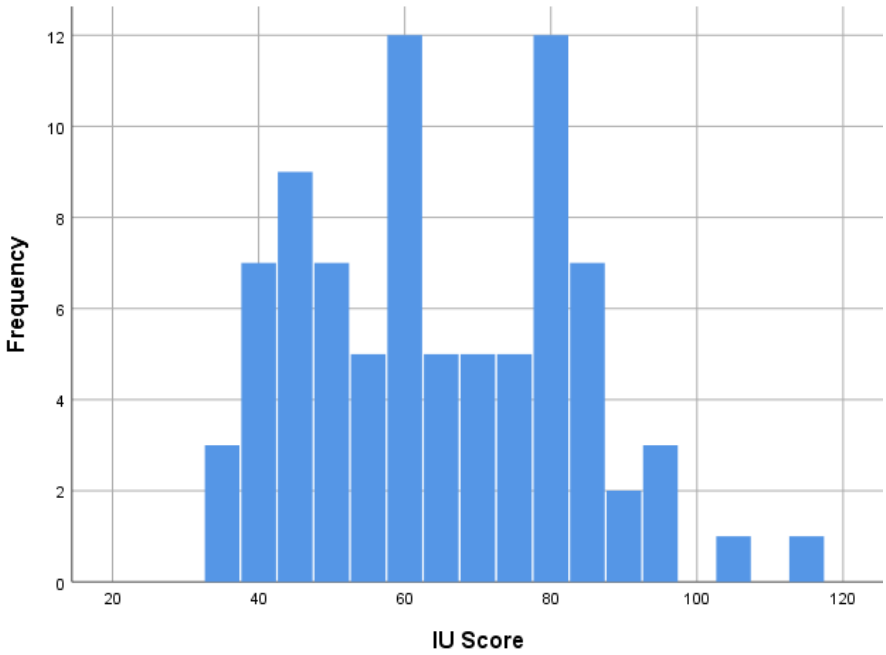
Seven participants did not answer all eight contingency awareness check questions correctly across both days. As removing these participants from the analyses did not alter the results reported, for completeness, data from these participants were not excluded from the data set.

Experiment 2

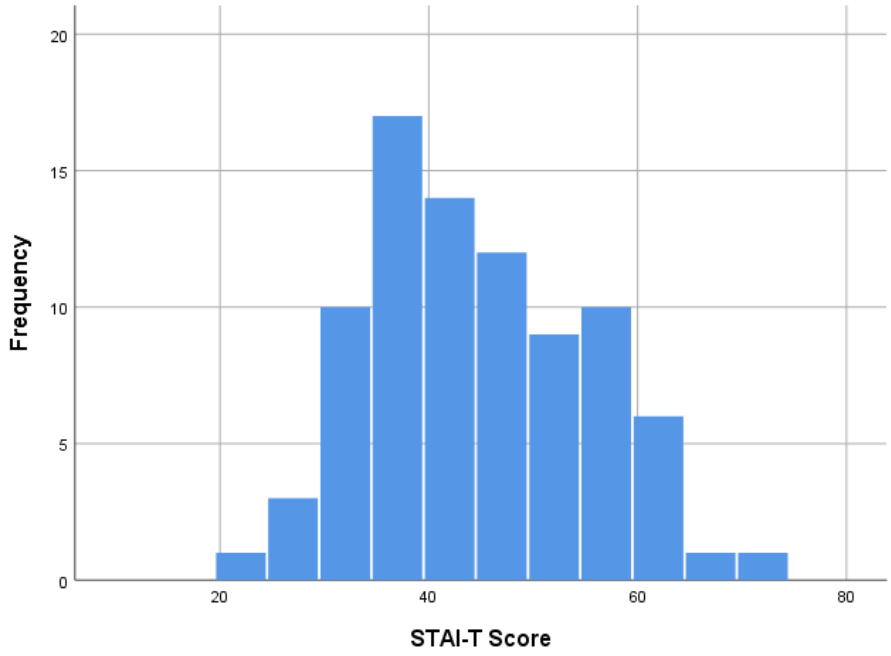
Distributions of individual differences scores



Supplementary Fig 6. Histogram of SPIN scores in experiment 2.



Supplementary Fig 7. Histogram of IU scores in experiment 2.



Supplementary Fig 8. Histogram of trait anxiety (STAI-T) scores in experiment 2.

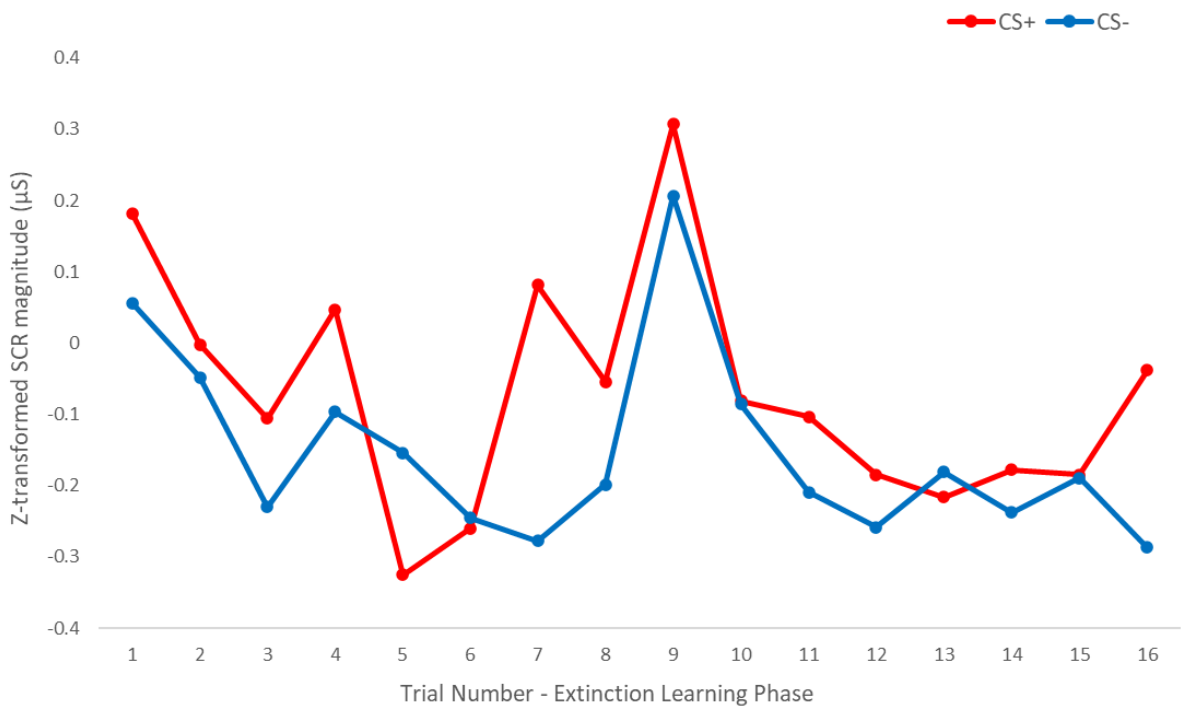
Correlations between anxiety measures

Social anxiety, IU, and trait anxiety measures were significantly positively correlated to one another, with the largest correlation between IU and trait anxiety, $r(84) = 0.73$, and the smallest correlation between social anxiety and trait anxiety, $r(84) = 0.71$. The correlation between IU and social anxiety was, $r(84) = .72$. All correlations were significant at the $p < 0.001$ level.

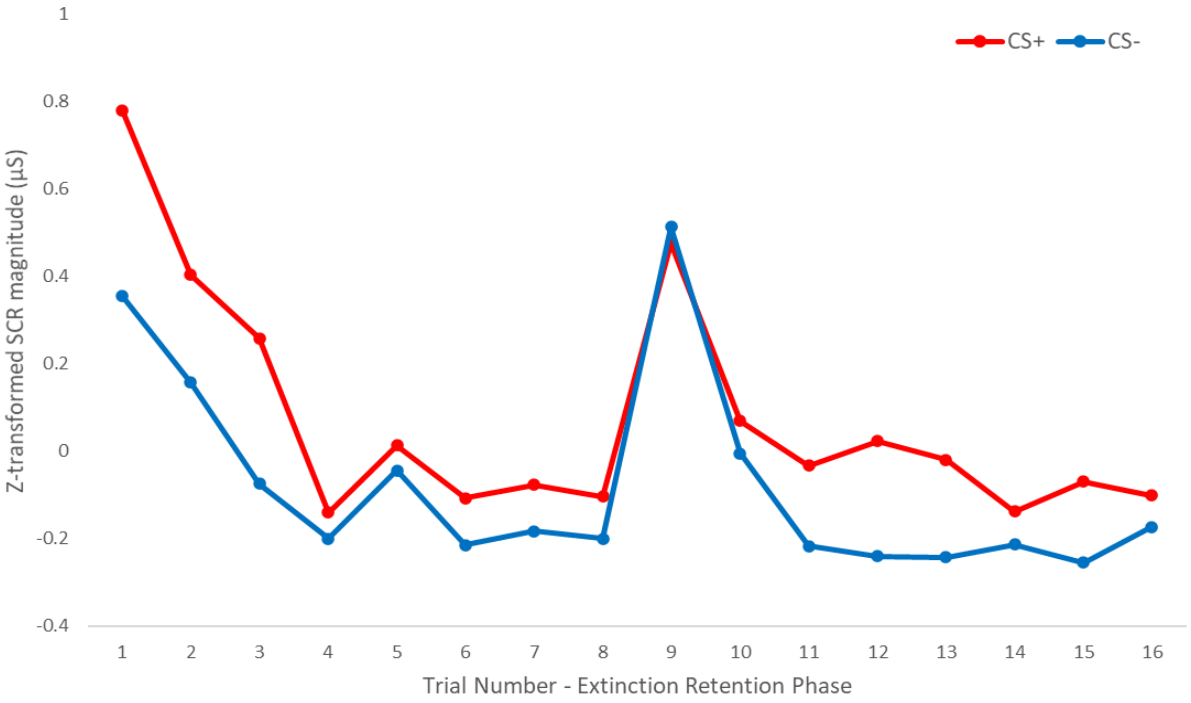
Learning Assessment

A conditioned response score was calculated for ratings of anxiety as well as SCR magnitude during the acquisition and extinction learning phase. As SCR magnitudes were not affected by context cues during the extinction learning phase in experiment 2, as they were in experiment 1, conditioned responses were calculated using SCR across the entire phase. Based on these criteria, no participants were identified as non-learners.

Trial-by-Trial SCR Magnitudes during Extinction Learning and Extinction Retention



Supplementary Fig 9. Mean SCR magnitude toward the CS and CS- for each trial across the Extinction Learning Phase. Square root transformed and Z-transformed SCR magnitude (µS). Skin conductance magnitude is measured in microSiemens.



Supplementary Fig 10. Mean SCR magnitude toward the CS and CS- for each trial across the Extinction Retention Phase. Square root transformed and Z-transformed SCR magnitude (µS). Skin conductance magnitude is measured in microSiemens.

The relationship between IU-12 and SCR

When IU-12 scores were entered into the MLM in place of IUS scores, the stimulus x time x IU interaction was at trend, but was no longer significant, $F(1, 247.73) = 2.69$, $p = .1$, for SCR during the extinction learning phase.

When IU-12 scores were entered into the MLM instead of IUS scores for SCR during extinction retention, the stimulus x time x IU interaction remained significant, $F(1, 326.01) = 4.8$, $p = .03$.

The relationship between IU-12 and anxiety ratings towards CS

There was not a significant relationship between IU and ratings of anxiety towards the CS when IU-12 scores were entered into the MLMs for anxiety ratings during extinction learning [Stimulus x Time x IU, $F(1, 185.77) = 0.7$, $p = .79$], and extinction retention [Stimulus x Time x IU, $F(1, 204.82) = 0.02$, $p = .88$]. This is in line with the original analyses reported in the manuscript.

The relationship between IU-12 and US expectancy ratings towards CS

There was not a significant relationship between IU and ratings of anxiety towards the CS when IU-12 scores were entered into the MLMs for anxiety ratings during extinction learning [Stimulus x Time x IU, $F(1, 219.66) = 0.4$, $p = .53$], and extinction retention [Stimulus x Time x IU, $F(1, 179.95) = 0.52$, $p = .47$]. This is in line with the original analyses reported in the manuscript.

CHAPTER 3.

Paper 2: The Effect of Social Anxiety on Threat Acquisition and Extinction: A Systematic Review

This manuscript has been submitted for publication in the Journal *Biological Psychology.*

Wake, S., van Reekum., C. M., & Dodd, H. The Effect of Social Anxiety on Threat Acquisition and Extinction: A Systematic Review. Manuscript Submitted.

Author Contributions:

S.W., C.v.R. & H.D. generated research questions. S.W. carried out the literature search, coding the abstracts and full texts (with assistance from M.A. and I.H. as noted above), extracted the data, conducted the analysis and interpretation and wrote the manuscript draft. C.v.R. and H.D. contributed to interpretation, critical manuscript revision and approval of the final manuscript.

Abstract

Although exposure-based therapy has been found to be effective at alleviating symptoms of social anxiety disorder, it often does not lead to full remission, and relapse after treatment is common. Exposure therapy is based on theoretical principles of extinction of conditioned fear responses. However, there are inconsistencies in findings across experiments that have investigated the effect of social anxiety on threat conditioning and extinction processes. This systematic review aimed to examine whether elevated levels of social anxiety are associated with abnormalities in threat conditioning and extinction processes. A second aim was to examine the sensitivity of various study designs and characteristics to detect social anxiety-related differences in threat conditioning and extinction. A systematic search was conducted, which identified fifteen experiments for inclusion in the review. The findings did not demonstrate compelling evidence that high levels of social anxiety are associated with atypical threat conditioning or extinction. Further, there was no convincing support that the use of a particular psychophysiological measure, subjective rating, or experimental parameter yields more consistent associations between social anxiety and conditioning processes. Future work in the laboratory should examine how compromised cognitive processes and avoidance behaviours, specifically related to social anxiety, affect the renewal of social fear after extinction learning to inform approaches to exposure-based treatments for social anxiety disorder.

Key words: Social Anxiety, Threat Acquisition, Threat Extinction, Exposure Therapy

1. Introduction

Social anxiety disorder (SAD) is characterised by marked fear and avoidance of social or performance situations (DSM-V; American Psychiatric Association, 2013), due to the belief that negative evaluation will result in humiliation and rejection by others (Clark & Wells, 1995). The disorder has an estimated lifetime prevalence of 12.1% (Ruscio et al., 2008), higher than any other anxiety disorder, except specific phobia (Kessler et al., 2005). Social anxiety can lead to significant disability in education, employment, and relationships (Stein & Kean, 200; Stein et al., 2000) and is associated with a variety of co-occurring conditions, including depression, generalised anxiety disorder, and substance abuse (Beesdo et al., 2007; Spence & Rapee, 2016).

Cognitive behaviour therapy (CBT) is the first-line intervention for the treatment of social anxiety (Pilling et al., 2013) and typically incorporates exposure therapy as a central component (Chesham et al., 2018; Heimberg, 2002). Exposure therapy involves gradual, repeated exposure to feared objects and contexts in the absence of the feared outcome and is based on the theoretical principle of extinction of conditioned fear responses (Craske et al., 2014). During extinction learning, a conditioned stimulus (CS) is repeatedly presented in the absence of the feared outcome until fear of the CS gradually declines. Although exposure therapy has been found to be effective in alleviating symptoms of SAD (Jorstad-Stein & Heimberg, 2009; Ponniah & Hollon, 2008), it often does not lead to full remission, and relapse after treatment is common (Hofmann & Smits, 2008). As fear extinction provides the (neuro)behavioural basis for exposure therapy (Craske et al., 2008), examining the relationship between social anxiety and fear conditioning and extinction may have implications for the treatment of SAD.

Most often, research on fear conditioning and extinction has employed a Pavlovian differential threat acquisition and extinction paradigm. During the acquisition phase, a neutral conditioned stimulus (CS+) is paired with an aversive unconditioned stimulus (US) so that the CS+ acquires the capacity to generate a defensive response when presented alone (conditioned response, CR). Another conditioned stimulus (CS-) serves as the comparison condition and hence is never paired with the US. Differential threat conditioning is typically observed by an increase in self-reported (i.e., US expectancy) or physiological fear-related responses (e.g., skin conductance response) to the CS+ compared to the CS-. During the extinction phase, the CS+ and CS- are both repeatedly presented in the absence of a US, leading to a decrease in the CR, as the CS+ loses its predictive value concerning the US. Extinction does not erase the learned threat association. Instead, it involves new safety learning which inhibits the expression of the original threat memory (Bouton,

1993; Milad & Quirk, 2012). Threat conditioning processes are considered significant in the pathogenesis and maintenance of pathological anxiety (Lonsdorf et al., 2017), the development and treatment of which can be modelled experimentally using threat acquisition and extinction paradigms.

In a meta-analysis that examined differences in classical fear conditioning and extinction of threat between 963 patients with stress and anxiety disorders and 1222 healthy control subjects, Duits et al. (2015) indicated that during threat acquisition, fear responses to safety cues (CS-) were elevated in patients with anxiety compared to non-anxious controls. In contrast, during extinction, patients revealed increased fear responses towards the CS+ compared to healthy controls. Further, patients tended to demonstrate persistent differentiation between the CS+ and CS- throughout the extinction phase, indicating delayed or reduced extinction in patients diagnosed with anxiety disorders. However, within the analyses of this review, Duits et al. (2015) did not differentiate between different subtypes of anxiety (e.g., social anxiety, generalised anxiety, phobias etc.) except for PTSD (i.e., PTSD vs 'other anxiety groups'). The review also did not consider experiments that examined individuals with elevated levels of anxiety, but who might not have received a formal diagnosis of an anxiety disorder. In relation to social anxiety, previous models have suggested that social anxiety should be conceptualised as existing along a severity continuum, as many individuals experience severe symptoms without meeting the threshold for a clinical diagnosis of SAD (Bögels et al., 2010; Spence and Rapee, 2016). Therefore, such subclinical samples may provide valuable insight into social anxiety-linked threat acquisition and extinction processes that otherwise would be overlooked by excluding individuals with milder cases that fall beneath the diagnostic threshold (Chesham et al., 2018; Ruscio, 2010).

Social anxiety is particularly of interest in the context of the conditioning and extinction literature for several reasons. First, as discussed above, exposure treatment for social anxiety often does not lead to full remission, and relapse is common. Second, there are inconsistencies in findings across experiments that have investigated the effect of social anxiety on fear conditioning and extinction processes. Individuals who have higher social anxiety may have particular difficulty learning to inhibit a feared response, given that anxiety in social situations is a common human experience (Ruscio, 2010). This would have important implications for treatment, but given the inconsistency across the literature, it would be premature to make this conclusion. The aim of the present study is, therefore, to systematically review the literature on conditioning and extinction processes in relation to social anxiety.

An initial scoping review of research in this field indicated there was considerable variation in task design, methodology and the dependent measures assessed across experiments. Due to this variation, a quantitative meta-analysis was not deemed appropriate. Instead, we systematically examined whether elevated levels of social anxiety are associated with abnormalities in threat conditioning and extinction processes. We also examined the sensitivity of various study designs and characteristics, for example, the use of subjective versus psychophysiological fear measures, to detect social anxiety-related differences in threat conditioning and extinction. Within the broader threat conditioning literature, subjective report measures of fear learning encompass both cognitive (i.e., ratings of CS-US expectancies or 'risk') and affective (i.e., ratings of valence, arousal, fear/anxiety associated with a CS) components. Psychophysiological indices are commonly used alongside subjective report measures and have the advantage of not being subject to self-report biases (Lonsdorf et al., 2017). Psychophysiological indices also provide information about changes, of which we are often unaware, in different bodily response systems (e.g., expressive responsivity or physiological arousal). The present review adopts a dimensional approach and includes research focused on clinical social anxiety as well as experiments that have investigated individual variation in social anxiety levels (i.e., trait social anxiety).

2. Method

2.1 Literature Search and Information Sources

The papers included in this review came from two separate literature searches and a previous meta-analysis. The first literature search (*Search 1*) was conducted in July 2017 to identity articles that aimed to investigate the relationship between anxiety (across all anxiety subtypes) and threat acquisition and extinction. All studies identified as part of this search that focused on social anxiety were retained for the present review. Because *Search 1* excluded studies that recruited patient samples, we extracted studies that had investigated the relationship between social anxiety disorder (SAD) and threat acquisition and extinction from the previously published meta-analysis carried out by Duits et al. (2015). We then conducted the second literature search (*Search 2*) to capture any additional relevant articles, including those focusing on either social anxiety disorder or trait levels of social anxiety, published between 2013 (after the end date of the article search for the Duits et al. (2015) meta-analysis) and December 2019.[5]

[5] Search 2 covered papers published between 2013 – 2019 as experiments that recruited patient populations (up until 2017) were excluded from Search 1 and therefore needed to be accounted for between 2013 – 2017 in Search 2.

2.1.1 Search 1:

Search 1 was carried out in PsychInfo, Web of Science and PubMed and used the search terms (conditioned OR conditioning OR extinction) AND (anxi* OR phobi* OR worry OR panic), that had to be present in the title and/or abstract of the paper. After duplicates had been removed across databases, 6038 records were identified, and abstracts were screened based on inclusion criteria. There were 456 full-text articles that were reviewed for eligibility. Of these, only six articles (Ahrens et al., 2014, Blechert et al., 2015, Ly et al., 2009, Olsson et al., 2013, Pejic et al., 2013, Tinoco-Gonzalez et al., 2014) investigated trait social anxiety assessed with a self-report measure and these were hence selected for inclusion in the current systematic review.

2.1.2 Extracting relevant studies from Duits et al. (2015) meta-analysis:

The Duits et al. (2015) review already examined experiments of threat conditioning and extinction in the anxiety disorders, including social anxiety disorder. Given that Search 1 excluded studies focusing on patient samples, we extracted articles from Duits et al. (2015) that recruited individuals with SAD. An additional three articles (Hermann et al., 2002; Lissek et al., 2008; Veit et al., 2002[6]) were selected for inclusion in the current review on this basis.

2.1.3 Search 2:

Search 2 was carried out to identify experiments published between 2013 and December 2019 and was performed in PsychInfo, Web of Science and PubMed. This date range was selected to gather articles published after the search end data of the Duits et al. (2015) review. The selection of studies was based on the following search terms that had to be present in the title and/or abstract of the paper: (conditioned OR conditioning OR extinction) AND social AND (anxi* OR phobi*). After removing duplicates between databases, 217 abstracts were extracted and screened. Thirteen full-text articles were then reviewed, of which five additional studies were included in the review (Reichenberger et al., 2017, Rabinak et al., 2017, Michalska et al., 2019, Ahrens et al., 2016, Shiban et al., 2015).

After searching, fourteen articles were identified as relevant for inclusion in the current systematic review. Reference lists of selected papers were screened, and one additional article was

[6] The Veit et al. (2002) was later excluded from the current systematic review during the quality check (see "Risk of Bias in Individual Experiments" for details).

identified and included in the review (Schneider et al., 2014), resulting in a total of fifteen published articles (see Figure 1).

2.2 Inclusion and Exclusion Criteria/Eligibility Criteria

Abstracts and full-text articles were only included in the review if they met the following eligibility criteria: 1) the study must be written in English, 2) the study must be an original, peer-reviewed experiment (i.e., not a dissertation, case study or review article), 3) participants must be human, 4) both classical aversive conditioning and extinction must be examined, 5) the study must recruit patients diagnosed with social anxiety disorder according to past or current DSM criteria (Search 2) or social anxiety must be measured using a standardised self-report measure of social anxiety (Search 1 and Search 2), 6) the study must not incorporate a treatment or intervention, including medication and/or therapy, 7) there must not be a mood/emotion/stress/pain induction or manipulation, including training, at any point during the study, 8) Subjective (i.e., ratings of valence/anxiety/expectancy) and/or psychophysiological (i.e., startle/skin conductance/corrugator EMG/heart rate/pupil) outcome measurements must be used to index the conditioned fear response, and 9) the experiments must use a correlational or between-subjects design.

Outcome measures relating to brain imaging (i.e., functional magnetic resonance imaging/positron emission tomography) were considered to be beyond the scope of the current review.

2.3 Study Selection

Study selection adhered to PRISMA guidelines (Liberati et al., 2009) (see Figure 6). First, abstracts from all sources were screened against eligibility criteria (outlined above), followed by the full-texts. The eligibility criteria for Search 1 and Search 2 were identical, except for criterion 5 (see above). During the study selection of Search 1, papers were excluded if patients with a formal diagnosis of SAD had been recruited. Articles from Search 2 were not excluded based on the recruitment of patient populations. A paper could be excluded at any stage of the screening process based on a 'no' response to any of the eligibility criteria; the first criterion that was not met was recorded as the reason for the rejection. Where criteria were coded as unclear (in the absence of any definite 'no' codes) at the abstract stage, articles were put through to the full-text screening.

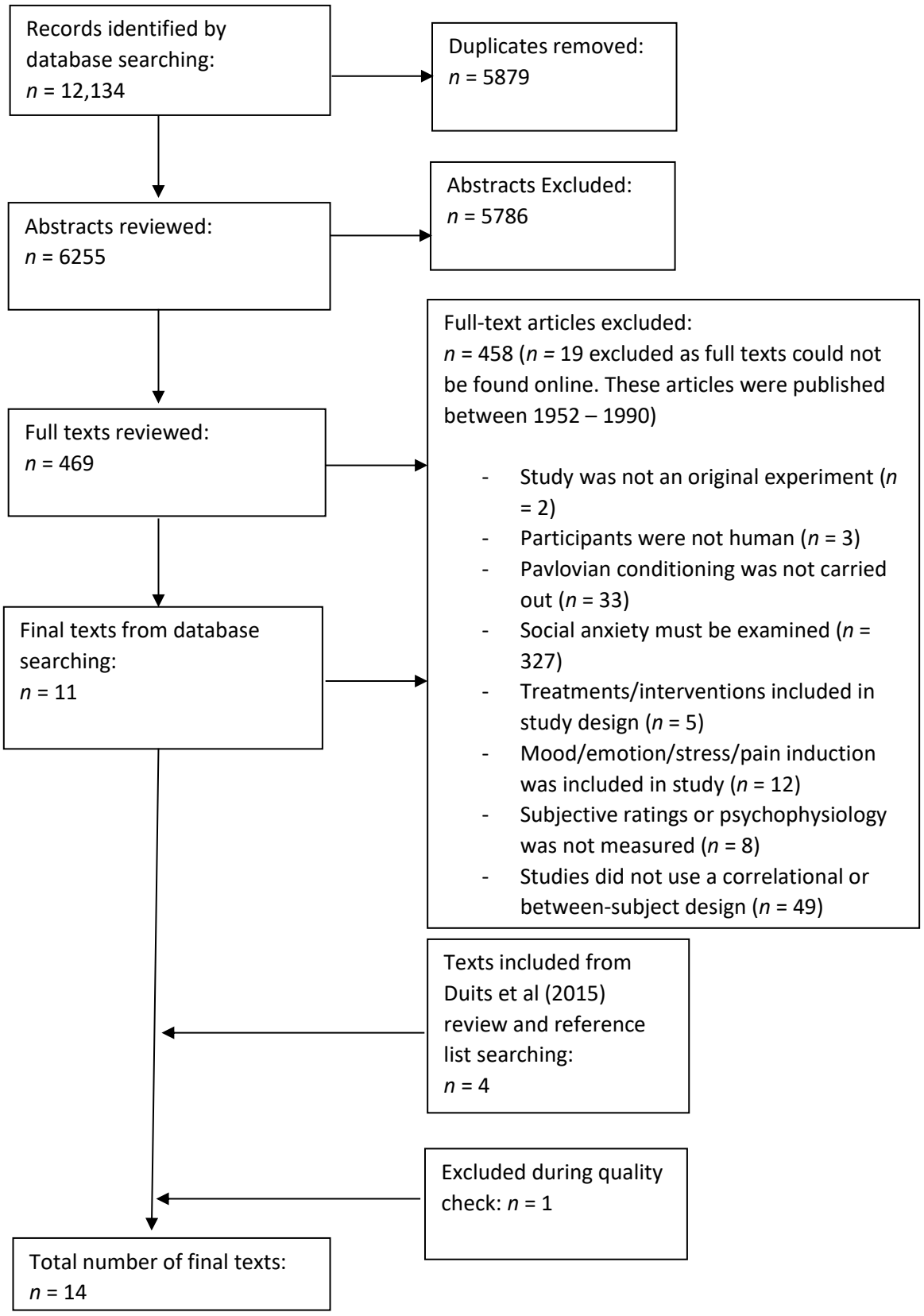


Figure 6. PRISMA Diagram combining search results across search 1, search 2, and the extracted articles from the Duits et al. (2015) meta-analysis.

2.4 Piloting and Inter-Rater Reliability

Eligibility criteria and search terms were piloted before Search 1 was conducted, and eligibility criteria were altered accordingly (criterion 6 and 7 were added). After completion of piloting, two coders (the first author, SW, and a postgraduate student, IH) checked the first 2000 abstracts of search 1 (33%). Based on these 2000 abstracts, a high level of inter-rater reliability was found between coders for accept/reject decisions (K = .95, p < .001). The remaining abstracts were coded by SW.

To ensure the reliability of the criteria for the full-text screening, SW and a second postgraduate student (MA) both assessed the first 249 full-texts (55%) against the eligibility criteria. Again, there was good inter-rater reliability (k = .69, p < .001) between coders for accept/reject decisions on the basis of these 249 full-texts. SW coded the remaining articles.

Any disagreements between coders at either stage of the screening were discussed to reach a consensus.

SW coded all abstracts and full-texts for Search 2 given that reliability had already been established in the context of Search 1.

2.5 Data Extraction

Once all of the full-texts had been screened, the first author extracted all of the relevant data, including 1) sample characteristics, 2) methodology, 3) statistical analyses conducted, and 4) the study findings that were relevant to the aims of the review.

2.6 Risk of Bias in Individual Experiments

The Standard Quality Assessment Criteria for Evaluating Primary Research Papers was used to indicate the overall quality of all the included studies (Kmet et al., 2004) (Table 1, Supplementary Material). Studies were scored on fourteen items on a checklist that assessed study design, methodology, accurate reporting of results, and conclusions made. Depending on the extent to which they met the criteria (2 = yes, 1 = partly, 0 = not addressed), a summary score was calculated for each study. Kmet et al. (2004) suggest that a relatively conservative cut off point for article inclusion is 75%. One of the selected papers (Veit et al., 2002) had a score of 64% and therefore, based on this criterion, was excluded from the current review, leaving a total of fourteen research articles. Otherwise, the studies included were of high quality, with scores ranging from 77% - 95%.

3. Results

3.1 Sample

3.1.1 Sample Characteristics

The fourteen articles identified and included in this review were published between 1999 and 2018. The majority of experiments (*n* = 7) contained German samples, while the remaining experiments included samples from the USA (*n* = 5), Spain (*n* = 1) and The Netherlands (*n* = 1). Nine experiments used a self-report measure to quantify levels of social anxiety, including the Liebowitz Social anxiety scale (*n* = 2; Blechert et al., 2015; Tinoco-Gonzalez et al., 2014), a pre-screening questionnaire based on DSM-IV criteria (*n* = 1; Ahrens et al., 2014), the Brief Fear of Negative Evaluation Scale (*n* = 1; Ly et al., 2009), a maternal report of Social Reticence (*n* = 1; Michalska et al., 2008), and the Social Phobia Inventory (*n* = 3; Pejic et al., 2013; Reichenberger et al., 2017; Shiban et al., 2015). The remaining experiments (*n* = 6) included samples of adults diagnosed with SAD and healthy control participants. Tinoco-Gonzalez et al. (2014) reported two separate experiments within their paper, one of which recruited a clinical sample of patients with SAD and the other measured social anxiety using the Liebowitz Social Anxiety Scale. All other papers reported only one experiment, so a total of fifteen separate experiments are referred to in this review. All experiments, apart from Michalska et al. (2008), recruited adult samples.

3.1.2 Clinical Social Anxiety

Six experiments compared patients with SAD to healthy control participants (HCs) to examine the effect of SAD on fear conditioning and extinction processes. Five of these experiments explored the impact of SAD during acquisition (Ahrens et al., 2016; Hermann et al., 2002; Lissek et al., 2008; Rabinak et al., 2017; Tinoco-Gonzalez et al., 2014) and, of these, four experiments also explored the relationship between SAD and threat extinction (Hermann et al., 2002; Lissek et al., 2008; Rabinak et al., 2017; Tinoco-Gonzalez et al., 2014 Exp 1). One study that recruited clinical samples did not carry out separate analyses to explore the impact of SAD on the acquisition and extinction phases (Schneider et al., 1999), but examined the data across phases.

The number of dependent variables (DV) measured when examining both threat acquisition and extinction varied across studies (range 1 to 7 dependent variables, see Table 5). For acquisition, three out of five experiments found an effect of social anxiety on differential conditioning on at least one dependent variable (DV)(Hermann et al., 2002, 4/8 DVs; Lissek et al., 2008, 1/4 DVs; Rabinak et al., 2017, 1/1 DVs); none found effects on every dependent variable. Similarly, two out of four

experiments that examined the impact of SAD during the threat extinction phase found an effect of SAD on at least one dependent variable (Hermann et al., 2002, 2/8 DVs; Tinoco-Gonzalez et al., 2014 Exp 1, 1/4 DVs). Further, Schneider et al. (1999) did not find an effect of SAD on differential conditioning in valence ratings (0/1 DVs) when investigating the relationship between SAD and conditioning processes across both phases.

3.1.3 Trait Social Anxiety

Nine experiments studied the relationship between trait social anxiety and threat conditioning and extinction. Eight of these experiments investigated the effect of social anxiety during threat acquisition (Ahrens et al., 2014; Blechert et al., 2015; Ly et al., 2009; Olsson et al., 2013; Pejic et al., 2013; Reichenberger et al., 2017; Shiban et al., 2015; Tinoco-Gonzalez et al., 2014 Exp 2) of which seven experiments also examined threat extinction (Ly et al., 2009, only examined acquisition). One study that assessed the relationship between levels of social reticence and fear conditioning processes collapsed the data across the acquisition and extinction phase in the analysis of dependent variables (Michalska et al., 2018).

Studies included a range in the number of dependent variables measured (range 1 to 4 DVs). Five out of eight experiments found a significant effect of trait social anxiety on differential conditioning in at least one dependent variable during threat acquisition (Ly et al., 2009, 1/2 DVs; Olsson et al., 2013, 1/1 DVs; Pejic et al., 2013, 2/4 DVs; Shiban et al., 2015, 1/3 DVs; Tinoco-Gonzalez et al., 2014 Exp 2, 1/4 DVs). During the threat extinction phase, four out of seven experiments found an effect of trait social anxiety on at least one dependent variable (Ahrens et al., 2014, 2/2 DVs; Blechert et al., 2015, 1/1 DVs; Olsson et al., 2013, 1/1 DVs; Shiban et al., 2015, 1/3 DVs). One study that examined the effect of trait social anxiety on dependent variables across the entire paradigm (Michalska et al., 2018, 0/2 DVs), did not find an effect of trait social anxiety during on conditioning processes.

Table 4. Sample Characteristics

Authors	Definition of social anxiety: Trait/Diagnosis	No. of Participants and *M*(Age)						Nationality of Sample
		Whole Sample	No. Female	Controls	No. Female	Socially Anxious	No. Female	
Ahrens et al. (2014)	Trait	NA	NA	23 (21.6)	14	24 (20.1)	15	German
Ahrens et al. (2016)	Diagnosis	NA	NA	26 (26.46)	8	29 (27.66)	12	German
Blechert et al. (2015)	Trait	NA	NA	38 (20.1)	20	33 (20.3)	23	North American
Hermann et al. (2002)	Diagnosis	NA	NA	19 (27.2)	0	14 (31.1)	0	German
Lissek et al. (2008)	Diagnosis	NA	NA	18 (28.11)	11	20 (30.63)	11	North American
Ly et al (2009)	Trait	NA	NA	22 (21.55)	6	26 (19.42)	18	Dutch
Michalska et al (2018)	Trait	59 (13.35)	NR	NA	NA	NA	NA	North American
Olsson et al. (2013)	Trait	43 (23)	21	13 (NR)	NR	14 (NR)	NR	North American

Pejic et al. (2013)	Trait	41 (23.49)	23	NR	NR	NR	NR	German
Rabinak et al. (2017)	Diagnosis	NA	NA	15 (22.87)	11	16 (27.00)	14	North American
Reichenberger et al. (2017)	Trait	44 (21.53)	32	NA	NA	NA	NA	German
Schneider et al. (1999)	Diagnosis	NA	NA	12 (NR)	0	12 (NR)	0	German
Shiban et al. (2015)	Trait	40 (22)	37	NR	NR	NR	NR	German
Tinoco-Gonzalez et al. (2014), Exp 1	Diagnosis	NA	NA	16 (30.06)	13	16 (25.81)	13	Spanish
Tinoco-Gonzalez et al. (2014), Exp 2	Trait	NA	NA	20 (21.55)	15	20 (20.15)	15	Spanish

NA, Not applicable; NR, Not Reported

3.2 Dependent Variables

3.2.1 Psychophysiology

3.2.1.1 Skin Conductance Response

Seven out of fifteen experiments recorded skin conductance response (SCR). Six experiments measured SCR during threat acquisition (Ahrens et al., 2016; Hermann et al., 2002; Ly et al., 2009; Olsson et al., 2013; Pejic et al., 2013; Reichenberger et al., 2017), of which two (Ly et al., 2009; Olsson et al., 2013) reported an effect of social anxiety on SCR towards the CS+ and CS- during acquisition. Ly et al. (2009) reported that high socially anxious participants demonstrated marginally higher SCR during the first CS- trial of acquisition. Olsson et al. (2013) reported that high socially anxious individuals displayed a larger differential conditioned response towards the CS+ compared to low socially anxious participants.

Four out of fifteen experiments measured SCR during threat extinction (Hermann et al., 2002; Olsson et al., 2013; Pejic et al., 2013; Reichenberger et al., 2017), of which two reported effects of social anxiety on SCR towards the CS (Hermann et al., 2002; Olsson et al., 2013). Hermann et al. (2002) reported that control subjects demonstrated differential SCR between the CS+ and CS- only during the first half of the extinction phase, while patients with SAD maintained differential SCR throughout the entire extinction phase. Olsson et al. (2013) demonstrated that high socially anxious individuals did not reveal successful extinction of the conditioned response in SCR across extinction when the CS was angry faces.

Michalska et al. (2018) examined the relationship between social anxiety and SCR towards CS collapsed across the entire fear conditioning and extinction paradigm and did not report an effect of social anxiety on SCR within their experiment.

3.2.1.2 Fear-Potentiated Startle

Six experiments measured fear-potentiated startle (FPS) during threat acquisition (Hermann et al., 2002; Lissek et al., 2008; Reichenberger et al., 2017; Shiban et al., 2015; Tinoco-Gonzalez et al., 2014 Exp 1 and Exp 2). One of these experiments reported an effect of social anxiety on FPS during threat acquisition (Lissek et al., 2008), in that socially anxious subjects demonstrated a greater startle response for the CS paired with a socially relevant negative (i.e., negative statements) US versus CSs paired with a neutral (i.e., neutral statements) and positive (i.e., positive statements) US respectively, but no effect of CS type on FPS was found among healthy control subjects.

All six of the experiments that recorded FPS during threat acquisition also examined the effect of social anxiety on FPS during threat extinction. None of these experiments reported an effect of social anxiety on FPS towards the CS+ and CS- during threat extinction.

3.2.1.3 Heart Rate

Three experiments measured heart rate during threat acquisition (Ahrens et al., 2016; Hermann et al., 2002; Shiban et al., 2015) and two experiments measured heart rate during extinction (Hermann et al., 2002; Shiban et al., 2015). None of these experiments reported an effect of social anxiety on heart rate during CS+ and CS- trials during either the acquisition or extinction phase.

3.2.1.4 Corrugator EMG Response

One study measured corrugator EMG response towards the CS+ and CS- during threat acquisition and extinction (Hermann et al., 2002). In this study there was an effect of social anxiety on the corrugator response elicited by the CS during threat acquisition, in that healthy control subjects, but not patients with SAD, showed an 'at trend' differential conditioning response of the right, but not left, corrugator muscle, but not during threat extinction. There was no effect of social anxiety in corrugator response during threat extinction.

3.2.2 Subjective Ratings

3.2.2.1 Valence Ratings

Nine experiments measured self-reported valence ratings towards both of the CS during acquisition (Ahrens et al., 2014; Ahrens et al., 2016; Blechert et al., 2015; Hermann et al., 2002; Lissek et al., 2008; Pejic et al., 2013; Shiban et al., 2015; Tinoco-Gonzalez et al., 2014 Exp 1 and Exp 2). Two of these experiments reported a relationship between levels of social anxiety and valence ratings towards the CS (Pejic et al., 2013; Shiban et al., 2015). Pejic et al. (2013) reported that higher social anxiety was associated with an increase in ratings of unpleasantness towards the CS after threat acquisition compared to lower levels of social anxiety. Further, Shiban et al. (2015) found that individuals with low levels of social anxiety rated the CS+ as more unpleasant compared to the CS-. However, individuals with high levels of social anxiety did not demonstrate a difference in valence ratings towards the CS+ and CS-, suggesting generalisation of the conditioned response across CS during threat acquisition in this group.

Eight of the above experiments also recorded self-reported valence ratings towards the CS during threat extinction (Ahrens et al., 2014; Blechert et al., 2015; Hermann et al., 2002; Lissek et al., 2008; Pejic et al., 2013; Shiban et al., 2015; Tinoco-Gonzalez et al., 2014 Exp 1 and Exp 2). Three of these experiments demonstrated effects of social anxiety on valence ratings to the CS+ and CS- during threat extinction (Ahrens et al., 2014; Blechert et al., 2015; Shiban et al., 2015). Ahrens et al. (2014) found that after threat extinction, low socially anxious individuals no longer discriminated between the three CS (CS negative, CS neutral, CS positive) in valence ratings, however, high socially anxious subjects continued to rate the CS negative as more unpleasant compared to the CS neutral and CS positive. Blechert et al. (2015) reported that high socially anxious subjects rated the CS negative as more unpleasant compared to low socially anxious subjects. However, group differences for the CS neutral and CS positive did not reach significance. Further, Shiban et al. (2015) found that low socially anxious individuals rated the CS+ as more unpleasant compared to the CS-. In contrast, high socially anxious individuals did not demonstrate discrimination between the CS+ and CS- in valence ratings.

Schnieder et al. (1999) investigated the effect of social anxiety on valence ratings towards the CS+ and CS- across threat acquisition and extinction and found that patients with SAD rated the CS+ as more negative compared to HC subjects.

3.2.2.2 US Expectancy

Five experiments measured US expectancy towards the CS after acquisition (Ahrens et al., 2016; Hermann et al., 2002; Ly et al., 2009; Rabinak et al., 2017; Reichenberger et al., 2017), of which two experiments reported an effect of social anxiety (Hermann et al., 2002; Rabinak et al., 2017). Hermann et al. (2002) reported that in comparison to HC subjects, socially anxious patients gave overall higher US expectancy ratings, which was due to enhanced US expectancy towards the CS-. Rabinak et al. (2017) also found that patients with SAD showed greater US expectancy towards the CS- during early and late threat acquisition compared to HCs.

Three experiments recorded ratings of US expectancy during threat extinction (Hermann et al., 2002; Rabinak et al., 2017; Reichenberger et al., 2017). One of these experiments reported an effect of social anxiety on US expectancy towards the CS (Hermann et al., 2002). Hermann et al. (2002) reported that simple contrasts comparing US expectancy ratings during early and late extinction (towards both CS) demonstrated that HCs, and not patients with SAD, reduced their US expectancy over time.

3.2.2.3 Arousal

Seven experiments measured self-reported arousal elicited by the CS during threat acquisition (Ahrens et al., 2014; Ahrens et al., 2016; Hermann et al., 2002; Lissek et al., 2008; Pejic et al., 2013; Tinoco-Gonzalez et al., 2014, Exp 1 and Exp 2), of which two experiments found a relationship between levels of social anxiety and arousal ratings (Hermann et al., 2002; Tinoco-Gonzalez et al., 2014). Hermann et al. (2002) found that in comparison to HCs, patients with SAD rated the CS as overall more arousing, this was accounted for by higher ratings of arousal towards the CS-. Further, Tinoco-Gonzalez et al. (2014, Exp 2) reported that high trait socially anxious individuals rated the CS negative as more arousing than the CS positive, however, there was not a difference in ratings of arousal towards the CS negative and CS positive for low trait socially anxious individuals.

Six experiments measured self-reported levels of arousal towards the CS during threat extinction (Ahrens et al., 2014; Hermann et al., 2002; Lissek et al., 2008; Pejic et al., 2013; Tinoco-Gonzalez et al., 2014). Two of these experiments reported an impact of social anxiety on ratings of arousal (Hermann et al., 2002; Tinoco-Gonzalez et al., 2014 Exp 1). Hermann et al. (2002) reported that patients with SAD gave higher arousal ratings, compared to HCs, and only differentiated between the CS+ and CS- during early extinction. Further, HC subjects rated the CS+ as more arousing compared to the CS-. Tinoco-Gonzalez et al. (2014, Exp 1) reported that arousal ratings towards the CS positive were higher for patients with SAD compared to HCs.

3.2.2.4 Fear/Anxiety

Six experiments measured levels of fear/anxiety elicited in response to the CS+ and CS- during threat acquisition (Lissek et al., 2008; Michalska et al., 2018; Pejic et al., 2013; Reichenberger et al., 2017; Tinoco-Gonzalez et al., 2014, Exp 1 and Exp 2). One of these experiments reported a relationship between the level of social anxiety and ratings of fear elicited by the CS during acquisition. Pejic et al. (2013) reported that a higher degree of social anxiety was associated with a stronger increase in fear ratings towards the CS post threat acquisition.

All five of these experiments also examined fear/anxiety ratings towards the CS during threat extinction (Lissek et al., 2008; Pejic et al., 2013; Reichenberger et al., 2017; Tinoco-Gonzalez et al., 2014, Exp 1 and Exp 2). None of these experiments reported an effect of social anxiety on fear/anxiety ratings elicited by the CS during threat extinction.

Table 5. Dependent Variables . "✓" indicates that the dependent variable was collected in the experiment.

Authors	Psychophysiology				Subjective Ratings			
	SCR	HR	Corrugator	FPS	US Expectancy	Fear	Arousal	Valence
Ahrens et al. (2014)							✓	✓
Ahrens et al. (2016)	✓	✓			✓		✓	✓
Blechert et al. (2015)								✓
Hermann et al. (2002)	✓	✓	✓	✓	✓		✓	✓
Lissek et al. (2008)				✓		✓	✓	✓
Ly et al (2009)	✓				✓			
Michalska et al (2018)	✓					✓		
Olsson et al. (2013)	✓							
Pejic et al. (2013)	✓					✓	✓	✓
Rabinak et al. (2017)					✓			
Reichenberger et al. (2017)	✓			✓	✓	✓		
Schneider et al. (1999)								✓
Shiban et al. (2015)		✓		✓				✓
Tinoco-Gonzalez et al. (2014), Exp 1				✓		✓	✓	✓
Tinoco-Gonzalez et al. (2014), Exp 2				✓		✓	✓	✓

SCR, Skin Conductance Response; HR, Heart Rate; FPS, Fear-Potentiated Startle; US, Unconditioned Stimulus.

3.3 Experimental Parameters

3.3.1 CS Type

Socially relevant CSs, including facial expressions and 'social agents' in virtual reality, were employed in thirteen experiments. During the acquisition phase, seven of these experiments found an effect of social anxiety on differential conditioning (Hermann et al., 2002; Lissek et al., 2008; Ly et al., 2009; Olsson et al., 2013; Pejic et al., 2013; Shiban et al., 2015, Tinoco-Gonzalez et al., 2014 Exp 2). During threat extinction, six experiments using socially relevant CSs found an effect of social anxiety on conditioning processes (Ahrens et al., 2014; Blechert et al., 2015; Hermann et al., 2002; Olsson et al., 2013; Shiban et al., 2015; Tinoco-Gonzalez et al., 2014 Exp 1). Two experiments incorporated socially irrelevant CSs (coloured bells and coloured streetlights) (Rabinak et al., 2017; Michalska et al., 2018). Rabinek et al. found an effect of social anxiety during the acquisition phase, but not the extinction phase. Michalska et al. (2018) did not find an effect of social anxiety on conditioning processes during either acquisition or extinction.

3.3.2 US Type

A socially relevant US, including vocal insults (i.e., "you disgust me") and critical statements (i.e., "get lost"), was used in seven experiments (Ahrens et al., 2014; Blechert et al., 2015; Lissek et al., 2008; Ly et al., 2009; Pejic et al., 2013, Tinoco-Gonzalez et al., 2014, Exp 1 and Exp 2). One experiment (Ly et al., 2009) combined and administered both a critical statement and an electric shock as US. Four of these experiments found an effect of social anxiety during acquisition (Lissek et al., 2008; Ly et al., 2009; Pejic et al., 2013, Tinoco-Gonzalez et al., 2014 Exp 2). During threat extinction, one experiment found an effect of social anxiety on conditioning processes (Blechert et al., 2015) and two experiments found a marginal effect of social anxiety during threat extinction (Ahrens et al., 2014; Tinoco-Gonzalez et al., 2014 Exp 1).

One study (Reichenberger et al., 2017) included US type as two between-subject conditions; one of which administered an electric shock and the other an air-blast to the neck with a spitting sound followed by the insult “get lost” over headphones. This study did not find that social anxiety was associated with compromised fear conditioning or extinction in either condition.

The remaining experiments did not use socially relevant US (i.e., female scream, odour, loud alarm, electric shock, white noise, air blast) (Ahrens et al., 2016; Hermann et al., 2002; Michalska et al., 2018; Olsson et al., 2013; Rabinak et al., 2017; Schneider et al., 1999; Shiban et al., 2015). Four of these experiments (Hermann et al., 2002; Olsson et al., 2013; Rabinak et al., 2017; Shiban et al.,

2015) reported an effect of social anxiety on responses towards the CS during threat acquisition. During threat extinction, three experiments that did not employ socially relevant US found an effect of social anxiety on conditioning processes (Hermann et al., 2002; Olsson et al., 2013; Shiban et al., 2015).

3.3.3 Reinforcement Schedule

Ten experiments used a 100% reinforcement schedule during the acquisition phase (Ahrens et al., 2014; Blechert et al., 2015; Hermann et al., 2002; Lissek et al., 2008; Ly et al., 2009; Olsson et al., 2013; Pejic et al., 2013, Schneider et al., 1999; Tinoco-Gonzalez et al., 2014 Exp 1 and Exp 2). Six of these experiments (Hermann et al., 2002; Lissek et al., 2008; Ly et al., 2009; Olsson et al., 2013; Pejic et al., 2013; Tinoco-Gonzalez et al., 2014 Exp 2) found a marginal effect of social anxiety on responses towards the CS in at least one dependent variable during threat acquisition. During threat extinction, six of the ten experiments that used a 100% reinforcement schedule (Ahrens et al., 2014; Blechert et al., 2015; Hermann et al., 2002; Olsson et al., 2013; Tinoco-Gonzalez et al., 2014 Exp 1 and Exp 2) found an effect of social anxiety on conditioning processes.

Three of the fifteen experiments employed a 75% reinforcement schedule during threat acquisition (Ahrens et al., 2016; Reichenberger et al., 2017; Shiban et al., 2015). One of these experiments (Shiban et al., 2015) found an effect of social anxiety on conditioning processes during threat acquisition and extinction.

One study used an 80% reinforcement schedule (Michalska et al., 2018) but did not find that social reticence as associated with differences in fear conditioning across dependent variables during threat acquisition or extinction. Another study (Rabinak et al., 2017) employed a 60% reinforcement schedule and found an effect of social anxiety on conditioning processes during threat acquisition, but not during threat extinction.

Table 6.
Study Characteristics and Experimental Parameters

Author	No. of Trials (Each Phase)		No. CS	Type CS	Type US	Reinforcement Rate	Duration CS	ITI Length
	ACQ	EXT						
Ahrens et al. (2014)	20	20	3	Faces	Critical vocal statements	100%	5000 ms	4500 – 5500 ms
Ahrens et al. (2016)	12	0	2	Faces	Female scream	75%	6000 ms	9000 – 12000 ms
Blechert et al. (2015)	4	8	3	Faces	Critical vocal statement	100%	6000 ms	25 – 45 sec
Hermann et al. (2002)	60	25	2	Faces	Odour	100%	5000 ms	17 – 21 sec
Lissek et al. (2008)	8	8	3	Faces	Critical vocal statement	100%	8000 ms	2000 ms
Ly et al (2009)	2 (2 x CS+) 4 (1 x CS-)	0	3	Faces	Critical vocal statement	100%	5000 ms	25 – 45 sec
Michalska et al (2018)	10	8	2	Coloured cartoon bells	Loud alarm	80%	8000 ms	8 – 21 sec
Olsson et al. (2013)	15	15	2	Faces	Electric shock	100%	6000 ms	12 – 15 sec
Pejic et al. (2013)	16	26	2	Faces	Critical vocal statement	100%	8000 ms	16.25 – 18.75 sec

Rabinak et al. (2017)	20	20	3	Outdoor scenes with coloured streetlights	White noise	60%	4000 ms	4000 – 9000 ms
Reichenberger et al. (2017)	12	12	2	Social agents	Electric shock OR critical vocal statement	75%	8000 ms	20 sec
Schneider et al. (1999)	30	10	2	Faces	Odour	100%	6000 ms	4000 ms
Shiban et al. (2015)	8	12	2	Social agents	Airblast and scream	75%	8000 ms	20 sec
Tinoco-Gonzalez et al. (2014), Exp 1	8	4	3	Faces	Critical vocal statement	100%	8000 ms	2000 ms
Tinoco-Gonzalez et al. (2014), Exp 2	8	4	3	Faces	Critical vocal statement	100%	8000 ms	2000 ms

ACQ, Acquisition; EXT, Extinction; CS, Conditioned stimulus; US, Unconditioned stimulus, ITI; Inter-trial interval.

4. Discussion

The purpose of this systematic review was to synthesise the available research to examine whether elevated levels of social anxiety are associated with compromised threat conditioning and extinction processes. The second aim of this review was to investigate the sensitivity of various study designs and characteristics to detect social anxiety-related differences in threat conditioning and extinction. The findings from this review do not demonstrate compelling evidence that high levels of social anxiety are associated with atypical threat conditioning or extinction. The included experiments were highly heterogeneous in their design, but there was little indication that particular design features or dependent variables were associated with more consistent effects of social anxiety. For example, across the fifteen experiments, there was no evidence that the experiments that had recruited patients diagnosed with SAD found more robust or consistent effects of social anxiety compared to experiments that used self-report measures of trait social anxiety. Further, there is no compelling support that the use of a particular psychophysiological measure (SCR, FPS, heart rate or corrugator response), subjective rating (valence, US expectancy, arousal, or fear/anxiety) or experimental parameter (i.e., CS type, US type and reinforcement schedule) yields more consistent associations between social anxiety and fear conditioning or extinction processes compared to any other. It is accurate though to conclude that outcome measures differed in terms of whether results were inconsistent or rare. For example, effects of social anxiety across certain outcome measures (i.e., SCR, corrugator response and self-reported ratings of valence, US expectancy and arousal) were inconsistent, whilst effects of social anxiety on other outcome measures (i.e., heart rate, FPS and self-reported fear/anxiety) were seldom if ever found. This suggests that whilst it is difficult to conclude that there is no effect of social anxiety on threat conditioning and extinction, it is clear that any effect that may exist is not large, robust or easily replicated. If the effect were robust, we would expect it to be observed more frequently across experiments and, where variation in results was found, for this to vary systematically according to study design parameters.

Across the wider threat conditioning literature, multiple outcome measures have been observed to tap into different underlying processes associated with individual differences during threat acquisition and extinction. The two most commonly measured physiological indices of conditioned fear responses are an increase in SCR and FPS. SCR is a measure of arousal and has been found to be reliably associated with individual differences in trait anxiety and intolerance of uncertainty (IU) (e.g., Morriss, Christakou, & van Reekum, 2015, 2016; Sjouwerman, Scharfenort, &

Lonsdorf, 2017). FPS is considered to be a specific fear index and has been found to be elevated in patients with PTSD in response to cues signalling danger, compared to healthy control subjects (Glover et al., 2011; Jovanovic et al., 2009), at times in the absence of an effect in SCR in these populations. Such findings indicate that conditioning paradigms similar to those reported in this review can capture individual differences in conditioning and extinction processes associated with anxiety. Given this, the findings of the present review are unlikely due to issues with the designs of conditioning studies, but instead indicate that social anxiety is not consistently associated with atypical conditioning or extinction processes.

Despite the absence of compelling evidence for compromised safety learning in social anxiety, prior findings demonstrate that relapse after exposure therapy is common for individuals with anxiety disorders, including social anxiety (Craske et al., 2014; Graham & Milad, 2011; Hofmann and Smits, 2008). An explanation, that aligns with the Clark and Wells (1997) model, is that a contributory maintaining factor of social anxiety may be specific core beliefs and assumptions that inflate the threat level of social stimuli. Therefore, the findings of this review indicate that deficits in safety learning are unlikely to be a core issue in social anxiety and, instead, that cognitive processes such as negative biases, dysfunctional beliefs and attentional biases may be more relevant. Previous work has shown that patients with social anxiety interpret ambiguous social events as more negative and mildly negative social events as more catastrophic compared to other anxious patients or non-anxious control participants (Wells & Clark, 1997). Further, patients with social anxiety, compared to control participants, are more likely to remember negative interpersonal interactions (O'Banion & Arkowitz, 1977), evaluate their social behaviour negatively and make internal attributions for social failure (Girodo, Dotzenroth & Stein, 1981). Such evaluations of social situations may be particularly resistant to modification during exposure therapy because, in contrast to other fears and phobias, social cognitions are largely inaccessible to disconfirmation (Craske, 2003; Foa et al., 1996), in that individuals with social anxiety are reliant on estimates of what they believe others think of their behaviour. Given that we would not expect that exposure alone would challenge these cognitions, our results align with the idea that relapse after exposure treatment is explained not by deficits in safety learning but by the enduring negative cognitions that underpin social anxiety.

Further, a key diagnostic feature of social anxiety disorder is the avoidance of social interaction and evaluation (American Psychiatric Association, 2013). Safety behaviours and avoidance maintain social anxiety because they serve to maintain erroneous beliefs, even though they are intended to reduce the risk of social failure and humiliation (Craske, 2003). Avoidance is

persistent in humans and animals and may even renew fear when the availability of avoidance returns after successful extinction has occurred (van Uijen et al., 2018; Vervliet and Indekeu, 2015). Despite the crucial role of avoidant behaviour in social anxiety, lab-based conditioning research has mainly focused on threat acquisition and extinction rather than the role of avoidance. Therefore, future work should examine how avoidance and negatively biased beliefs and assumptions affect the renewal of fear following threat extinction. Such work is required to bridge the gap between conditioning and extinction processes investigated in the laboratory and exposure therapy and will inform models of social anxiety research and therapy to help prevent relapse in individuals with social anxiety disorder.

This systematic review has a number of limitations that warrant discussion. First, only published experiments were included in the review. Although there was no convincing support for the aims outlined, it is likely that the magnitude of the association between social anxiety and threat conditioning and extinction would be further weakened with the inclusion of unpublished experiments, more likely to contain null results. Further, due to the considerable variation in experimental design and analyses across experiments and the lack of reporting of means and standard deviations of null findings, we were not able to quantify effect sizes in order to conduct a meta-analysis. A final limitation is that the review search was not conducted in the traditional way because of a change in focus during the research process. Nevertheless, we have provided an honest and clear account of how the searches were conducted and are confident that all relevant papers were identified through this process.

5. Conclusion

This review indicates that there is relatively little support for the hypothesis that social anxiety is associated with compromised threat acquisition or extinction. There is significant heterogeneity across experiments in terms of design parameters and no evidence that results vary systematically across these parameters. Future work in the laboratory should examine how compromised cognitive processes and avoidance behaviours, specifically related to social anxiety, affect the renewal of social fear after extinction learning to improve the efficacy of exposure-based treatments for social anxiety disorder.

Acknowledgements

The authors wish to thank Maria Amerikanou and Ingelin Hansen for their assistance in coding the texts. This research was funded by an Economic and Social Research Council (ESRC) Doctoral Studentship awarded to Shannon Wake (ES/J500148/1).

Author Contributions

SW, CvR. & HD generated research questions. SW carried out the literature search, coding the abstracts and full texts (with assistance from MA and IH as noted above), extracted the data, conducted the analysis and interpretation and wrote the manuscript draft. CvR and HD contributed to interpretation, critical manuscript revision and approval of the final manuscript.

Conflicts of Interest Statement

The authors have no competing interests to declare.

References

Ahrens, L. M., Mühlberger, A., Pauli, P., & Wieser, M. J. (2014). Impaired visuocortical discrimination learning of socially conditioned stimuli in social anxiety. *Social Cognitive and Affective Neuroscience*, *10*(7), 929–937.

American Psychiatric Association (2013). Diagnostic and statistical manual of mental disorders (5th ed.). Arlington, VA: American Psychiatric Publishing.

Beesdo, K., Bittner, A., Pine, D. S., Stein, M. B., Höfler, M., Lieb, R., & Wittchen, H. U. (2007). Incidence of social anxiety disorder and the consistent risk for secondary depression in the first three decades of life. *Archives of general psychiatry*, *64*(8), 903-912.

Blechert, J., Wilhelm, F. H., Williams, H., Braams, B. R., Jou, J., & Gross, J. J. (2015). Reappraisal facilitates extinction in healthy and socially anxious individuals. *Journal of Behavior Therapy and Experimental Psychiatry*, *46*, 141–150.

Bögels, S. M., Alden, L., Beidel, D. C., Clark, L. A., Pine, D. S., Stein, M. B., & Voncken, M. (2010). Social anxiety disorder: questions and answers for the DSM-V. Depression and anxiety, 27(2), 168-189.

Bouton, M. E. (1993). Context, time, and memory retrieval in the interference paradigms of Pavlovian learning. *Psychological Bulletin,* 114(1):80-99.

Chesham, R. K., Malouff, J. M., & Schutte, N. S. (2018). Meta-Analysis of the Efficacy of Virtual Reality Exposure Therapy for Social Anxiety. *Behaviour Change*, *35*(3), 152–166.

Clark, D. M., & Wells, A. (1995). A cognitive model of social phobia. In R. G. Heimberg, M. R. Liebowitz, D. A. Hope, & F. R. Schneier (Eds.), Social Phobia: Diagnosis, Assessment, and Treatment (69-93). New York, NY: Guilford Press.

Clark, D. M., & Wells, A. (1997). Cognitive therapy for anxiety disorders. *Review of psychiatry*, *16*, I-9.

Craske, M. G. (2003). *Origins of Phobias and Anxiety Disorders: Why More Women Than Men?* California, USA: Elsevier.

Craske, M. G., Kircanski, K., Zelikowsky, M., Mystkowski, J., Chowdhury, N., & Baker, A. (2008). Optimizing inhibitory learning during exposure therapy. *Behaviour research and therapy*, *46*(1), 5-27.

Craske, M., Treanor, M., Conway, C., Zbozinek, T., & Vervliet, B. (2014). Maximizing Exposure Therapy: An Inhibitory Learning Approach. *Behav Res Ther.*, *58*(310), 10–23.

Duits, P., Cath, D. C., Lissek, S., Hox, J. J., Hamm, A. O., Engelhard, I. M., … Baas, J. M. P. (2015). Updated meta-analysis of classical fear conditioning in the anxiety disorders. *Depression and Anxiety*, *32*(4), 239–253.

Foa, E., Franklin, M., Perry, K., & Herbert, J. (1996). Cognitive biases in generalised social phobia. *Journal of abnormal psychology*, *105*(3), 433-439.

Girodo, M., Dotzenroth, S. E., & Stein, S. J. (1981). Casual attribution bias in shy males: Implications for self-esteem and self-confidence. Cognitive Therapy Research, 5, 325-338.

Glover, E. M., Phifer, J. E., Crain, D. F., Norrholm, S. D., Davis, M., Bradley, B., … Jovanovic, T. (2011). Tools for translational neuroscience: PTSD is associated with heightened fear responses using acoustic startle but not skin conductance measures. Depression and Anxiety, 28(12), 1058–1066.

Graham, B. M., & Milad, M. R. (2011). The study of fear extinction: implications for anxiety disorders. *The American journal of psychiatry*, *168*(12), 1255–1265.

Heimberg, R. G. (2002) Cognitive-behavioral therapy for social anxiety disorder: Current status and future directions. Biological Psychiatry 51, 101–108.

Hermann, C., Ziegler, S., Birbaumer, N., & Flor, H. (2002). Psychophysiological and subjective indicators of aversive Pavlovian conditioning in generalized social phobia. *Biological Psychiatry*, *52*(4), 328–337.

Hofmann, S.G., Smits, J.A., 2008. Cognitive-behavioral therapy for adult anxiety disorders: a meta-analysis of randomised placebo-controlled trials. *Journal Clinical Psychiatry,* 69(4).

Jorstad-Stein, E.C., & Heimberg, R.G. (2009). Social phobia: an update on treatment. *Psychiatric Clinics of North America,* 32(3), 641-663.

Jovanovic T, et al. Posttraumatic stress disorder may be associated with impaired fear inhibition: relation to symptom severity. Psychiatry Res 2009;167:151–160.

Kessler, R.C., Berglund, P., Demler, O., Jin, R., Merikangas, K.R., Walters, E.E., 2005. Lifetime prevalence and age-of-onset distributions of DSM-IV disorders in the National Comorbidity Survey Replication. Arch. Gen. Psychiatry 62 (6), 593–602.

Kmet, L. M., Cook, L. S., & Lee, R. C. (2004). Standard quality assessment criteria for evaluating primary research papers from a variety of fields.

Liberati, A., Altman, D. G., Tetzlaff, J., Mulrow, C., Gøtzsche, P. C., Ioannidis, J. P., ... & Moher, D. (2009). The PRISMA statement for reporting systematic reviews and meta-analyses of studies that evaluate health care interventions: explanation and elaboration. *PLoS Med*, *6*(7), e1000100.

Lissek, S., Levenson, J., Biggs, A. L., Johnson, L. L., Ameli, R., Pine, D. S., & Grillon, C. (2008). Elevated fear conditioning to socially relevant unconditioned stimuli in social anxiety disorder. *American Journal of Psychiatry*, *165*(1), 124–132.

Lonsdorf, T. B., Menz, M. M., Andreatta, M., Fullana, M. A., Golkar, A., Haaker, J., … Merz, C. J. (2017). Don't fear 'fear conditioning': Methodological considerations for the design and analysis of studies on human fear acquisition, extinction, and return of fear. *Neuroscience and Biobehavioral Reviews*, *77*, 247–285.

Ly, V., & Roelofs, K. (2009). Social anxiety and cognitive expectancy of aversive outcome in avoidance conditioning. *Behaviour Research and Therapy*, *47*(10), 840–847.

Michalska, K. J., Feldman, J. S., Ivie, E. J., Shechner, T., Sequeira, S., Averbeck, B., … Pine, D. S. (2019). Early-childhood social reticence predicts SCR-BOLD coupling during fear extinction recall in preadolescent youth. *Developmental Cognitive Neuroscience*, *36*(May 2018), 100605.

Milad, M. R., & Quirk, G. J. (2012). Fear extinction as a model for translational neuroscience: ten years of progress. *Annual review of psychology*, *63*, 129–151.

Morriss, J., Christakou, A., & van Reekum, C. M. (2015). Intolerance of uncertainty predicts fear extinction in amygdala-ventromedial prefrontal cortical circuitry. *Biology of Mood and Anxiety Disorders*, *5*(1).

Morriss, J., Christakou, A., & van Reekum, C. M. (2016). Nothing is safe: Intolerance of uncertainty is associated with compromised fear extinction learning. *Biological Psychology*, *121*, 187–193.

O'Banion, K., & Arkowitz, H. (1977). Social anxiety and selective memory for affective information about the self. *Social Behavior and Personality: an international journal*, *5*(2), 321-328.

Olsson, A., Carmona, S., Downey, G., Bolger, N., & Ochsner, K. N. (2013). Learning biases underlying individual differences in sensitivity to social rejection. *Emotion*, *13*(4), 616–621.

Pejic, T., Hermann, A., Vaitl, D., & Stark, R. (2013). Social anxiety modulates amygdala activation during social conditioning. *Social Cognitive and Affective Neuroscience*, *8*(3), 267–276.

Pilling, S., Mayo-Wilson, E., Mavranezouli, I., Kew, K., Taylor, C., & Clark, D. M. (2013). Recognition, assessment and treatment of social anxiety disorder: summary of NICE guidance. *Bmj*, *346*.

Ponniah, K., & Hollon, S.D., (2008). Empirically supported psychological interventions for social phobia in adults: a qualitative review of randomised controlled trials. *Psychological Medicine,* 38, 3-14.

Rabinak, C. A., Mori, S., Lyons, M., Milad, M. R., & Phan, K. L. (2017). Acquisition of CS-US contingencies during Pavlovian fear conditioning and extinction in social anxiety disorder and posttraumatic stress disorder. *Journal of Affective Disorders*, *207*(June 2016), 76–85.

Reichenberger, J., Pfaller, M., Forster, D., Gerczuk, J., Shiban, Y., & Mühlberger, A. (2019). Men scare me more: Gender differences in social fear conditioning in virtual reality. *Frontiers in Psychology*, *10*(JULY), 1–20.

Ruscio, A. M., Brown, T. A., Chiu, W. T., Sareen, J., Stein, M. B., & Kessler, R. C. (2008). Social fears and social phobia in the USA: results from the national comorbidity survey replication. Psychological Medicine, 38(1), 15e28.

Schneider, F., Weiss, U., Kessler, C., Müller-Gärtner, H. W., Posse, S., Salloum, J. B., … Birbaumer, N. (1999). Subcortical correlates of differential classical conditioning of aversive emotional reactions in social phobia. *Biological Psychiatry*, *45*(7), 863–871.

Shiban, Y., Reichenberger, J., Neumann, I. D., & Mühlberger, A. (2015). Social conditioning and extinction paradigm: A translational study in virtual reality. *Frontiers in Psychology*, *6*(APR), 1–10.

Sjouwerman, R., Scharfenort, R., & Lonsdorf, T. B. (2017). Individual differences in fear learning: Specificity to trait-anxiety beyond other measures of negative affect, and mediation via amygdala activation. *BioRxiv*, 233528.

Spence, S. H., & Rapee, R. M. (2016). The etiology of social anxiety disorder: An evidence-based model. *Behaviour Research and Therapy*, *86*, 50–67.

Stein, M.B., Kean, Y.M., 2000. Disability and quality of life in social phobia: epidemiologic findings. Am. J. Psychiatry 157 (10), 1606–1613.

Stein, M.B., Torgrud, L.J., Walker, J.R., 2000. Social phobia symptoms, subtypes, and severity: findings from a community survey. Arch. Gen. Psychiatry 57 (11), 1046–1052.

Tinoco-González, D., Fullana, M. A., Torrents-Rodas, D., Bonillo, A., Vervliet, B., Pailhez, G., … Torrubia, R. (2015). Conditioned Subjective Responses to Socially Relevant Stimuli in Social Anxiety Disorder and Subclinical Social Anxiety. *Clinical Psychology and Psychotherapy*, *22*(3), 221–231.

van Uijen, S.L., Leer, A., Engelhard, I.M., 2018. Safety behavior after extinction triggers a return of threat expectancy. Behav. Ther. (N. Y.) 49, 450–458.

Veit, R., Flor, H., Erb, M., Hermann, C., Lotze, M., Grodd, W., & Birbaumer, N. (2002). Brain circuits involved in emotional learning in antisocial behavior and social phobia in humans. *Neuroscience Letters*, *328*(3), 233–236.

Vervliet, B., & Indekeu, E. (2015). Low-cost avoidance behaviors are resistant to fear extinction in humans. Frontiers in Behavioral Neuroscience, 9.

Supplementary Materials

Table 1 – Quality Assessment (Part 1)

	Question/objective sufficiently described?	Study design evident and appropriate?	Method of subject/comparison group selection or source of information/input variables described and appropriate?	Subject (and comparison group, if applicable) characteristics sufficiently described?	If interventional and random allocation was possible, was it described?	If interventional and blinding of investigators was possible, was it reported?	If interventional and blinding of subjects was possible, was it reported?
Ahrens (2014)	2	2	2	2	N/A	N/A	N/A
Ahrens (2016)	2	2	2	2	N/A	N/A	N/A
Blechert (2015)	2	2	1	2	N/A	N/A	N/A
Hermann (2002)	2	2	1	2	N/A	N/A	N/A
Lissek (2008)	2	2	2	2	N/A	N/A	N/A
Ly (2009)	2	2	2	2	N/A	N/A	N/A
Michalska (2018)	2	2	2	2	N/A	N/A	N/A

Olsson (2013)	2	2	2	2	N/A	N/A	N/A
Pejic (2013)	2	1	2	1	N/A	N/A	N/A
Rabinak (2017)	2	2	2	2	N/A	N/A	N/A
Reichenberger (2017)	2	2	1	1	N/A	N/A	N/A
Schnieder (1999)	1	2	2	2	N/A	N/A	N/A
Shiban (2015)	2	2	2	1	N/A	N/A	N/A
Tinoco-Gonzalez (2014)	2	2	2	2	N/A	N/A	N/A
Veit (2002)	1	2	1	0	N/A	N/A	N/A

Quality Assessment (Part 2)

	Outcome and (if applicable) exposure measure (s) well defined?	Sample size appropriate?	Analytic methods described/justified and appropriate?	Some estimate of variance is reported for the main results?	Controlled for confounding?	Results reported in sufficient detail?	Conclusions supported by the results?	Total score/possible maximum score, %

Ahrens (2014)	2	2	2	1	1	2	2	20/22 = 91%
Ahrens (2016)	2	2	2	2	1	2	2	21/22 = 95%
Blechert (2015)	1	2	2	1	2	2	2	19/22 = 86%
Hermann (2002)	2	1	2	1	1	2	2	18/22 = 82%
Lissek (2008)	2	1	2	2	2	2	2	21/22 = 95%
Ly (2009)	2	2	2	1	1	2	2	20/22 = 91%
Michalska (2018)	1	2	2	1	1	2	2	19/22 = 86%
Olsson (2013)	1	1	1	1	1	2	2	17/22 = 77%
Pejic (2013)	2	2	1	1	1	2	2	17/22 = 77%
Rabinak (2017)	1	1	2	2	2	2	2	20/22 = 91%
Reichenberger (2017)	2	1	2	2	1	2	2	18/22 = 82%
Schnieder (1999)	2	1	1	1	1	2	2	17/22 = 77%

Shiban (2015)	2	1	2	1	1	2	2	18/22 = 82%
Tinoco-Gonzalez (2014)	2	1	2	1	2	2	2	20/22 = 91%
Veit (2002)	2	1	1	1	1	2	2	14/22 = 64%

Note: Studies were scored on the extent to which they met the criteria (2 = yes fully addressed, 1 = partly addressed, 0 = not addressed). Items not relevant to a particular study designed were classified as "" and were subsequently excluded from the summary score. A summary score was then made for each study which resulted from scoring all applicable items on the scale and dividing by the total score possible for the applicable items. A full outline of the description of items and scoring guidelines can be found in Kmet and colleagues (2004) guidelines.

CHAPTER 4.

Paper 3: The Effect of Social Anxiety on the Acquisition and Extinction of Low-Cost Avoidance

This manuscript has been submitted for publication in the Journal *Behaviour, Research and Therapy.*

Wake, S., van Reekum., C. M., & Dodd, H. The Effect of Social Anxiety on the Acquisition and Extinction of Low-Cost Avoidance.

Author Contributions:

S.W., C.v.R. and H.D. designed the study. S.W. collected the data, conducted the analysis, interpretation and wrote the manuscript draft. C.v.R. and H.D. contributed to interpretation, critical manuscript revsion and approval of the final manuscript.

Abstract

Excessive avoidance and safety behaviours are a hallmark feature of social anxiety disorder. However, the conditioning and extinction of avoidance behaviour in social anxiety is understudied. Here, we examined the effect of individual differences in social anxiety on low-cost operant avoidance conditioning and extinction in 80 female participants. We employed an avoidance conditioning and extinction paradigm and measured skin conductance response, threat expectancy ratings and avoidance behaviour throughout the task. Findings demonstrated that elevated levels of social anxiety predicted the generalisation of conditioned avoidance responses across to safety cues during avoidance conditioning. When the opportunity to avoid was returned after extinction learning, elevated social anxiety was associated with increased avoidance behaviour to both threat and safety cues. The results suggest that compromised extinction of avoidance behaviour is a characteristic of social anxiety and supports the strategy of minimising avoidance and safety behaviours during exposure therapy for the treatment of social anxiety disorder. Future research should utilise the avoidance conditioning and extinction paradigm as a laboratory model for clinical research to investigate how, and under what circumstances, the extinction of avoidance and safety behaviours can be improved for individuals high in social anxiety.

Keywords: Social anxiety, avoidance, extinction, threat expectancy, exposure

1. Introduction

Excessive avoidance behaviour, in which an overt action delays or prevents an approaching aversive event, is a defining characteristic of anxiety disorders (American Psychiatric Association [APA], 2013), including social anxiety disorder (SAD). SAD is characterised by the persistent fear and avoidance of social interaction or performance situations in which there is potential for scrutiny or negative evaluation from others (APA, 2013). Although learning to avoid potential threat is adaptive and key to survival, it is unnecessary when the objective danger is absent or low.

In the laboratory, avoidance learning is usually investigated with the use of threat-conditioning and extinction paradigms (Dymond and Roche, 2009; Vervliet and Raes, 2013). Pavlovian threat conditioning and extinction serve as widely used models within translational research aimed at investigating the psychobiological mechanisms of the development, maintenance, and treatment of clinical anxiety (Milad & Quirk, 2012). Through classic threat conditioning, an initially neutral cue (conditioned stimulus, CS) is associated with an aversive stimulus (unconditioned stimulus, US). Repeated presentations of a neutral cue (CS+) with an aversive stimulus can result in defensive responses, consistent with the US, to the neutral cue alone (conditioned response, CR). During threat extinction, the CS+ is repeatedly presented in the absence of the US, leading to a decline in the CR as the CS+ loses its predictive value concerning the US (Milad and Quirk, 2012). Within avoidance conditioning paradigms, an avoidance conditioning phase is typically presented between threat acquisition and extinction. During avoidance conditioning, a simple motor response (such as pressing a button) in the presence of the CS+ prevents the presentation of the US, which can lead to the acquisition of conditioned avoidance.

Principles of threat extinction serve as a model for exposure therapy, used for the treatment of anxiety disorders (Dunsmoor, et al., 2015; Foa et al., 1989; Milad & Quirk, 2012), including social anxiety disorder. Exposure-based therapies aim to oppose flawed associations between intrinsically safe situations (CS) and imagined dangerous outcomes (US), by repeatedly exposing the patient to the objects or situations that elicit fear (Vervliet, Craske & Hermans, 2013). Although exposure therapy has been found to be effective in alleviating symptoms of clinical anxiety (Jorstad-Stein & Heimberg, 2009; Ponniah & Hollon, 2008), it often does not lead to full remission and relapse after treatment is common (Hofmann & Smits, 2008). Across the avoidance conditioning literature, active avoidance has been found to change or prevent the course of extinction and avoidance behaviours remain after extinction learning has occurred (Andreatta et al., 2017; Lovibond et al., 2009; Morriss et al., 2018). For example, in a study that conditioned avoidance behaviour (a button press

prevented an electric shock during CS presentation) before threat extinction, Vervliet and Indekeu (2015) found that once the option to avoid was once again provided after an extinction phase, avoidance behaviour returned and resulted in a return of threat expectancy towards the CS. Further, Van Uijen, Leer and Engelhard (2018) have reported that avoidance behaviour after threat extinction predicts a return of threat expectancy. Such findings present obstacles to interventions based on extinction principles, such as exposure therapy, as the mere availability of avoidance following treatment may be sufficient to renew fear. Avoidance, therefore, provides one explanation as to why patients with anxiety disorders, including social anxiety, experience a return of symptoms after exposure therapy (Dymond, 2019).

Cognitive models of social anxiety propose that socially anxious individuals engage in various 'in-situation or subtle safety behaviours', such as avoiding eye-contact or talking (Clark & Wells, 1995; Rapee & Heimberg, 1997). The use of such safety behaviours prevents socially anxious individuals from processing exposure accurately as the non-occurrence of feared outcomes (i.e., embarrassment and rejection) is attributed to the safety behaviours that were engaged. This, in turn, reinforces the safety behaviour (Rudaz et al., 2017). Further, subtle safety behaviours, such as avoiding eye-contact, are examples of 'low-cost' avoidance as they can go unnoticed by others. Because of the low-cost of carrying out safety behaviours, they may be difficult to inhibit and therefore, resistant to extinction (Vervliet & Indekeu, 2015). As a result, low-cost avoidance might present lasting vulnerability for relapse of social fear and avoidance symptomology after exposure therapy, for individuals with social anxiety.

Despite the crucial role of avoidance behaviour in social anxiety, the fear-learning literature has largely focused on learning mechanisms such as threat extinction; research investigating the learning processes responsible for the acquisition and maintenance of maladaptive avoidance in social anxiety are comparatively under-studied (Dymond, 2019; Krypotos, Vervliet & Englehard, 2018). One study that has examined the role of social anxiety on avoidance learning within a differential avoidance conditioning task (Ly & Roelofs, 2009) found that higher levels of social anxiety were associated with greater US expectancy during avoidance conditioning. However, the effect of social anxiety on the extinction of avoidance behaviour has not yet been investigated. As relapse after exposure therapy is common in SAD, further research examining the extinction of avoidance behaviour in socially anxious individuals is of value to inform clinical research aimed at improving the efficacy of exposure-based treatments for social anxiety.

The aims of the current study are twofold. First, we aimed to replicate and extend the findings of previous literature that has examined whether the availability of avoidance alters extinction learning (Morriss et al., 2018; Van Uijen, Leer & Engelhard, 2018; Vervliet & Indekeu, 2015), with the use of socially relevant stimuli and an extended extinction learning phase compared to the majority of previous literature. Second, we aimed to examine the effect of individual differences in social anxiety on low-cost operant avoidance conditioning and extinction during an avoidance test phase. We modified the experimental design of a previous avoidance learning and extinction paradigm (Vervliet & Indekeu, 2015) to include a socially relevant CS and US and an extended extinction learning and avoidance test phase. The task comprised five separate phases: threat acquisition, avoidance conditioning, threat extinction, avoidance test and re-extinction. Neutral facial expressions were used as CS and an aversive vocal comment and electric shock were used as US, with a 50% reinforcement rate in the threat acquisition phase. Throughout the avoidance conditioning phase, participants could press the space bar during the CS+ (and CS-) to avoid the US. Following this avoidance conditioning, we included an extinction phase with no avoidance option. During the avoidance test phase, which followed, the opportunity to avoid every trial (CS+ and CS-) was returned. During this phase, the US was never presented with the CS+, regardless of avoidance behaviour. During the final re-extinction test phase, the CS+ and CS- were again presented without the US and without the opportunity to avoid.

Throughout the task, we recorded skin conductance responses (SCR), US expectancy ratings and behavioural avoidance responses measured through a button press. As the process of extinction is best observed across time (Morriss, Hoare & van Reekum, 2018), the extinction phase was split into 'early' and 'late' trials during SCR analysis. We hypothesised that during threat acquisition, all participants, regardless of their level of social anxiety, would exhibit greater levels of conditioned responding, indexed by larger skin conductance response (SCR) magnitudes and higher expectancy ratings towards a learned threat (CS+) versus safety cue (CS-). During the avoidance conditioning phase, we predicted that high levels of social anxiety would be associated with increased overall avoidance, indicated by a button press, to both the CS+ and CS-, compared to low levels of social anxiety. When the option to avoid was removed in the threat extinction phase, we hypothesised that during early threat extinction, all participants, regardless of level of social anxiety, would demonstrate a significantly higher skin conductance responsivity towards the CS+ compared to the CS-. Due to an extended threat extinction phase compared to that used in Vervliet and Indekeu's (2015) experiment, we expected successful extinction of differential skin conductance response during the late part of the threat extinction phase across all participants. During the avoidance test

phase, when the option to avoid was returned, we again hypothesised that higher levels of social anxiety would be associated with increased avoidance behaviour toward both the threat (CS+) and safety (CS-) cue. Given prior research showing that increased return of avoidance behaviour leads to a return of threat expectancy towards the CS+, we predicted that during the re-extinction phase, higher relative to lower levels of social anxiety would be associated with a recovery of the conditioned response, indexed by elevated skin conductance responding to CS+ versus CS- trials.

To test whether effects were related to social anxiety specifically and not the result of transdiagnostic processes that underpin anxiety more broadly, we carried out further analyses that controlled for trait anxiety and Intolerance of Uncertainty (IU), both of which have been linked to impaired extinction learning within previous work (Dunsmoor et al., 2015; Lucas, Luck, & Lipp, 2018; Morriss, Christakou, & Van Reekum, 2015, 2016; Morriss & van Reekum, 2019).

2. Methods

2.1 Preregistration

This study was preregistered on the Open Science Framework before data were collected, https://osf.io/3vtdr

2.2 Participants

Eighty female participants (age; *M* = 20.1*,* SD = 1.87; Ethnicity: 46 White, 15 Middle Eastern/Arab, 7 Asian, 5 Mixed, 1 Black, and 6 not specified) took part in this study. Participants were recruited if they were female and between the ages of 18 and 35. Two participants were excluded from the analysis of SCR data; one due to data saving issues and the other due to technical problems with the SCR electrodes. Two participants were excluded from the analysis of avoidance response data due to incorrect button presses during avoidance phases resulting in missing data. Therefore, 78 participants were included in the analysis of SCR and avoidance response data and 80 participants were included in the analysis of US expectancy ratings.

Females were recruited due to the consistently higher prevalence of social anxiety in females compared to males (Remes et al., 2016). Females also demonstrate higher levels of social anxiety when using a dimensional approach (Sosic et al., 2008). Further, female faces, and voices were used as conditioned and unconditioned stimuli, and it was thought that a female voice administering critical statements would have a different threat value to male participants compared to female participants.

The sample size for this experiment was estimated based upon power analyses using repeated measures ANCOVA, using the effect size $n^2 = 0.22$, gained from a previous experiment that reported the main effect of CS for SCR during extinction after avoidance learning (Vervliet & Indeken, 2015). The following parameters were used: effect size, f = 0.53 (converted from n2 = 0.22), α error probability = 0.01, Power (1-β error probability) = 0.95, number of groups = 2 (CS+, CS-), numerator df = 2, number of covariates = 4 (SPIN, IU, Trait Anxiety, BFNES). The total sample size suggested was n = 87[7].

The procedure was approved by the University of Reading Research Ethics Committee.

2.3 Procedure

Upon arrival at the laboratory, participants were informed about the experimental procedures and asked to complete a consent form. They were seated in the testing booth where they completed a series of questionnaires (see "Questionnaires" below for details) on a computer. After completing the questionnaires, participants were asked to wash their hands, without using soap, before returning to the testing booth. Headphones were placed on the participant's head, and physiological sensors were attached to the participant's index, middle and ring finger on the left hand. The stimulator electrode was placed on the little finger of the left hand and the level of shock for each participant was set following procedures outlined in Delgado, Nearing, LeDoux, & Phelps (2008). An initial shock was delivered at a very low level (0.5 mV) and was gradually increased in steps of 0.5 mV. After the delivery of each shock, participants rated the sensation on a scale of 1 ("not painful at all") to 10 ("extremely painful"). When a rating of "8" was reached, the experimenter reduced the intensity of shock by 1 step to achieve the appropriate level. Participants were informed that the intensity of the shock would remain at this level for the duration of the experiment. Before the task started participants were first instructed verbally and sequentially by text on the computer screen: (1) that throughout the task they would see some faces and at times may hear a statement and receive an electric shock; (2) at certain points throughout the task a red dot would appear in the top left-hand corner of the screen. When this red dot was presented, they had the choice to press the space bar. They were instructed that if they chose to press the space bar, they may prevent the statement and the electric shock; (3) to respond to the ratings scales that followed the end of each block of trials using number keys on the keyboard with their right hand, and (4) to stay as still as possible. Participants did not receive instructions about the contingencies between CS and US. At

[7] Preregistered power analysis suggested that we recruit 87 participants, however, data collection had to be terminated prematurely due to the Covid-19 outbreak in the UK.

this point, the conditioning task (see 'Conditioning Task' below for details) was presented on the computer screen whilst electrodermal activity, pulse, avoidance responses and expectancy ratings were recorded. After the conditioning task was complete, participants were asked to rate how anxious and unpleasant (1 = "not at all", 9 = "extremely") the shock and statement made them feel. The session took approximately 45 minutes in total.

2.4 Avoidance Conditioning Task

The conditioning task was designed using E-Prime 2.0 software (Psychology Software Tools Ltd, Pittsburgh, PA). Visual stimuli were presented using a screen resolution of 800 x 600 with a 60 Hertz refresh rate. Participants sat approximately 60 cm from the computer screen. Visual stimuli included two photographs of neutral expressions of two female identities taken from the Chicago Face Database (Ma, Correll & Wittenbrink, 2015). Actors were chosen from a set of 37 white female faces based on normative data collected from over 90 individuals (96 raters for identity 1 and 91 raters for identity 2). The two identities were chosen based on having comparable subjective ratings of age and expressions of happiness, anger and disgust presented in the neutral expression rated on a 7-point Likert scale. One was brunette, the other blonde. The critical vocal statement was presented through headphones and consisted of a female voice shouting "Get Lost" at approximately 80 dB (Ly & Roelofs, 2009). The volume of the statement was standardised across participants by using volume settings on the presentation computer. The electric shock was paired and presented with the statement to make the US more aversive.

The task comprised five phases: threat acquisition, avoidance conditioning, threat extinction, avoidance test, and re-extinction (Figure 1a). During threat acquisition, one of the female identities (blonde or brunette) was paired with the electric shock and critical statement 50% of the time (CS+), whilst the other identity (brunette or blonde) was always presented alone (CS-). The 50% pairing rate was designed to maximise the unpredictability of the CS+/US contingency (Grady, Bowen, Hyde, Totsch, & Knight, 2016). Conditioning contingencies were counterbalanced across subjects, with half of participants receiving the blonde identity paired with the US and the other half of participants receiving the brunette identity paired with the US. Following threat acquisition, the avoidance conditioning phase took place during which the CS+ and CS- were presented in the same manner as during threat acquisition, however when a red square was presented with the CS, participants were given the opportunity to avoid the US on any given trial by pressing the space bar. If the participant chose not to avoid, they would always receive the US during CS+ trials. However, if they chose to avoid when presented with the CS+, the US would not be administered. The US was never presented

during CS- trials, regardless of avoidance behaviour. During the threat extinction phase, the CS+ and CS- were displayed but with no opportunity to avoid and no presentation of the US. Next, in order to assess the persistence of avoidant responding, the opportunity to avoid was again provided within the avoidance test phase. During the avoidance test phase, the US was never presented during CS+ and CS- trials, even if the participant chose not to avoid the CS+. The opportunity to avoid was again removed in the final re-extinction phase, during which the CS+ and CS- were displayed without the presentation of the US.

The acquisition phase consisted of 24 trials (6 CS+ paired, 6 CS+ unpaired and 12 CS-) and the avoidance conditioning phase 16 trials (8CS+ and 8 CS-). The threat extinction phase had 32 trials (16 CS+ and 16 CS-), the avoidance test phase 16 trials (8 CS+ and 8 CS-) and the re-extinction phase 8 trials (4 CS+ and 4 CS-) (Figure 1a). Blocks of trials in threat acquisition were made up of 12 trials, 8 trials in avoidance learning and the avoidance test phase, 16 trials during threat extinction and 4 trials in the re-extinction phase. Experimental trials throughout the task were pseudo-randomised. The first trial of the acquisition phase was always paired and there was always an equal number of CS+ and CS- trials in each block. Trials within blocks were randomised. Conditioning contingencies were counterbalanced across participants, with half of participants receiving the blonde identity as the CS+ and the other half of participants receiving the brunette identity as the CS+.

During threat acquisition the CS was presented for 4000 ms. During reinforced trials, the statement was presented 3000 ms after CS onset. The shock was presented 3800 ms after CS onset and both the statement and the shock co-terminated with the trial. Avoidance trials (both avoidance conditioning and avoidance test phases) had a maximum length of 10000 ms, however this period varied in length depending on whether the participant chose to avoid. During avoidance trials the CS was displayed alone for 1000 ms, followed by the presentation of the avoidance cue. The avoidance cue consisted of a red square displayed in the top left-hand corner of the screen and was presented for a maximum of 2000 ms. If the participant pressed the space bar to ‘avoid’, the red square would disappear, and the CS would be presented alone for a further 7000 ms. During avoidance conditioning, if the participant chose not to avoid, the statement (duration 1000 ms) and shock (duration 200 ms) were presented during CS+ trials and co-terminated with the trial. Therefore, the duration of avoidance trials could vary between 8000 ms – 10000 ms, depending on the participant’s response. The CS was presented alone for 4000 ms during threat extinction and re-extinction trials. A jittered ITI, ranging between 8000 ms and 10000 ms, consisted of a blank black screen and followed each stimulus presentation throughout the task (Figure 1b).

Participants were asked to rate on a 9-point Likert scale their expectancy of hearing the statement and receiving the stimulation when presented with each identity (1 = “don’t expect”, 9 = “do expect”) at the following points: before acquisition; before avoidance learning; before threat extinction; before avoidance test; before re-extinction; after re-extinction.

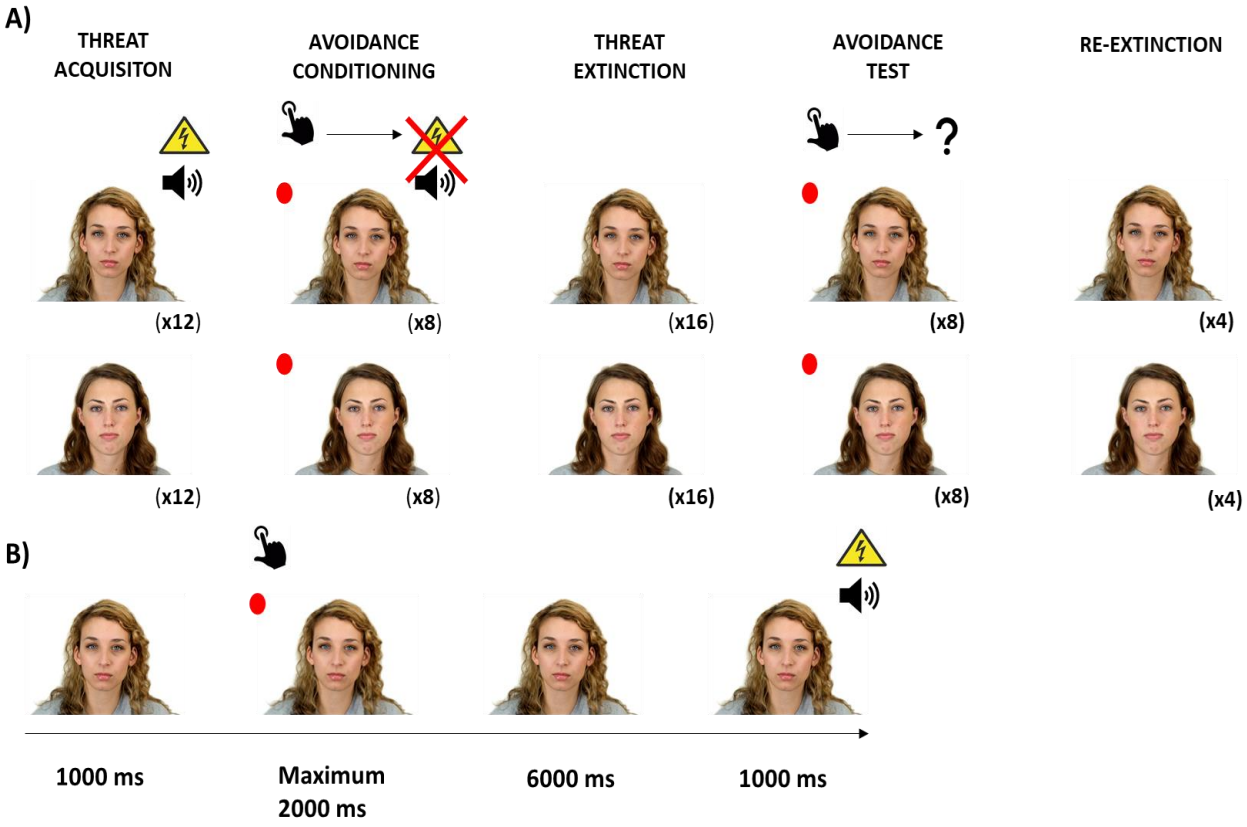


Figure 7. (A): Overview of the experimental phases. During threat acquisiton, one of the identities was associated with an electric shock and an aversive statement in 50% of trials (i.e., 6 trials). During the avoidance conditioning phase, pressing the space bar when the red dot appeared on the screen canceled the presentation of the electric shock and aversive statement during CS+ trials. The opportunity to avoid was removed in the threat extinction phase and the electric shock and aversive statement was never presented. During the avoidance test phase, the opportunity to avoid was returned but the electric shock and aversive statement was never presented, regardless of avoidance behaviour. During the re-extinxtion phase, the opportunity to avoid was again removed and the electric shock and aversive statement was never presented. **(B):** Timeline of an avoidance conditioning trial. The idenity was presented alone for 1000 ms. A red dot then appeared in the corner of the screen for 2000 ms to inform the participant that they could make an avoidance response by pressing the space bar. If the participant chose to avoid, the red dot would disappear immediately after the button press and the idenity would be presented alone for 7000 ms. If the participant did not choose to avoid, the red dot would disappear after 2000 ms and the identitiy would remain on screen for the remained of the trial. The aversive statement was presented after 9000 ms after the onset of the trial and co-terminated with the trial. The electric shock had a duration of 200 ms and also co-terminated with the trial.

2.5 Questionnaires

To assess social anxiety, we administered the Social Phobia Inventory (SPIN) (Connor, Davidson, Churchill, Sherwood, Foa, & Weisler, 2000). The SPIN consists of 17 items that are rated on a 5-point Likert scale. We also administered the Intolerance of Uncertainty Scale (IUS) (Freeston, Rhéaume, Letarte, Dugas, & Ladouceur, 1994), which contains 27 items that are rated on a 5-point Likert Scale, and the Trait section of the State-Trait Anxiety Inventory (Spielberger, Gorsuch, Lushene, Vagg, & Jacobs, 1983), which is made up of 20 items rated on a 4-point Likert scale. Cronbach's alphas for all scales were > .89. The state section of the STAI was not considered to be of interest in this study and so was not administered (See Appendices for Questionnaire measures). The Brief Fear of Negative Evaluation (BFNE) Scale (Leary, 1983) was administered but scores were not included in the analyses of the current data.

2.6 Avoidance Behaviour Data Scoring

Avoidance responses were scored as 1 (vs. 0) and proportion of avoided trials scores were calculated per participant for each CS (CS+ and CS-) during each avoidance phase (avoidance acquisition and avoidance test), i.e., total number of avoided trials divided by the total number of CS+ or CS- trials.

2.7 Physiological Acquisition and Scoring

Physiological recordings were obtained using AD Instruments (AD Instruments Ltd, Chalgrove, Oxfordshire) hardware and software. Electrodermal activity was measured with dry MLT118F stainless steel bipolar finger electrodes that were attached to the distal phalanges of the index and middle fingers of the non-dominant hand. A low constant-voltage AC excitation of 22 mVrms at 75 Hz was passed through the electrodes, which were connected to a PowerLab 8/35, and converted to DC before being digitised and stored. The electrodermal signal was converted from volts to microSiemens using AD Instruments software (AD Instruments Ltd, Chalgrove, Oxfordshire). An ML138 Bio Amp connected to a ML870 PowerLab Unit Model 8/30 amplified the electrodermal and IBI signals, which was be digitized through a 16-bit A/D converter at 1000 Hz. IBI signals were used only to identify movement artefacts and were not analysed. The electrodermal signal was converted from volts to microSiemens using AD Instruments software (AD Instruments Ltd, Chalgrove, Oxfordshire).

Skin conductance responses were marked using ADinstruments software (AD Instruments Ltd, Chalgrove, Oxfordshire) and extracted using Matlab R2017a software (The MathWorks, Inc.,

Natick, Massachusetts, United States). We used a similar scoring procedure to previous studies (Morriss, 2019; Morriss et al., 2019). Skin conductance responses (SCR) were scored when there was an increase of skin conductance level exceeding 0.03 microSiemens (Dawson, Schell, & Filion, 2000). The amplitude of each response was scored as the difference between the onset and the maximum deflection prior to the signal flattening out or decreasing. SCR onsets and respective peaks were counted if the SCR onset was within 0.5-3.5 seconds (CS response) following CS onset during threat acquisition, threat extinction and re-extinction phases. SCR was not analysed during avoidance conditioning and avoidance test trials due to confounds created by movement during avoidance responses. Trials with no discernible SCRs were scored as zero. SCR magnitudes were square root transformed to reduce skew and z-scored within-subjects across all trials to control for interindividual differences in skin conductance responsiveness (Ben-Shakhar, 1985). CS+ non-reinforced and CS- trials were included in the analysis during acquisition, but CS+ reinforced trials were discarded to avoid confounds from the sound and electric shock. SCR magnitudes were calculated from remaining trials by averaging SCR-transformed values and zeros for each condition. Non-responders were defined as those who responded to 10% or less of the CS+ unpaired and CS- trials (Morriss, Chapman, Tomlinson, & Van Reekum, 2018; Xia, Dymond, Lloyd, & Vervliet, 2017). Two non-responders were identified in this experiment. As excluding non-responders did not alter the pattern or significance of SCR findings, for completeness non-responders were included in the analysis of the SCR data.

2.8 Learning Assessment

To assess whether participants had learnt the association between the neutral cue and the electric shock and vocal statement, we calculated conditioned response scores for expectancy ratings and SCR magnitude during the acquisition phase. For SCR throughout the acquisition phase, the conditioned response scores were calculated for each participant as the mean CS+ value minus the mean CS- value. The conditioned response scores for expectancy ratings were calculated as the expectancy rating towards the CS+ minus the expectancy rating towards the CS- post acquisition. This is similar to previous work that has assessed conditioned responses in extinction (Milad et al, 2009; Morriss, Christakou, & van Reekum, 2016). A positive differential response score indicated by a larger response to the CS+ relative to the CS-, demonstrates a conditioned response. Based on these criteria, two participants were identified as non-learners as they did not display a differential response in either ratings or SCR magnitude during acquisition. As removing these participants did

not alter the significance of the results reported, for completeness we decided to include these participants in the analysis.

2.9 Data Analyses

The analyses were conducted using the mixed procedure in SPSS 25.0 (SPSS, Inc; Chicago, Illinois). We conducted separate Multi Level Models (MLMs) for SCR magnitude, avoidance responses and US expectancy ratings during threat acquisition, avoidance conditioning, threat extinction, avoidance test and re-extinction phases. For SCR magnitude and ratings during the acquisition phase, we entered Stimulus (CS+, CS-) at level 1 and individual subjects at level 2. For avoidance response during avoidance conditioning and the avoidance test phase, we entered Stimulus (CS+, CS-) at level 1 and individual subjects at level 2. For SCR magnitude during threat extinction, we entered Stimulus (CS+, CS-) and Time (Early, Late threat extinction) at level 1 and individual subjects at level 2. For SCR magnitude during the re-extinction phase, we entered Stimulus (CS+, CS-) at level 1 and individual subjects at level 2. For the analysis of US expectancy ratings, Stimulus (CS+, CS-) and Block (after acquisition, after avoidance conditioning, after threat extinction, after avoidance test and after re-extinction) were entered at level 1 and individual subjects were entered at level 2. In all of the above MLMs, SPIN scores were entered into the model first to capture the effects of social anxiety on stimulus type and/or time/block. Subsequently, to examine the specificity of SPIN findings, further analyses were carried out in which IU and STAI-T scores were also added to the model as main effects and interacting with manipulated variables (i.e., stimulus type and time/block). In the MLMs that included the three predictor variables (SPIN, IU, STAI-T), a significant interaction between conditions of interest and one individual differences variable, but not the others, suggests specificity.

Fixed effects included Stimulus and Time. A diagonal covariance matrix for level 1 was used in all models. A random intercept for each participant was included as random effects, where a variance components covariance structure was used. We used a maximum likelihood estimator for the MLMs and corrected post-hoc tests for multiple comparisons using the Benjamini-Hochberg False Discovery Rate procedure (Benjamini & Hochberg, 1995).

Where a significant interaction with SPIN was observed, follow-up pairwise comparisons were performed on the estimated marginal means of the relevant conditions at specific values of + or – 1 SD of the mean individual difference score. These values are estimated from the multilevel model of the complete sample, not unlike performing a simple slopes analysis in a multiple

regression analysis. Similar analyses have been published elsewhere (Morriss et al., 2016; Morriss et al., 2020).

3. Results

3.1 Self-reported Reactions to Unconditioned Stimuli

Participants rated the electric shock (M = 5.6, SD = 1.98) and critical vocal statement (M = 6.64, SD = 1.86) as making them feel anxious (where 1 = “not at all”, 9 = “extremely”) after completing the task. A paired samples t-test indicated that participants rated the critical statement as making them feel significantly more anxious compared to the electric shock, $t(77) = 5.42$, $p < .001$. Individual differences in social anxiety were not significantly associated with ratings of anxiety elicited by the critical statement, $r(78) = 0.04$, $p = .75$.

3.2 Threat Acquisition

SCR magnitude was significantly greater towards the CS+ compared to the CS- during the threat acquisition phase [$F(1, 78) = 33.95$, $p = <.001$, see Table 7].

There was no significant difference in anxiety ratings between the CS+ and CS- before acquisition, however, after acquisition anxiety ratings were significantly higher towards the CS+ versus the CS- [Stimulus, $F(1, 165.16) = 283.6$, $p < .001$, Time, $F(1, 165.16) = 144.69$, $p < .001$, Stimulus x Time, $F(1, 165.16) = 283.6$, $p < .001$, see Table 1]. These findings indicate that conditioning was effective during the acquisition phase.

During threat acquisition, there were no significant interactions with or main effects of social anxiety on SCR magnitude, max $F = 0.37$, or US expectancy ratings post-acquisition, max $F = 0.9$, when entered into the model alone, or with IU and trait anxiety scores.

3.3 Avoidance Conditioning

During avoidance conditioning, participants avoided the CS+ significantly more than the CS-, [Stimulus, $F(1, 78) = 62.54$, $p = <.001$, see Table 7].

Individual differences in social anxiety were associated with avoidance responses during the avoidance conditioning phase, when social anxiety scores were included in the model alone, [Stimulus x SPIN, $F(1,78) = 5.36$, $p = .02$]. Individuals scoring higher in the SPIN tended to demonstrate less discrimination between avoidance responses towards the CS+ (M = 0.79, SE = 0.05)

versus the CS- (*M* = 0.52, *SE* = 0.07), p < .001, relative to individuals with lower SPIN scores: CS+ (*M* = 0.82, *SE* = 0.05), CS- (*M* = 0.34, *SE* = 0.07), *p* < .001, see Figure 9.

In the model that included IU and trait anxiety scores with social anxiety scores (as well as their individual interactions with stimulus), the above Stimulus x SPIN interaction was no longer significant [Stimulus x SPIN, *F*(1, 78) = 2.3, *p* =.13]. This suggests that the above effect is not specific to social anxiety when controlling for anxiety traits captured by IU and STAI-T. However, there were also no significant interactions with, or main effects of IU or STAI-T, for avoidance behaviour during avoidance conditioning in this analysis, max *F* = 1.73.

3.4 Threat Extinction

During threat extinction, SCR was significantly higher to the CS+ compared to the CS- during early, *p* < .001, and late, *p* = .002, extinction learning [Stimulus, *F*(1, 306.84) = 32.38, *p* <.001, see Table 1 and Figure 2]. Further, SCR magnitude significantly reduced between early and late extinction learning towards the CS+, *p* = .02, but not the CS-, *p* = .3, [Time, *F*(1, 306.84) = 5.42, *p* =.02, see Table 7 and Figure 8]. There was not a significant stimulus x time interaction for SCR magnitude during extinction learning [Stimulus x Time, *F*(1, 306.84) = 1.29, *p* =.26].

During threat extinction, individual differences in social anxiety were not related to SCR magnitude towards the CS+ and CS-, [Stimulus x SPIN, *F*(1, 307.31) = 0.1, p = .93; Time x SPIN, *F*(1, 307.31) = 3.37, p = .07; Stimulus x Time x SPIN, *F*(1, 307.31) = 0.4, *p* = .53].

Further, there were not any effects of social anxiety on SCR magnitude when controlling for variance accounted for by IU and STAI-T scores, [Stimulus x SPIN, *F*(1, 306.56) = 0.04, p = .85; Time x SPIN, *F*(1, 306.56) = 1.76, p = .19; Stimulus x Time x SPIN, *F*(1, 306.56) = 0.1, p = .76]. There were also no significant interactions with, or main effects of IU or STAI-T, on SCR magnitude during extinction learning, max *F* = 0.82.

3.5 Avoidance Test

During the avoidance test phase, participants avoided the CS+ significantly more than the CS-, [Stimulus, *F*(1, 78) = 17.58, *p* <.001, see Table 7].

There was not a significant stimulus x social anxiety interaction, [Stimulus x SPIN, *F*(1,78) = 0.71, *p* = .4], but we found a main effect of social anxiety on avoidance responses during the avoidance test phase, [SPIN, *F*(1,78) = 4.52, *p* = .04]: Individuals with higher SPIN scores tended to

avoid the CS+ (*M* = 0.63, *SE* = 0.08) and CS- (*M* = 0.43, *SE* = 0.08) more than individuals with lower SPIN scores: CS+ (*M* = 0.36, *SE* = 0.08), CS- (*M* = 0.22, *SE* = 0.08), see Figure 9.

In the model that included IU and STAI-T scores with social anxiety scores, the main effect of social anxiety remained significant suggesting specificity, [SPIN, $F(1, 78) = 4.68$, $p = .03$]. Further, there were no significant interactions with, or main effects of IU or STAI-T observed for avoidance behaviour during the avoidance test phase, max $F = 1.99$.

3.6 Re-extinction

SCR magnitude during re-extinction was significantly greater towards the CS+ compared to the CS-, $p = .008$ [Stimulus, $F(1,78) = 7.35$, $p = .008$, see Table 7 and Figure 8].

Individual differences in social anxiety were not related to SCR magnitude during re-extinction when entered into the model alone, [Stimulus x SPIN, $F(1,78) < .001$, $p = .99$].

Further, Individual differences in social anxiety were not related to SCR magnitude during re-extinction, when controlling for IU and STAI-T scores [Stimulus x SPIN, $F(1,78) < .001$, $p = .99$]. Also, there were no significant interactions with, or main effects of IU or STAI-T, for SCR magnitude during the re-extinction phase, max $F = 0.15$.

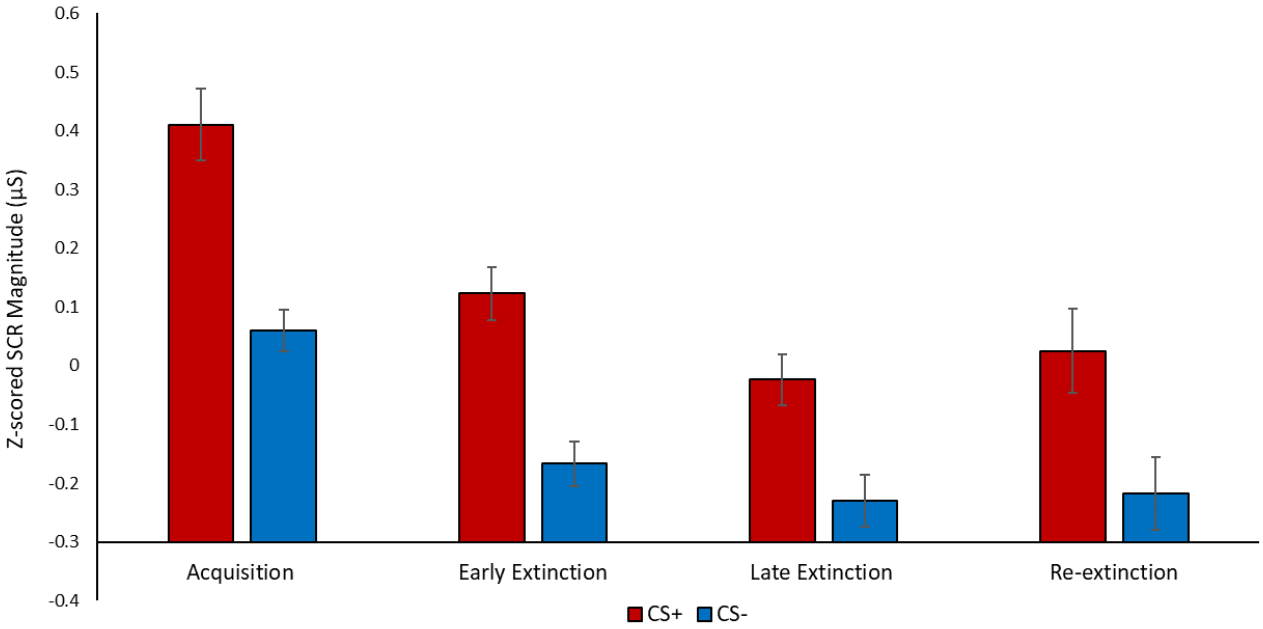


Figure 8. Bar graph depicting mean SCR magnitude during threat acquisition, early extinction learning, late extinction learning and re-extinction. Bars represent standard error. Skin conductance magnitude is measured in microSiemens(µS), which was square root and z-transformed. SCR was significantly greater during CS+ trials compared to CS- trials during threat acquisition, early extinction learning, late extinction learning and re-extinction.

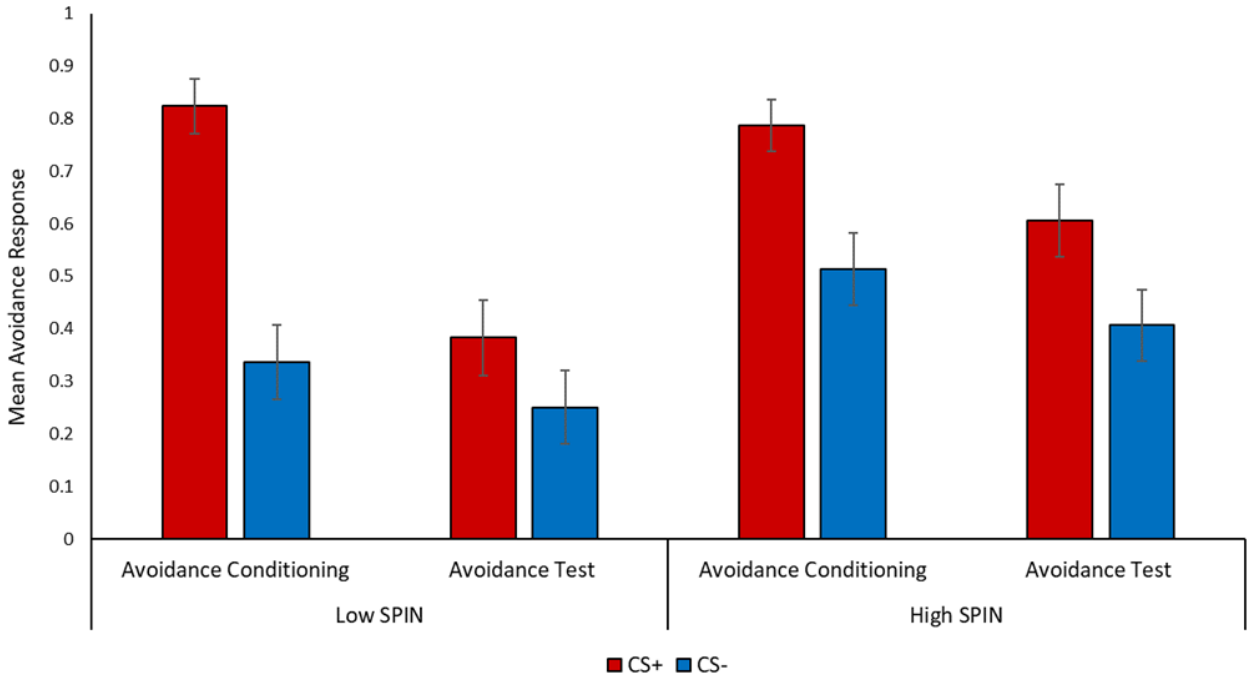


Figure 9. Bar graph depicting mean avoidance responses towards the CS+ and CS- during the acquisition of avoidance phase and the avoidance test phase for SPIN scores estimated at specific values of + or – 1 *SD* of the mean. Bars represent standard error. High SPIN scores, relative to low SPIN scores, were associated with increased avoidance of CS- trials during the avoidance conditioning phase. During the avoidance test phase, high SPIN scores, relative to low SPIN scores, were associated with increased avoidance responses to both the CS+ and CS-.

3.7 US Expectancy Ratings Throughout the Task

Higher expectancy ratings of the US with the CS+ versus the CS- were found at every timepoint (after acquisition, after avoidance conditioning, after extinction learning, after avoidance test and after the re-extinction phase) of the task after threat acquisition [Stimulus, $F(1, 489.86) = 679.92$, $p < .001$, Block, $F(4, 216.23) = 93.26$, $p < .001$, Stimulus x Block, $F(4, 216.23) = 63.54$, $p < .001$, see Table 7].

The stimulus x block x social anxiety interaction for US expectancy ratings throughout the task was not significant when SPIN scores were entered into the model alone, [Stimulus x Block x SPIN, $F(4, 214.66) = 0.62$, $p = .65$]. However, there was a stimulus x SPIN interaction, [Stimulus x SPIN, $F(1, 475.82 = 10.81$, $p = .001$] and a Block x SPIN interaction, [Block x SPIN, $F(4, 214.66) = 5.05$, $p = .001$]. Individuals with higher SPIN scores tended to have greater expectancy of the US with the CS+ versus the CS-, relative to individuals with lower SPIN scores, after extinction learning, after the avoidance test phase and after the re-extinction phase (see Table 8 and Figure 10).

The above analysis was repeated, with IU and STAI-T scores included in the model alongside SPIN scores, and again there was not a stimulus x block x social anxiety interaction, [Stimulus x Block x SPIN, $F(4, 215.74) = 0.35$, $p = .82$]. But, the stimulus x social anxiety and the block x social anxiety interactions remained significant when controlling for variance accounted for by IU and STAI-T scores and their interactions with stimulus and block, suggesting specificity for social anxiety, [Stimulus x SPIN, $F(1, 478.03 = 10.86$, $p = .001$; Time x SPIN, $F(4, 215.74) = 3.74$, $p = .006$]. Further, there were no significant interactions with, or main effects of, IU or STAI-T observed for US expectancy ratings throughout the task, max $F = 1.18$.

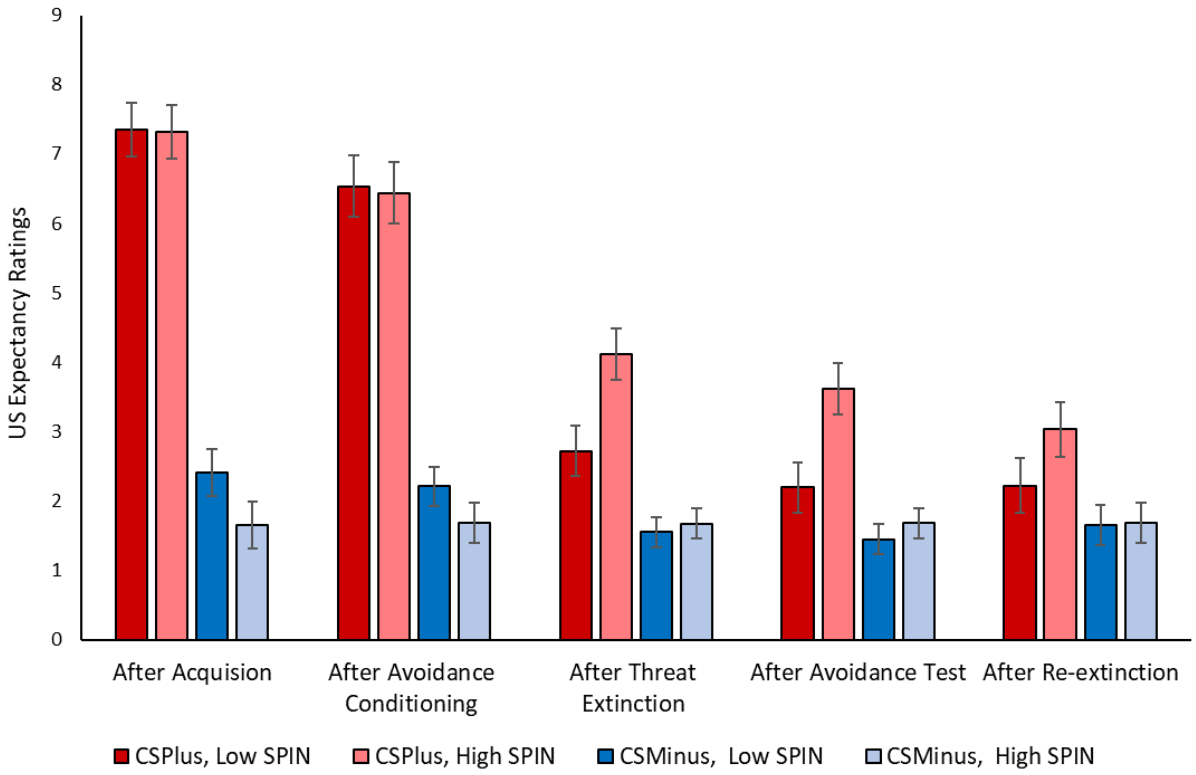


Figure 10. Bar graph depicting mean US expectancy ratings towards the CS+ and CS- throughout the paradigm for SPIN scores estimated at specific values of + or – 1 SD of the mean. Bars represent standard error. High SPIN scores, relative to low SPIN scores were associated with elevated US expectancy ratings towards the CS+ after extinction learning, after the avoidance test phase and after the re-extinction phase.

Table 7.
Summary of means (SD) for each dependent variable as a function of condition (CS+ and CS-), separately for threat acquisition, avoidance conditioning, early and late threat extinction, avoidance test and re-extinction phases.

Measure	Pre-Acquisition		Acquisition		Avoidance Conditioning		Early Threat Extinction		Late Threat Extinction		Avoidance Test		Re-Extinction	
	CS+	CS-	CS+	CS-	CS+	CS-	CS+	CS-	CS+	CS-	CS+	CS-	CS+	CS-
Square root transformed and z-scores SCR magnitude (√μs)			.394	.058			.123	-.024	-.167	-.218			.025	-.218
			(.541)	(.317)			(.393)	(.392)	(.331)	(.390)			(.634)	(.544)
Avoidance Responses					0.805	0.428					0.498	0.332		
					(.314)	(.443)					(.0450)	(.433)		
US Expectancy Rating (1-9)	2.8	2.76	7.34	2.04	6.49	1.95			3.41	1.61	2.90	1.56	2.63	1.68
	(1.64)	(1.69)	(1.27)	(1.82)	(2.12)	(1.65)			(2.07)	(1.28)	(2.10)	(1.32)	(2.16)	(1.61)

Note: SCR magnitude (√μS), square root transformed and z-scored skin conductance magnitude measured in microSiemens.

Table 8.
Summary of means (SE) for US expectancy ratings as a function of condition (CS+ and CS-) throughout the task (After Acquisition, After Avoidance Conditioning, After Extinction Learning, After Avoidance Test, After Re-extinction) for high (+ 1 SD) and low (- 1 SD) SPIN scores.

US Expectancy Rating (1-9)	After Acquisition		After Avoidance Conditioning		After Threat Extinction		After Avoidance Test		After Re-Extinction	
	CS+	CS-	CS+	CS-	CS+	CS-	CS+	CS-	CS+	CS-
Low SPIN	7.35	2.41	6.54	2.21	2.72	1.56	2.19	1.45	2.22	1.66
	(.38)	(.34)	(.44)	(.28)	(.36)	(.22)	(.36)	(.22)	(.39)	(.29)
High SPIN	7.32	1.66	6.44	1.68	4.11	1.67	3.62	1.68	3.03	1.69
	(.39)	(.34)	(.45)	(.28)	(.37)	(.22)	(.36)	(.22)	(.39)	(.29)

4. Discussion

The main aim of the current experiment was to examine the effect of individual differences in social anxiety on low-cost operant avoidance conditioning and extinction. A second aim was to replicate and extend prior findings (Morriss et al., 2018; Van Uijen et al., 2018; Vervliet & Indekeu, 2015), specifically whether the availability of avoidance alters the expression of learned threat during extinction learning and re-extinction, in the context of socially relevant stimuli and an extended threat extinction phase compared to that used in the majority of the previous literature. Hence, the main findings of this study are twofold. First, in line with our a-priori hypotheses, the results demonstrated that individual differences in social anxiety were associated with avoidance behaviour during both the avoidance conditioning and the avoidance test phase. Second, we replicated the results of previous work that has demonstrated that active avoidance alters or prevents the course of extinction learning (Morriss et al., 2018; Van Uijen et al., 2018; Vervliet & Indekeu, 2015).

During the avoidance conditioning and avoidance test phases, avoidance responses consisted of a button press during an "avoidance cue" that appeared on screen during both conditioned threat (CS+) and safety (CS-) cues. Throughout avoidance conditioning, if the participant did not press to avoid during CS+ trials, the US was always administered but never during CS- trials. During the avoidance test phase, the US was never administered during CS+ or CS- trials, regardless of avoidance behaviour. We found that individuals with elevated levels of social anxiety tended to unnecessarily avoid the conditioned safety cue (CS-) to a greater extent compared to individuals with lower self-reported social anxiety, during avoidance conditioning. This finding suggests an increased tendency in socially anxious individuals to generalise conditioned avoidance behaviour across to safety cues, during an initial avoidance conditioning phase. During the avoidance test phase, higher social anxiety relative to lower social anxiety was associated with increased avoidance responding during both conditioned threat (CS+) and safety (CS-) cues, indicating persistent avoidance behaviour following threat extinction. This finding was in line with hypotheses and implies that elevated social anxiety predicts the maintenance of maladaptive avoidance behaviour after extinction learning. Further, individuals with elevated social anxiety tended to demonstrate greater threat expectancy toward the CS+ versus the CS-, relative to individuals with lower levels of social anxiety, after extinction learning, after the avoidance test phase and the re-extinction phase. Nevertheless, contrary to hypotheses, social anxiety was not associated with SCR during the re-extinction phase. The results of the current study validate and extend the findings of Ly and Roelofs (2009) and

provide support for the hypothesis that avoidance behaviour is resistant to extinction in individuals with higher levels of social anxiety.

As mentioned, there was an effect of social anxiety on avoidance responses towards the CS- during the avoidance conditioning phase. However, it is important to consider that when IU and trait anxiety scores were included in the model with social anxiety scores, as main effects and interacting with manipulated variables, the effect of social anxiety on avoidance responses during the avoidance conditioning phase was no longer present. This result suggests that the above finding may not be specific to social anxiety over and above other individual differences measures such as IU and trait anxiety. In contrast, during the avoidance test phase, the effect of social anxiety on avoidance responses towards the CS+ and CS- was present both when entered alone in the model and when controlling for IU and trait anxiety scores. This finding suggests specificity for the effect of social anxiety on avoidance behaviour during the avoidance test phase and demonstrates that compromised extinction of avoidance behaviour is a characteristic of elevated levels of social anxiety.

During the extinction learning phase (where avoidance was unavailable and learned threat associations were not being reinforced by the US), we found continued differential skin conductance responses for threat versus safety cues across all participants. During the re-extinction phase, participants demonstrated continued threat-based arousal to learned threat, indexed by larger SCR to the CS+ compared to the CS-. Further, threat expectancy ratings for all participants remained significantly greater towards the CS+ compared to the CS- throughout the task. These findings provide further evidence that avoidance behaviour compromises extinction learning resulting in extinction resistance to learned threat cues. In their previous study, Vervliet and Indekeu (2015) report the fact that threat extinction was not complete at the end of extinction learning as a limitation of their study. In an attempt to prevent a similar effect, we increased the number of extinction learning trials from 24 (12 CS+, 12 CS-; Vervliet & Indekeu, 2015) to 32 (16 CS+, 16 CS-) as used in standard extinction protocols (Dunsmoor et al., 2015; Lucas et al., 2018; Morriss et al., 2015; Morriss et al., 2016). Although threat expectancy ratings and SCR towards the CS+ did significantly decrease from early to late extinction learning, differential responding between the CS+ and CS- remained significant. It is therefore possible that residual threat expectancy might be responsible for the use of avoidance behaviour during the avoidance test phase in our study. To adequately examine the mechanisms responsible for the return of avoidance behaviour in social anxiety after exposure

therapy, elimination of threat expectancy is required, as minimal levels of fear may be sufficient to trigger a return of avoidance behaviour.

In the current study there was no cost associated with the avoidance behaviour. When faced with potential threat or danger, choosing to avoid can be an adaptive behaviour. For example, in this experiment choosing to avoid the CS+ during avoidance conditioning trials would be an adaptive response to avoid the presentation of the US. However, the maintenance of an avoidance response when the threat is no longer present (i.e., CS+ trials during the avoidance test phase) can result in the individual not learning or overestimating the chance of threat. The cognitive-behavioural model of social anxiety posits that socially anxious individuals often believe that avoidance and safety behaviours are necessary to complete a social interaction without costly outcomes such as negative evaluation (Heimberg et al., 2014). However, low-cost clinical avoidance behaviours, such as avoiding eye contact or minimising participation in a conversation, can prevent disconfirming experiences and insulates the individual from learning about the outcome of their social behaviours (Dymond et al., 2019). Low-cost safety behaviours become costly as they prevent the individual from engaging in desired activities (Vervliet & Indekeu, 2015) and have been associated with negative perceptions by others (Heimberg et al., 2014; Hirsch et al., 2004). For the above reasons, this research provides support for the strategy of minimising safety behaviours during exposure therapy and may be particularly relevant for clinicians using current exposure-based treatments for patients with social anxiety disorder.

A potential limitation of the current experiment is that we recruited young, female, university students. Therefore, it should be highlighted that the findings can only be interpreted in relation to females and we cannot make conclusions about avoidance behaviour in males. Females were specifically recruited in this experiment due to social anxiety being more prevalent in females compared to males (Remes et al., 2016; Sosic et al., 2008), as well as the use of female identities as CS and a female voice used as the US. While previous work examining the effect of social anxiety on avoidance behaviour has recruited males and females (Ly & Roelofs, 2009), 18 out of 26 highly socially anxious participants in this study were female. Future work should therefore examine whether there are gender differences in the effect of social anxiety on avoidance behaviour.

A second potential limitation is that we employed a second socially irrelevant US (i.e., an electric shock) alongside the negative verbal statement. It is possible that the use of a double US was perceived as largely aversive and contributed to the absence of extinction learning throughout the task. In line with previous literature that has highlighted the strengths of using socially relevant

stimuli when investigating the role of social anxiety on conditioning processes (Lissek et al., 2008; Pejic et al., 2013), we presented negative verbal feedback as US. However, the electric shock was included due to previous work that indicated that habituation to negative statements during acquisition resulted in the conditioned response not lasting into the extinction phase (Lissek et al., 2008). Considering that the primary focus of the current work was on the effect of social anxiety on avoidance conditioning and extinction, we endeavoured to maximise the number of participants, regardless of their level of social anxiety, who developed a conditioned response towards the CS+ that lasted into the avoidance conditioning phase. Further, it was important that participants did not habituate to the US during avoidance conditioning and hence result in a lack of motivation to avoid the threat cue (CS+).

In conclusion, individual differences in social anxiety were associated with avoidance behaviour during avoidance conditioning and an avoidance test phase. Further, we have replicated the findings of previous literature and have demonstrated that avoidance behaviour prevents the course of extinction learning, despite an extended threat extinction phase compared to that used in previous studies (Van Uijen, Leer & Engelhard, 2018; Vervliet & Indekeu, 2015). These results support the notion that the avoidance conditioning and extinction procedure provides a potential laboratory-based model for clinical research aimed at preventing the relapse of social anxiety symptomology and improving the effectiveness of exposure therapy for the treatment of SAD. Future research should utilise this approach to investigate how and under what circumstances the extinction of safety behaviour can be improved for individuals with elevated levels of social anxiety.

Acknowledgements

The authors wish to thank participants for taking part in this experiment and Rebecca Borcsok for assistance with collecting the data. This research was funded by an Economic and Social Research Council (ESRC) Doctoral Studentship awarded to Shannon Wake (ES/J500148/1).

Author Contributions

SW, CvR and HD designed the study. SW collected the data, conducted the analysis, interpretation and wrote the manuscript draft. CvR and HD contributed to interpretation, critical manuscript revsion and approval of the final manuscript.

Data Transparency and Conflicts of Interest Statements

The dataset reported here is not part of any published or currently in press works. The authors have no competing interests to declare.

References

American Psychiatric Association (2013). Diagnostic and statistical manual of mental disorders (5th ed.). Arlington, VA: American Psychiatric Publishing.

Andreatta, M., Michelmann, S., Pauli, P., & Hewig, J. (2017). Learning processes un- derlying avoidance of negative outcomes. Psychophysiology, 54(4), 578–590.

Benjamini, Y., & Hochberg, Y. (1995). Controlling the false discovery rate: a practical and powerful approach to multiple testing. Journal of the Royal Statistical Society: Series B (Methodological), 57(1), 289–300.

Clark, D. M., & Wells, A. (1995). A cognitive model of social phobia. In R. G. Heimberg, M. R. Liebowitz, D. A. Hope, & F. R. Schneier (Eds.), Social Phobia: Diagnosis, Assessment, and Treatment (69-93). New York, NY: Guilford Press.

Connor, K., Davidson, J., Churchill, L., Sherwood, A., Weisler, R., & Foa, E. (2000). Psychometric properties of the Social Phobia Inventory (SPIN): New self-rating scale. *British Journal of Psychiatry, 176*(4), 379-386.

Dawson, M. E., Schell, A. M., Hazlett, E. A., Nuechterlein, K. H., & Filion, D. L. (2000). On the clinical and cognitive meaning of impaired sensorimotor gating in schizophrenia. *Psychiatry Research*, *96*(3), 187–197.

Delgado, M. R., Nearing, K. I., LeDoux, J. E., & Phelps, E. A. (2008). Neural Circuitry Underlying the Regulation of Conditioned Fear and Its Relation to Extinction. *Neuron*, *59*(5), 829–838.

Dunsmoor, J. E., Campese, V. D., Ceceli, A. O., LeDoux, J. E., & Phelps, E. A. (2015). Novelty-Facilitated Extinction: Providing a Novel Outcome in Place of an Expected Threat Diminshes Recovery of Defensive Responses. *Biological Psychiatry,* 78(3), 203–209.

Dymond, S. (2019). Overcoming avoidance in anxiety disorders: The contributions of Pavlovian and operant avoidance extinction methods. *Neuroscience and Biobehavioral Reviews*, *98*(January), 61–70.

Dymond, S., Roche, B., 2009. A contemporary behavior analysis of anxiety and avoid- ance. Behav. Anal. 32, 7–28.

Foa, E. B., Steketee, G., & Rothbaum, B. O. (1989). Behavioral/cognitive conceptualizations of post-traumatic stress disorder. *Behavior Therapy,* 20(2), 155–176.

Freeston, M. H., Rhéaume, J., Letarte, H., Dugas, M. J., & Ladouceur, R. (1994). Why do people worry? *Personality and Individual Differences, 17*(6), 791-802.

Grady, A. K., Bowen, K. H., Hyde, A. T., Totsch, S. K., & Knight, D. C. (2016). Effect of continuous and partial reinforcement on the acquisition and extinction of human conditioned fear. *Behavioral Neuroscience*, 130(36).

Heimberg, R. G., Brozovich, F. A., & Rapee, R. M. (2014). A Cognitive-Behavioural Model of Social Anxiety Disorder. In *Social Anxiety* (Third Edit).

Hirsch, C. R., & Clark, D. M. (2004). Information-processing bias in social phobia. *Clinical Psychology Review*, *24*(7), 799–825.

Hofmann, S.G., Smits, J.A., 2008. Cognitive-behavioral therapy for adult anxiety disorders: a meta-analysis of randomized placebo-controlled trials. Journal Clinical Psychiatry, 69(4).

Jorstad-Stein, E.C., & Heimberg, R.G. (2009). Social phobia: an update on treatment. Psychiatric Clinics of North America, 32(3), 641-663.

Krypotos, A. M., Vervliet, B., & Engelhard, I. M. (2018). The validity of human avoidance paradigms. *Behaviour Research and Therapy*, *111*(October), 99–105.

Leary, M. R. (1983). A brief version of the Fear of Negative Evaluation Scale. *Personality and Social Psychology Bulletin*, *9*(3), 371-375.

Lissek, S., Levenson, J., Biggs, A. L., Johnson, L. L., Ameli, R., Pine, D. S., & Grillon, C. (2008). Elevated fear conditioning to socially relevant unconditioned stimuli in social anxiety disorder. *American Journal of Psychiatry*, *165*(1), 124–132.

Lovibond, P. F., Mitchell, C. J., Minard, E., Brady, A., & Menzies, R. G. (2009). Safety behaviours preserve threat beliefs: Protection from extinction of human fear con- ditioning by an avoidance response. *Behaviour Research and Therapy,* 47(8), 716–720.

Ly, V., & Roelofs, K. (2009). Social anxiety and cognitive expectancy of aversive outcome in avoidance conditioning. *Behaviour Research and Therapy*, *47*(10), 840–847.

Lucas, K., Luck, C. C., & Lipp, O. V. (2018). Behaviour Research and Therapy Novelty-facilitated extinction and the reinstatement of conditional human fear. *Behaviour Research and Therapy*, *109*, 68–74.

Ma, D.S., Correll, J. & Wittenbrink, B. Behav Res (2015) 47: 1122. The Chicago face database: A free stimulus set of faces and norming data.

Milad, M. R., Pitman, R. K., Ellis, C. B., Gold, A. L., Shin, L. M., Lasko, N. B., ... & Rauch, S. L. (2009). Neurobiological basis of failure to recall extinction memory in posttraumatic stress disorder. *Biological psychiatry*, *66*(12), 1075-1082.

Milad, M. R., and Quirk, G. J. (2012). Fear extinction as a model for translational neuroscience: ten years of progress. Annu. Rev. Psychol. 63, 129–151.

Morriss, J., Chapman, C., Tomlinson, S., van Reekum, C.M., 2018. Escape the bear and fall to the lion: the impact of avoidance availability on threat acquisition and extinction. Biol. Psychol. 138, 73–80.

Morriss, J., Christakou, A., & van Reekum, C. M. (2015). Intolerance of uncertainty predicts fear extinction in amygdala-ventromedial prefrontal cortical circuitry. *Biology of Mood and Anxiety Disorders*, *5*(1).

Morriss, J., Christakou, A., & van Reekum, C. M. (2016). Nothing is safe: Intolerance of uncertainty is associated with compromised fear extinction learning. *Biological Psychology*, *121*, 187–193.

Morriss, J., & van Reekum, C. M. (2019). Multimodal evidence for delayed fear extinction in adolescence and young adulthood. *Scientific Reports*, *9*(7748).

Morriss, J., Hoare, S., & Reekum, C. M. van Reekum. (2018). It's time: A commentary on fear extinction in the human brain using fMRI. *Neuroscience and Biobehavioral Reviews*, *94*(May), 321–322.

Morriss, J., Wake, S., Lindner, M., McSorley, E., & Dodd, H. (2020). How many times do I need to see to believe? The impact of intolerance of uncertainty and exposure experience on safety-learning and retention in young adults. *International Journal of Psychophysiology*.

Ponniah, K., & Hollon, S.D., (2008). Empirically supported psychological interventions for social phobia in adults: a qualitative review of randomized controlled trials. Psychological Medicine, 38, 3-14.

Rapee, R. M., & Heimberg, R. G. (1997). A cognitive-behavioral model of anxiety in social phobia. *Behaviour Research and Therapy*, *35*(8), 741–756.

Remes, O., Brayne, C., van, d. L. R., & Lafortune, L. (2016). A systematic review of reviews on the prevalence of anxiety disorders in adult populations. *Brain and Behavior*.

Rudaz, M., Ledermann, T., Margraf, J., Becker, E. S., & Craske, M. G. (2017). The moderating role of avoidance behavior on anxiety over time: Is there a difference between social anxiety disorder and specific phobia? *PLoS ONE*, *12*(7), 1–14.

Sosic, Z., Gieler, U., & Stangier, U. (2008). Screening for social phobia in medical in-and outpatients with the German version of the Social Phobia Inventory (SPIN). *Journal of Anxiety Disorders*, *22*(5), 849-859.

Spielberger, C. D., Gorsuch, R. L., Lushene, R., Vagg, P. R., & Jacobs, G. A. (1983). *Manual for the State-Trait Anxiety Inventory*. Palo Alto, CA: Consulting Psychologists Press.

van Uijen, S.L., Leer, A., Engelhard, I.M., 2018. Safety behavior after extinction triggers a return of threat expectancy. *Behav. Ther.* (N. Y.) 49, 450–458.

Vervliet, B., Craske, M. G., and Hermans, D. (2013). Fear extinction and relapse: state of the art. *Annu. Rev. Clin. Psychol*. 9, 215–248.

Vervliet, B., & Indekeu, E. (2015). Low-cost avoidance behaviors are resistant to fear extinction in humans. Frontiers in Behavioral Neuroscience, 9.

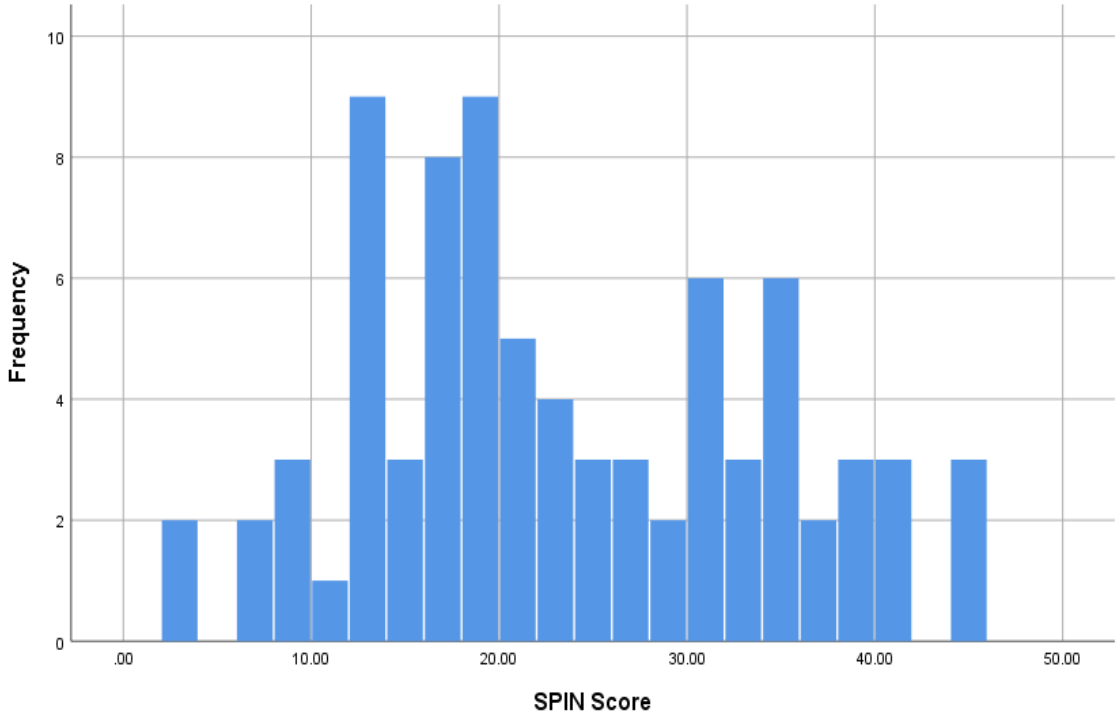
Vervliet, B., Raes, F., 2013. Criteria of validity in experimental psychopathology: appli- cation to models of anxiety and depression. Psychol. Med. (Paris) 43, 2241–2244.

Wittchen, H.U., Fehm, L. (2003). Epidemiology and natural course of social fears and social phobia. Acta Psychiatrica Scandinavica Supplementum, 417,4–18.

Xia, W., Dymond, S., Lloyd, K., & Vervliet, B. (2017). Partial reinforcement of avoidance and resistance to extinction in humans. *Behaviour Research and Therapy*, *96*, 79–89.

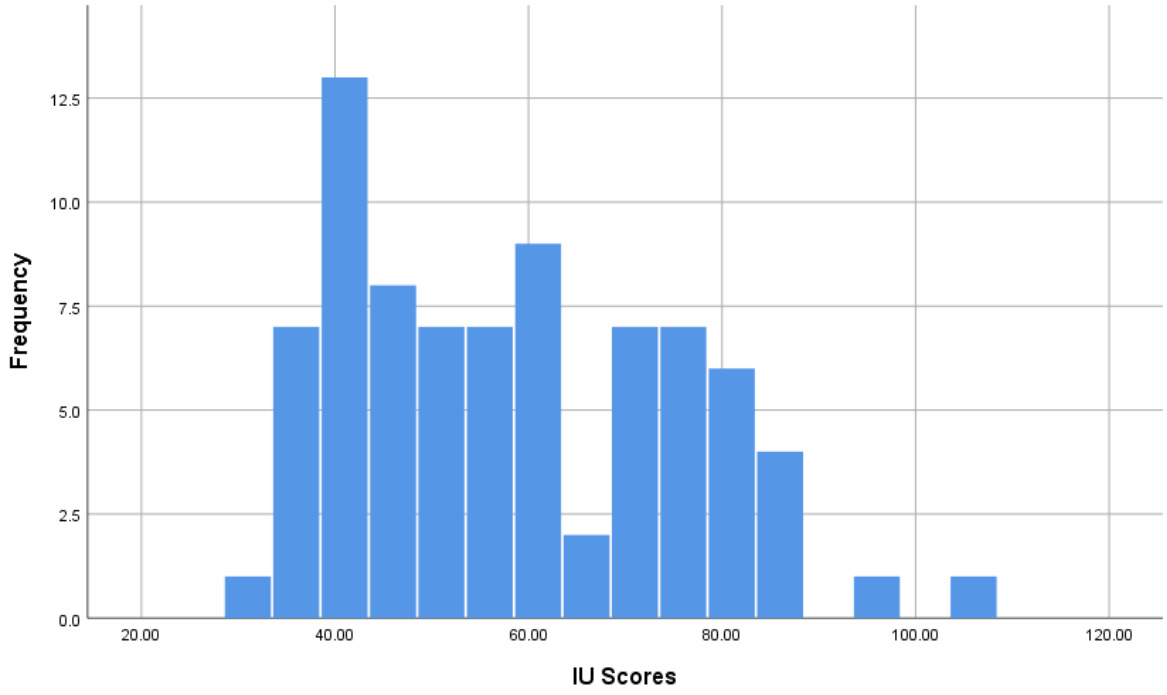
Supplementary Materials

Distributions of Individual Differences Scores

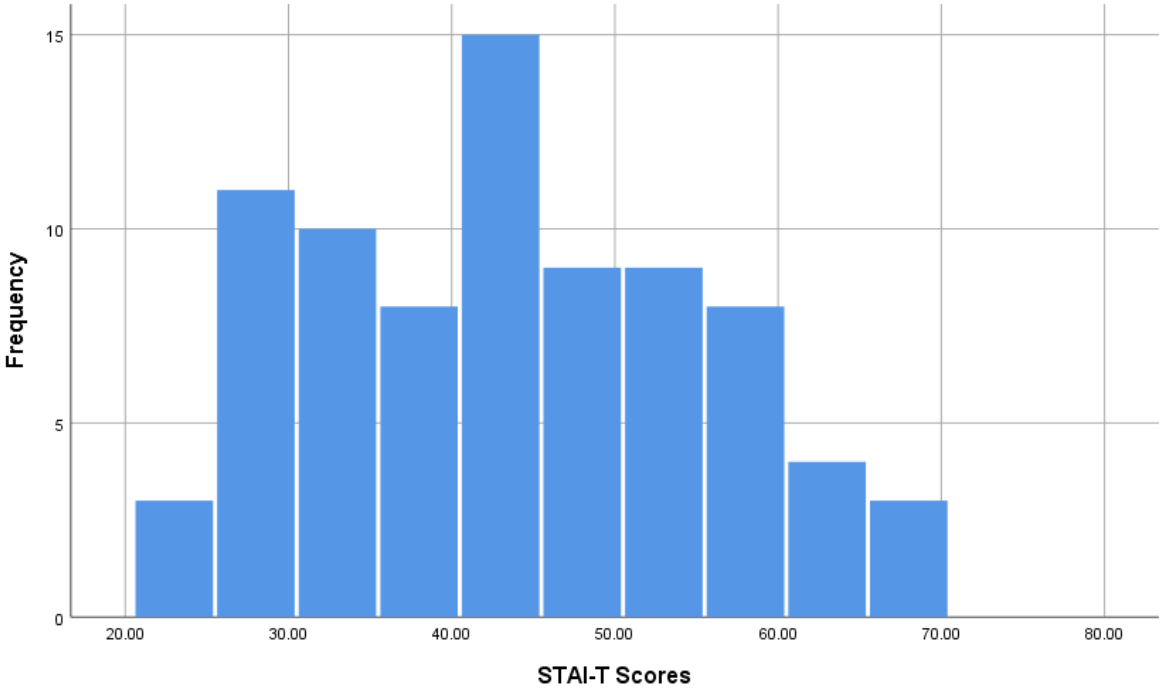


Supplementary Figure 1. Histogram of SPIN scores.

Previous research indicates that a cut-off score of 19 should be used to distinguish between individuals with pathological levels of social anxiety and those without. A SPIN score > 40 is considered severe social anxiety.



Supplementary Fig 2. Histogram of IU scores.



Supplementary Fig 3. Histogram of trait anxiety (STAI-T).

CHAPTER 5.

General Discussion of Thesis

5. General Discussion

The primary aim of this thesis was to examine the relationship between individual differences in social anxiety and learning processes within Pavlovian threat extinction paradigms. Compared to the wider literature that has examined safety learning within anxiety and stress disorders (Duits et al., 2015), little research has specifically examined the association between social anxiety and threat extinction. Across the relatively limited literature in this field, there are inconsistencies in the findings and where effects of social anxiety are reported, it is not clear whether such effects are specific to social anxiety and not the outcome of broader transdiagnostic processes that underlie anxiety more generally (i.e., trait anxiety and intolerance of uncertainty (IU)). Further, there are notable gaps in the literature surrounding the relationship between social anxiety and the extinction of avoidance behaviour. An increased understanding of how learning mechanisms might be compromised in social anxiety can facilitate clinical research aimed at improving the outcome of exposure-based treatments for social anxiety disorder.

This thesis had three specific objectives: 1) to examine individual differences in social anxiety and safety learning processes, 2) to bring clarity to the current literature regarding the relationship between social anxiety and threat conditioning and extinction, and 3) to investigate the relationship between individual difference in social anxiety and low-cost operant avoidance conditioning and extinction.

The following discussion first provides a general overview of the findings from each paper, followed by a review of how these results relate to the aims and objectives of the thesis. This is followed by a consideration of how the results of the thesis as a whole sit within findings across previous literature. Next, the strengths and limitations of the body of work are considered. The final sections then discuss the implications of the results and provide suggestions for future work.

5.1 Review of the Studies

5.1.1 Paper 1

While there is consensus that compromised extinction learning is related to elevated levels of anxiety (Duits et al., 2015; Lonsdorf & Merz, 2017), there are inconsistencies in the literature regarding the relationship between threat extinction and social anxiety specifically. Paper 1 therefore aimed to address three primary research questions: 1) Are individual differences in social anxiety related to compromised threat extinction and retention?, 2) Are previous findings of a relationship between transdiagnostic measures of anxiety (i.e., trait anxiety and IU) and extinction

learning and retention replicated?, 3) Are any effects of social anxiety on extinction learning and retention robust after controlling for transdiagnostic features of anxiety (i.e., trait anxiety and IU)? We investigated these questions within two separate socially relevant conditioning experiments using neutral facial expressions as CS and utterances reflecting negative social evaluation alongside an electric shock as US. The first experiment employed a cognitive component during extinction, while the second experiment used a standard extinction paradigm. Skin conductance response and subjective ratings of anxiety and US expectancy were collected across both experiments.

Contrary to hypotheses, the findings of both experiments in Paper 1 did not demonstrate that social anxiety is associated with delayed or impaired safety learning during threat extinction or retention. Instead, the results across both experiments found that IU-related mechanisms disrupt threat extinction processes, across both psychophysiological and self-report measures, even when using a socially relevant conditioning task. The results of the study therefore replicate and extend previous findings regarding the effect of IU on extinction processes, but do not provide support for the hypothesis that compromised safety learning and retention is associated with increased levels of social anxiety. As a result, Paper 1 concludes that safety learning processes might be altered by constructs related to broader negative affect (i.e., IU) that underpin anxiety, rather than by features specific to individual anxiety subtypes.

5.1.2 Paper 2

While there are inconsistencies in the findings across previous literature that has examined the relationship between social anxiety and threat extinction, it is not clear whether such inconsistencies are the result of the considerable variation in the task design, methodology and dependent variables assessed across prior work. In paper 2, a systematic review of research that has investigated the association between social anxiety and threat conditioning and extinction was therefore conducted. This review examined the sensitivity of various study designs and characteristics to detect social anxiety-related differences in threat conditioning and extinction. The review adopted a dimensional approach and included studies that had recruited individuals with social anxiety disorder as well as individuals with high social anxiety symptoms, as measured by self-report.

The systematic review concluded that there is not convincing evidence that elevated social anxiety is related to compromised threat conditioning or extinction. There was significant heterogeneity across experiments in their design, however, there was no indication that particular

design features or dependent variables were associated with more reliable effects of social anxiety. Thus, this study concluded that deficits in safety learning are unlikely to be a core issue in social anxiety, bringing clarity to the literature. Instead, this work suggests that other maintenance factors of social anxiety, such as avoidance or safety behaviours, may be responsible for the return of fear related symptoms after exposure therapy.

5.1.3 Paper 3

Research aimed at improving the efficacy of exposure therapy and preventing the relapse of social anxiety related symptoms has largely focused on learning mechanisms, such as threat extinction. However, excessive avoidance behaviour, in which an overt action delays or prevents an approaching event, is a defining characteristic of social anxiety. Avoidance prevents accurate processing of exposure as the non-occurrence of the feared outcome is attributed to the avoidance behaviour carried out. Paper 3 therefore aimed to address the lack of research in this field and examined the effect of individual differences in social anxiety on low-cost operate avoidance conditioning and extinction. A second aim of this paper was to replicate and extend the findings from previous literature that has examined whether the availability of avoidance alters extinction learning.

In line with hypotheses, the results of Paper 3 indicated that higher levels of social anxiety predicted greater generalisation of avoidance responses across to safety cues during avoidance conditioning. Further, when the opportunity to avoid was returned after a threat extinction phase, higher social anxiety was associated with elevated avoidance responses to both threat and safety cues. The findings of this study also replicated those of previous work and demonstrated that active avoidance alters or prevents the course of extinction learning (Morriss et al., 2018; van Uijen et al., 2018; Vervliet & Indekeu, 2015). Paper 3 therefore concludes that compromised extinction of avoidance behaviour may be characteristic of social anxiety.

5.1.4 Discussion of the Results in Relation to the Primary Aim of the Thesis

Social anxiety disorder is one of the most prevalent psychiatric disorders (Magee et al., 1996; Ruscio et al., 2008) and many patients remain symptomatic after receiving treatment that includes exposure therapy (Craske & Mystkowski, 2006; Otto et al., 2000). The primary aim of this thesis was to examine whether social anxiety is associated with compromised threat extinction processes. The purpose of investigating this aim was to shed light on the erroneous learning processes that might play a role in the maintenance or return of social anxiety related symptoms after exposure therapy.

Furthering our understanding of the learning processes involved in the maintenance of threat associations in social anxiety has implications for improving the efficacy of exposure therapy for the treatment of social anxiety disorder.

Inconsistent with original hypotheses, Paper 1 did not provide evidence that social anxiety is associated with impaired extinction of the conditioned response across two separate socially relevant conditioning experiments. Similarly, a follow-up systematic review of the literature, carried out in Paper 2, also did not provide support for the relationship between social anxiety and compromised safety learning in the context of threat conditioning and extinction paradigms. Hence, the findings from Paper 1 and Paper 2 suggest that deficits in safety learning, (i.e., learning that something that was once threatening is now safe) are unlikely to be specifically related to social anxiety. Instead, the results from Paper 1 demonstrate that compromised safety learning may be associated with broader and transdiagnostic features of anxiety (i.e., intolerance of uncertainty), rather than by features specific to individual anxiety subtypes. Thus, the results of Paper 1 and Paper 2 suggest that compromised safety learning is unlikely to be a central mechanism responsible for the maintenance of threat associations in social anxiety.

While the threat conditioning and extinction paradigms included in Paper 1 and Paper 2 model procedural elements of exposure therapy (i.e., safety learning), these tasks did not incorporate or examine how primary or defining features of social anxiety impact safety learning and retention. The cognitive-behavioural models of social anxiety (Clark & Wells, 1995; Rapee & Heimberg, 1997; Heimberg, Brozovich & Rapee, 2010; Wong & Rapee, 2016) emphasise the role of avoidance and "safety behaviours" in the maintenance of social anxiety related symptoms, as such behaviours prevent the individual from experiencing situations that contradict their internal negative beliefs about feared consequences. Evidence from Paper 3 supports this claim as compared to individuals with low levels of social anxiety, individuals with elevated social anxiety demonstrated persistent avoidance behaviour to both threat (CS+) and safety (CS-) cues after extinction learning, as well as increased US expectancy ratings towards the CS+.

When considering the findings obtained throughout this thesis in relation to the primary aim, it could be argued that distinct sub-processes of extinction learning might have unique associations with specific anxiety subtypes and anxiety-related traits. For example, Paper 1 demonstrated that IU, and not social anxiety or trait anxiety related mechanisms, were associated with disrupted safety learning and retention. Whereas Paper 3 demonstrated that individual differences in social anxiety, and not IU or trait anxiety, were associated with elevated and persistent avoidance behaviour, even after safety learning had occurred. Hence, in the case of social

anxiety, compromised extinction of operant avoidance behaviour, and not safety learning processes, may be associated with the maintenance or return of fear related symptoms.

5.2 Comparison to the Literature

5.2.1 Comparison to the Social Anxiety and Threat Extinction Literature

Overall, the findings of Paper 1 and Paper 2 demonstrate that social anxiety does not reliably predict deficits in safety learning and brings clarity to the literature in several ways. First, Paper 1 provides an explanation for the discrepancies in findings across the field regarding the relationship between social anxiety and safety learning. In line with several studies (Lissek et al., 2008; Reichenberger et al., 2017; Tinoco-Gonzalez et al., 2015), Paper 1 failed to demonstrate that social anxiety is associated with deficits in threat extinction and retention across both psychophysiological and subjective measures. Instead, within two separate experiments, Paper 1 found that IU related mechanisms disrupt threat extinction processes. Paper 1 aimed to tease apart transdiagnostic and social anxiety specific vulnerabilities in safety learning and retention processes by capturing several trait anxiety measures (i.e., social anxiety, trait anxiety and IU), and testing for the specificity of social anxiety related effects. Naturally, such trait variables are strongly correlated, however, each includes a unique component (Lonsdorf & Merz, 2017). As we did not find an effect of social anxiety on SCR magnitude or subjective ratings towards conditioned stimuli, follow up analyses that controlled for IU and trait anxiety were not conducted. Nevertheless, the presence of IU effects in Paper 1 highlights the need to pinpoint the facet of negative affect at the core of any association between trait variables and threat extinction processes. For instance, across the social anxiety and threat extinction literature, reported results are restricted to the measurement of social anxiety only, either through self-report or within clinically diagnosed samples. Therefore, in studies that report an association between social anxiety and extinction learning (i.e., Hermann et al., 2002; Olsson et al., 2013; Rabinak et al., 2016), it could be that other broader, but correlated traits of anxiety known to be related to threat extinction (i.e., IU) may have been driving the effects of social anxiety reported.

Further, in response to the findings of Paper 1, the aim of Paper 2 was to systematically review the previous literature on conditioning and extinction processes in relation to social anxiety to uncover further possible explanations for the inconsistencies in findings across the literature. For example, an initial scoping review of the literature indicated that there was considerable variation in task design, methodology and outcome measures assessed across experiments. However, the systematic review did not indicate that the use of a particular psychophysiological measure,

subjective rating, or experimental parameter yielded particularly consistent associations between social anxiety and conditioning processes. Thus, the systematic review did not provide compelling evidence that high levels of social anxiety are associated with atypical threat conditioning or extinction within 14 published articles.

The findings of Paper 1 and Paper 2 do not provide support for the hypothesis that social anxiety is associated with compromised extinction learning and retention. This might suggest that other maladaptive processes related to social anxiety account for the maintenance or return of social fear after exposure therapy. Models of social anxiety propose key cognitive and behavioural components that present lasting vulnerability for the relapse of social anxiety (Clark & Wells, 1995; Rapee & Heimberg, 1997; Heimberg, Brozovich & Rapee, 2010; Wong & Rapee, 2016). For example, it is proposed that the use of safety-behaviours prevent individuals with social anxiety from processing exposure effectively as the non-occurrence of feared outcomes is attributed to the safety-behaviour engaged. Despite this, to our knowledge, only one published study has examined the role of social anxiety on avoidance learning within a differential avoidance conditioning task (Ly & Roelofs, 2009). This study demonstrated that higher levels of social anxiety was associated with greater US expectancy during avoidance conditioning. However, until the work of Paper 3 in this thesis, the effect of social anxiety on the extinction of avoidance behaviour had not yet been investigated across the literature. Paper 3 found that increased social anxiety was associated with the generalisation of conditioned avoidance behaviour across to safety cues (CS-) during avoidance conditioning. During a later extinction of avoidance phase, when the opportunity to avoid was returned after threat extinction, elevated social anxiety predicted persistent avoidance behaviour to both threat (CS+) and safety cues (CS-). Thus, the results of Paper 3 validate and extend the findings of Ly and Roelofs (2009) and provide support for the hypothesis that avoidance behaviour is resistant to extinction in individuals with increased social anxiety.

In summary, the results of this thesis indicate that learning principles related to the acquisition and persistence of maladaptive avoidance, and not threat extinction or retention, are more likely to be implicated in the maintenance of social anxiety. However, research examining the relationship between social anxiety and the learning processes responsible for maladaptive avoidance is in its infancy. Further work is required to better our understanding of how and under what conditions avoidance behaviour is sustained and associated with the persistent and intense fear of social evaluation, characteristic of social anxiety.

5.3.2 Replication of Results Across the Wider Literature

Beyond social anxiety, the work of this thesis also contributes more broadly to the threat extinction and avoidance literature. As outlined within the General Introduction, recent work has begun to investigate how IU affects extinction processes and has demonstrated that elevated IU predicts reduced safety learning, demonstrated by increased skin conductance responding (SCR) to cues that no longer signal threat throughout extinction learning and retention (Dunsmoor et al. 2015; Lucas et al. 2018; Morriss et al. 2015, 2016; Morriss, 2019; Morriss and van Reekum 2019). Paper 1 of this thesis showed that individual differences in IU were associated with compromised extinction processes within two separate socially relevant conditioning paradigms. Experiment 1 (Paper 1) included a cognitive component within the extinction learning and retention phases and found that elevated IU was associated with the generalisation of threat across safe and dangerous context cues in trials that were safe but included the presence of the CS+. Further, in experiment 2 (Paper 1) higher IU predicted continued threat-based arousal to learned threat, indexed by larger SCR to the CS+ compared to the CS-, at the end of the extinction learning phase on day 1 and across the extinction retention phase on day 2. Thus, the results of Paper 1 support the compromising role of IU on extinction processes reported across the literature and builds upon this work in the context of socially relevant stimuli (i.e., neutral facial expressions as CS and negative evaluative statements as US).

In relation to the avoidance conditioning literature, previous work has found that active avoidance alters or prevents the course of extinction learning and persists after extinction learning has occurred (Andreatta et al., 2017; Lovibond et al., 2009; Morriss et al., 2018; Vervliet & Indekeu, 2015). Further, it has been reported that avoidance behaviour after threat extinction predicts a return of threat expectancy (van Uijen et al., 2018). Paper 3 aimed to replicate and extend these findings with the use of socially relevant stimuli and an extended extinction learning phase compared that used across the majority of the prior avoidance literature. Based on the evidence presented in Paper 3, it appears that avoidance behaviour compromises extinction learning and results in continued threat expectancy towards cues that no longer signal threat. Thus, we can infer that avoidance behaviour not only results in extinction resistance to learned threat cues, but the persistence of avoidance behaviour may also be sufficient to maintain or renew fear following treatment.

5.3 Alternative Explanations for the Findings

There may be alternative explanations for why we did not uncover a relationship between social anxiety and threat extinction and retention and these will now be considered.

5.3.2 Research Context

Previous literature has argued that the experimental context might impact the expression of any individual difference variable within outcome measures during threat conditioning and extinction studies (Lissek at al., 2006; Lonsdorf et al., 2017). Therefore, a possible explanation behind the null results regarding the relationship between social anxiety and safety learning is the context in which the research was conducted. Although the experimental work throughout this thesis used socially relevant stimuli as CS and US, it is possible that images of neutral facial expressions and generic critical statements are not capable of eliciting the fears or dysfunctional cognitions related to social anxiety (i.e., fear of negative evaluation or the allocation of attention towards potential social threat). As a result, the social stimuli employed throughout this thesis may not have been sufficiently ecologically valid to uncover differences in safety learning associated with social anxiety. Further, participants were aware that they were taking part in a psychology experiment and therefore likely realised that the negative statements administered as US were not specifically directed at them. Indeed, findings from both experiments reported in Paper 1 demonstrated that individual differences in social anxiety were not correlated with ratings of anxiety elicited by the negative statements, indicating that individuals with elevated levels of social anxiety did not rate the negative vocal statements as more anxiety provoking compared to individuals with lower levels of social anxiety. While threat extinction paradigms serve as a model for exposure therapy, perhaps the bridge between the laboratory and the clinic is not as stable for social anxiety as it is for other transdiagnostic features or subtypes of anxiety. For example, within threat extinction paradigms we can tap into processes related to IU as extinction tasks are uncertain by nature. The omission of the US response could provoke a sense of future threat uncertainty in some individuals (Dunsmoor et al., 2015). Further, we might be able to examine specific phobia by presenting stimuli specifically related to that phobia. For instance, images of a spider are likely to elicit a fear response that may be more resistant to extinction in individuals with arachnophobia. However, this may not be as simple when the fear is related to the self, others, or a context that we cannot make authentic within threat extinction tasks carried out in a simple laboratory situation (i.e., fear of negative evaluation or social failure).

Further, models of social anxiety highlight key cognitive and behavioural components that account for the maintenance of social anxiety disorder (Clark & Wells, 1995; Rapee & Heimberg, 1997; Heimberg, Brozovich & Rapee, 2010; Wong & Rapee, 2016). Typically, threat extinction paradigms include a threat acquisition phase, during which a previously neutral stimulus is presented with an aversive stimulus which, in turn, generates a conditioned response to the neutral stimulus alone (CS+), and a threat extinction phase, during which the CS+ is repeatedly presented in the absence of the US resulting in a decline of the conditioned response. The reduction of the conditioned response over time during the extinction phase is thought to reflect changes in contingency beliefs and threat expectancy (for review see Hofmann, 2008). Thus, in the simplest format, threat extinction tasks may not target the higher-order cognitive biases associated with social anxiety as proposed by the cognitive-behavioural models of social anxiety. Despite this, however, the findings of Paper 3 suggest that threat extinction tasks can be modified to target the avoidance and safety behaviours associated with social anxiety. It may be that when provided with the opportunity to avoid, individuals with social anxiety choose to engage in this behaviour even when the level of social evaluative threat is perceived to be low. This suggestion is in keeping with the cognitive-behavioural models of social anxiety outlined in the General Introduction of this thesis that emphasise the central role of avoidance in the maintenance of social anxiety.

5.3.1 Outcome Measures

Throughout the wider human threat extinction literature, conditioned responses are most commonly measured as skin conductance responses (SCRs), fear potentiated startle responses (FPS), ratings of fear or anxiety, US expectancy ratings, or patterns of neural activation. The experimental work included in this thesis (i.e., Paper 1 and Paper 3) assessed conditioned responses using SCR and subjective ratings of anxiety and US expectancy as outcome measures. However, there is suggestion across the field that different outcome measures might capture distinct dimensions of threat acquisition and extinction. For example, SCRs and FPSs are both psychophysiological indices, however, SCR is a measure of arousal in response to a stimulus, while FPS is considered to be a specific defensive index of fear (Lonsdorf et al., 2017). Hence, it may be that different dependent variables vary in their propensity to capture subtle inter individual differences in threat extinction processes associated with specific subtypes of anxiety (Lonsdorf & Merz, 2017). As mentioned above, it is unlikely that threat extinction paradigms elicit levels of social threat, and thus arousal, comparable to that experienced in the real world. As a result, perhaps measures of physiological arousal, such as SCR, are less likely, compared to other measures, to capture subtle variations in

conditioned responding associated with social anxiety across the extinction paradigms employed throughout this thesis.

Despite this, the findings from Paper 2 indicate that no particular outcome variable was associated with more robust or consistent effects of social anxiety on threat extinction across the literature. Further, when examining the effect of social anxiety on safety learning in Paper 1, we also did not find effects of social anxiety on subjective ratings of anxiety elicited by the conditioned stimuli or US expectancy ratings. However, when the opportunity to avoid was introduced into the paradigm in Paper 3, elevated social anxiety was associated with increased US expectancy towards the CS+ versus the CS- after extinction learning, an avoidance test phase and a re-extinction phase, compared to individuals with lower levels of social anxiety. Nevertheless, an effect of social anxiety on SCR during the threat extinction or re-extinction phase remained absent in Paper 3.

5.3.3 Limitations Concerning the Sample

The experimental work of this thesis (i.e., Paper 1 and Paper 3) recruited female university students primarily from a Psychology department. As a result, the findings presented in Paper 1 and Paper 3 can only be interpreted in relation to young females and we cannot make assumptions about safety-learning or avoidance behaviours in older samples, or males. Females were specifically targeted for recruitment in this work on account of social anxiety being more prevalent in females compared to males (Remes et al., 2016; Sosic et al., 2008). Further, female identities and voices were used as CS and US within all three experimental tasks employed throughout this thesis. Due to the social relevance of the tasks, it was thought that there might be different connotations attached to critical statements delivered by a female voice across males and females. The majority of previous work that has examined the relationship between social anxiety and threat conditioning and extinction has recruited samples of both males and females. Nevertheless, a systematic review of the findings of these studies (i.e., Paper 2) did not produce convincing evidence that compromised threat acquisition or extinction is associated with social anxiety. For this reason, it appears unlikely that the null results reported in Paper 1 are due to the female sample recruited. To our knowledge, only one other study has examined the effect of social anxiety on avoidance behaviour within an avoidance conditioning study, and this study recruited both males and females (Ly & Roelofs, 2009). However, 18 out of 26 highly socially anxious participants in this study were female meaning that the findings were more heavily influenced by female participants even in this mixed sex study. The literature in this area is extremely sparse and to increase the generalisability of results, future work should recruit both males and females.

5.4 Strengths of the Research

5.4.1 Consideration of Broader Measures of Anxiety

There is evidence across the threat extinction literature for an association between various individual differences traits or cognitive biases related to anxiety and threat extinction processes (for review see Lonsdorf & Merz, 2017). However, few studies across the wider anxiety literature (Chin et al., 2016; Dunsmoor et al., 2015; Morriss et al., 2015; 2016; Morriss et al., 2020; Wake et al., 2020) have examined the specificity of their results to individual trait variables over and above other connected and correlated facets of negative affect. However, until the work of this thesis, the specificity of an effect of social anxiety on threat extinction processes had not been considered. It is accepted across the field that social anxiety is correlated with transdiagnostic traits, such as trait anxiety and IU (Boelen & Reijntjes, 2009; Carleton, Collimore & Asmundson, 2007; McEvoy et al., 2019; Mogg & Bradley, 2002; Whiting et al., 2014), and these same trait variables have been linked to deficits in threat extinction processes. Therefore, an initial hypothesis for the discrepancy in findings across the social anxiety and threat extinction literature was that variance in dispositional traits, such as IU and trait anxiety, had not been accounted for in previous work. As a result, in the studies that found an association between social anxiety and compromised threat extinction, it may have been these trait variables driving the effect of social anxiety. Therefore, one of the main strengths of Paper 1 and Paper 3 is the multidimensional approach employed to identify unique characteristics associated with specific features of anxiety (i.e., social anxiety, IU and trait anxiety) in relation to threat extinction processes. As mentioned, Paper 1 indicated that IU, and not social anxiety or trait anxiety, was associated with disrupted safety learning and retention. Whereas Paper 3 showed that individual differences in social anxiety, and not IU or trait anxiety, were associated with elevated and persistent avoidance behaviour to both threat and safety cues, even after safety learning has occurred. Future work in this field should continue to assess the specificity of various trait markers of anxiety and negative affect on extinction learning processes. This approach will enable us to tease apart the transdiagnostic and disorder specific features of anxiety to better inform target driven treatment strategies based on specific characteristics of the individual.

5.4.2 Dimensional Approach

As mentioned in the General Introduction of this thesis, there is an increasing tendency to adopt a dimensional approach to the conceptualisation of social anxiety that incorporates individuals experiencing subclinical levels of social anxiety but who may also experience notable

impairments across various aspects of their lives (Fehm et al., 2008; Kanppe et al., 2009). This broad definition of social anxiety is in line with the National Institute of Mental Health Research Domain Criteria (RDoc; National Institute of Mental Health, 2011). As a result, the dimensional assessment of individual difference variables is a strength of the experimental work carried out in this thesis. Historically, however, threat conditioning and extinction research often employs a between-subject design that compares clinical samples with non-clinical control subjects when examining learning processes related to anxiety. Further, where individual differences variables have been administered, participants are often recruited from the extreme ends of the variable or a median split is employed to transform a continuous variable into a categorical variable (Lonsdorf & Merz, 2017). This is true for the vast majority of the studies (all but 1; Michalska et al., 2018) included in the systematic review of Paper 2. Such methods reduce the full spectrum of variance and result in decreased power (Altman & Royston, 2006). While we cannot rule out that we may have obtained different effects related to social anxiety had we compared clinically diagnosed groups with control groups throughout this work, we recruited appropriately large sample sizes to support the dimensional approach. Further, we are confident that we captured the full range of scores and that there was sufficient variance across the full social anxiety dimension.

5.4.3 Novelty in the Methods Employed

Many patients with SAD remain symptomatic or experience a return of fear after initial intervention with exposure therapy (Otto et al., 2000). Despite this, research examining the processes responsible for the return of fear in social anxiety is extremely sparse. For instance, to our knowledge, just two studies have investigated the relationship between social anxiety and retention of the extinction memory (Pejic et al., 2013; Rabinak et al., 2017), and both studies recruited small sample sizes ($n < 42$ in both studies). Further, only one study has examined the relationship between social anxiety and avoidance behaviour within a differential avoidance conditioning task (Ly & Roelofs, 2009). However, before the work of this thesis, the effect of social anxiety on the extinction of avoidance behaviour had not previously been examined. Therefore, a strength of this thesis is the novelty of particular task features employed within relatively large sample sizes. Paper 1 is comprised of two separate experimental studies, both of which include an extinction retention phase that occurred 24 hours after extinction learning. Further, Paper 3 included an "avoidance test" phase during which the opportunity to avoid the conditioned stimuli was returned to participants after an extinction learning phase. Although the extinction of avoidance behaviour had been examined previously in similar paradigms (Vervliet & Indekeu, 2015), to our knowledge, Paper 3 is

the first study that has examined whether social anxiety is associated with increased avoidance behaviour after safety learning.

When interpreting the results of Paper 1 and Paper 3 in relation to one another, it could be suggested that the return of social anxiety related symptoms after exposure therapy may be the consequence of persistent avoidance behaviour after exposure, rather than compromised safety learning processes during exposure.

5.5 Implications of the Research and Future Directions

Overall, the findings of the research conducted throughout this thesis suggest that deficits in safety learning processes are unlikely to be a core feature implicated in the maintenance of fear specific to social anxiety. Instead, this work demonstrated that elevated social anxiety is not associated with difficulties in updating the value of learned threat cues to safety cues. Based on this notion, exposure therapy should be a highly effective treatment for social anxiety. However, many patients with social anxiety remain symptomatic after initial intervention with exposure therapy (Gordon et al., 2014; Otto et al., 2000), and the results of this thesis may provide several explanations for why this might be. First, IU is recognised as an important transdiagnostic component of anxiety and stress disorders (Carleton, 2016a; 2016b; Dugas et al., 2004; Grupe & Nitschke, 2013), and previous research has demonstrated a relationship between social anxiety and IU (Boelen & Reijntjes, 2009; Carleton et al., 2010). It might be that socially anxious patients experiencing a return of symptoms after exposure therapy are those who also possess elevated level of IU. Second, Paper 3 demonstrated that persistent and generalised avoidance behaviour after extinction learning (i.e., exposure) is specifically associated with increased social anxiety. Therefore, targeted treatment for social anxiety may be required depending on the specific profile presented by the individual. For example, an individual diagnosed with social anxiety who is also high on IU may benefit from treatment focused on promoting safety learning and retention. However, another individual diagnosed with social anxiety may not be particularly intolerant to uncertainty but may be more inclined to engage in maladaptive safety or avoidance behaviours. For this individual, exposure therapy aimed towards the extinction of avoidance behaviours may be more effective.

Despite such implications, research that has examined the relationship between social anxiety and avoidance learning and extinction is extremely sparse and there are a number of remaining questions and plausible directions for future research. Paper 3 investigated the association between social anxiety and avoidance behaviours within a low-cost avoidance conditioning paradigm that employed socially relevant stimuli. However, the validity of low-cost

avoidance conditioning paradigms has been criticised across the literature, as avoidance responses require minimal effort and arguably resemble an adaptive reaction in such circumstances (i.e., button press to avoid aversive stimulus) (Pittig et al., 2020a). In response to this criticism, recent research has navigated towards the use of costly avoidance tasks during which avoidance responses are placed within approach-avoid conflicts, such as positive outcomes as an incentive to approach (Pittig, 2019; Pittig & Dehler, 2019; Pittig et al., 2014), or the infliction of further cost associated with avoidance (Hunt et al., 2019; Meulders et al., 2016; Rattel et al., 2017). Heimberg, Brozovich and Rapee's (2010) updated cognitive-behavioural model of social anxiety posited that socially anxious individuals not only fear negative evaluation, but evaluation regardless of the valence. Based on this suggestion we might expect social anxiety to be associated with increased avoidance responses regardless of the valence of the outcome of the avoidance behaviour (i.e., cost or reward). While recent work has investigated costly avoidance within patients diagnosed with anxiety disorders (Pittig et al., 2020a), investigation of the mechanisms underlying costly avoidance in social anxiety specifically, and its response to treatment, is yet to be carried out. Social anxiety is associated with increased risk of poorer attainment of qualifications (Ranta et al., 2009; van Ameringen et al., 2013), poorer performance and days off work (Stein et al., 1999), being bullied (Whisman et al., 2000), as well as fewer friendships across all areas of life (Acquah et al., 2016; Ranta et al., 2009). Such work is therefore an important avenue for further research due to the highly detrimental impact avoidance of social situations and contexts is likely have on an individual's life.

The paradigm employed in Paper 3, as well as the tasks used across the previous avoidance conditioning literature referred to throughout this thesis, have all focused on US avoidance. For instance, US avoidance involves an avoidance response during CS presentation to prevent the occurrence of the US while the CS is endured. However, the motivation behind the avoidance response may also be driven by the CS in itself. For example, CS avoidance prevents the occurrence of the CS, and as a consequence the US is not administered. In relation to social anxiety, the complete avoidance of a social event can be considered to be CS avoidance. However, safety behaviours, such as avoiding eye contact during social interaction, can be regarded as US avoidance as the social situation is approached (i.e., the CS), however, certain behaviours are performed to reduce the level of threat. Both CS and US avoidance are highly applicable to a clinical setting, however, the learning mechanisms underlying CS avoidance in social anxiety has not been examined in the laboratory. Feared social situations (i.e., the CS) are typically approached during exposure therapy for social anxiety, therefore, this work is an important focus for future clinical research to shed light on the potential mechanisms and moderators of CS avoidance related to social anxiety.

5.6 Conclusion

The primary aim of this thesis was to examine the relationship between individual differences in social anxiety and learning processes within threat extinction paradigms. Overall, the work of this thesis demonstrated that in the case of social anxiety, compromised extinction of operant avoidance behaviour, and not safety learning processes, were associated with the maintenance of threat associations. This work advances our understanding of the role of social anxiety on safety and avoidance learning processes and points towards certain priorities for future research. The work has implications for exposure-based treatments for social anxiety and suggests that individualised treatment that specifically targets compromised learning processes characteristic of the individual may improve treatment outcomes.

References

Acquah, E. O., Topalli, P. Z., Wilson, M. L., Junttila, N., & Niemi, P. M. (2016). Adolescent loneliness and social anxiety as predictors of bullying victimisation. *International Journal of Adolescence and Youth*, *21*(3), 320-331.

Altman, D. G., & Royston, P. (2006). The cost of dichotomising continuous variables. *Bmj*, *332*(7549), 1080.

Andreatta, M., Michelmann, S., Pauli, P., & Hewig, J. (2017). Learning processes un- derlying avoidance of negative outcomes. Psychophysiology, 54(4), 578–590.

Boelen, P. A., & Reijntjes, A. (2009). Intolerance of uncertainty and social anxiety. Journal of Anxiety Disorders, 23, 130-135.

Carleton, R. N. (2016a). Fear of the unknown: One fear to rule them all? *Journal of Anxiety Disorders,* 41, 5–21.

Carleton, R. N. (2016b). Into the unknown: A review and synthesis of contemporary models involving uncertainty. *Journal of Anxiety Disorders,* 39, 30–43.

Carleton, R. N., et al. (2010). "It's not just the judgements - it's that I don't know": Intolerance of uncertainty as a predictor of social anxiety. Journal of Anxiety Disorders, 24, 189-195.

Carleton, R. N., Collimore, K. C., & Asmundson, G. J. (2007). Social anxiety and fear of negative evaluation: Construct validity of the BFNE-II. *Journal of Anxiety Disorders*, *21*(1), 131-141.

Chin, B., Nelson, B.D., Jackson, F., Hajcak, G., 2016. Intolerance of uncertainty and startle potentiation in relation to different threat reinforcement rates. Int. J. Psychophysiol. 99 (January), 79–84.

Clark, D. M., & Wells, A. (1995). A cognitive model of social phobia. In R. G. Heimberg, M. R. Liebowitz, D. A. Hope, & F. R. Schneier (Eds.), Social Phobia: Diagnosis, Assessment, and Treatment (69-93). New York, NY: Guilford Press.

Craske, M. G., & Mystkowski, J. L. (2006). Exposure Therapy and Extinction: Clinical Studies.

Dugas, M. J., Buhr, K., & Ladouceur, R. (2004). The role of intolerance of uncertainty in etiology and maintenance of generalised anxiety disorder. In R. G. Heimberg, C. L. Turk, & D. S. Mennin (Eds.), Generalised anxiety disorder: Advances in research and practice (pp. 143–163). New York, NY: Guilford Press

Dunsmoor, J. E., Campese, V. D., Ceceli, A. O., Ledoux, J. E., & Phelps, E. A. (2015). Archival Report Novelty-Facilitated Extinction: Providing a Novel Outcome in Place of an Expected Threat Diminishes Recovery of Defensive Responses. *Biological Psychiatry*, 1–8.

Duits, P., Cath, D. C., Lissek, S., Hox, J. J., Hamm, A. O., Engelhard, I. M., … Baas, J. M. P. (2015). Updated meta-analysis of classical fear conditioning in the anxiety disorders. *Depression and Anxiety*, *32*(4), 239–253.

Fehm, L., Beesdo, K., Jacobi, F., & Fiedler, A. (2008). Social anxiety disorder above and below the diagnostic threshold: prevalence, comorbidity and impairment in the general population. *Social psychiatry and psychiatric epidemiology*, *43*(4), 257-265.

Grupe, D. W., & Nitschke, J. B. (2013). Uncertainty and anticipation in anxiety: An integrated neurobiological and psychological perspective. *Nature Reviews Neuroscience,* 14, 488–501.

Heimberg, R. G., Brozovich, F. A., & Rapee, R. M. (2010). A cognitive behavioral model of social anxiety disorder: Update and extension. In *Social anxiety* (pp. 395-422). Academic Press.

Hermann, C., Ziegler, S., Birbaumer, N., & Flor, H. (2002). Psychophysiological and subjective indicators of aversive pavlovian conditioning in generalised social phobia. *Biological Psychiatry*, *52*(4), 328–337.

Hunt, C., Cooper, S. E., Hartnell, M. P., & Lissek, S. (2019). Anxiety sensitivity and intolerance of uncertainty facilitate associations between generalized pavlovian fear and maladaptive avoidance decisions. Journal of Abnormal Psychology, 128(4), 315–326.

Knappe, S., Beesdo, K., Fehm, L., Höfler, M., Lieb, R., & Wittchen, H. U. (2009). Do parental psychopathology and unfavorable family environment predict the persistence of social phobia?. *Journal of Anxiety Disorders*, *23*(7), 986-994.

Lissek, S., Levenson, J., Biggs, A. L., Johnson, L. L., Ameli, R., Pine, D. S., & Grillon, C. (2008). Elevated fear conditioning to socially relevant unconditioned stimuli in social anxiety disorder. *American Journal of Psychiatry*, *165*(1), 124–132.

Lissek, S., Pine, D.S., Grillon, C., 2006. The strong situation: a potential impediment to studying the psychobiology and pharmacology of anxiety disorders. Biol. Psychol. 72 (June (3)), 265–270.

Lonsdorf, T. B., Menz, M. M., Andreatta, M., Fullana, M. A., Golkar, A., Haaker, J., … Merz, C. J. (2017). Don't fear 'fear conditioning': Methodological considerations for the design and analysis of studies on human fear acquisition, extinction, and return of fear. *Neuroscience and Biobehavioral Reviews*, *77*, 247–285.

Lonsdorf, T. B., & Merz, C. J. (2017). More than just noise: Inter-individual differences in fear acquisition, extinction and return of fear in humans - Biological, experiential, temperamental factors, and methodological pitfalls. *Neuroscience and Biobehavioral Reviews,* 80, 703-728.

Lovibond, P. F., Mitchell, C. J., Minard, E., Brady, A., & Menzies, R. G. (2009). Safety behaviours preserve threat beliefs: Protection from extinction of human fear con- ditioning by an avoidance response. *Behaviour Research and Therapy,* 47(8), 716–720.

Lucas, K., Luck, C. C., & Lipp, O. V. (2018). Behaviour Research and Therapy Novelty-facilitated extinction and the reinstatement of conditional human fear. *Behaviour Research and Therapy*, *109*, 68–74.

Ly, V., & Roelofs, K. (2009). Social anxiety and cognitive expectancy of aversive outcome in avoidance conditioning. *Behaviour Research and Therapy*, *47*(10), 840-847.

Magee, W. J., Eaton, W. W., Wittchen, H. U., McGonagle, K. A., & Kessler, R. C. (1996). Agoraphobia, simple phobia, and social phobia in the National Comorbidity Survey. *Archives of general psychiatry*, *53*(2), 159-168.

Meulders, A., Franssen, M., Fonteyne, R., & Vlaeyen, J. W. S. (2016). Acquisition and extinction of operant pain-related avoidance behavior using a 3 degrees-of-freedom robotic arm. Pain, 157(5), 1094–1104.

McEvoy, P. M., Hyett, M. P., Shihata, S., Price, J. E., & Strachan, L. (2019). The impact of methodological and measurement factors on transdiagnostic associations with intolerance of uncertainty: A meta-analysis. *Clinical psychology review*, *73*, 101778.

Michalska, K. J., Feldman, J. S., Ivie, E. J., Shechner, T., Sequeira, S., Averbeck, B., … Pine, D. S. (2019). Early-childhood social reticence predicts SCR-BOLD coupling during fear extinction recall in preadolescent youth. *Developmental Cognitive Neuroscience*, *36*(May 2018), 100605.

Mogg, K., & Bradley, B. P. (2002). Selective orienting of attention to masked threat faces in social anxiety. *Behaviour research and therapy*, *40*(12), 1403-1414.

Morriss, J. (2019). What do I do now? Intolerance of uncertainty is associated with discrete patterns of anticipatory physiological responding to different contexts. Psychophysiology, 56(9).

Morriss, J., Chapman, C., Tomlinson, S., & van Reekum, C. M. (2018). Escape the bear and fall to the lion: The impact of avoidance availability on threat acquisition and extinction. *Biological Psychology*, *138*(August), 73–80.

Morriss, J., Christakou, A., & van Reekum, C. M. (2015). Intolerance of uncertainty predicts fear extinction in amygdala-ventromedial prefrontal cortical circuitry. *Biology of Mood and Anxiety Disorders*, *5*(1).

Morriss, J., Christakou, A., & van Reekum, C. M. (2016). Nothing is safe: Intolerance of uncertainty is associated with compromised fear extinction learning. *Biological Psychology*, *121*, 187–193.

Morriss, J., Christakou, A., & van Reekum, C. M. (2019). Multimodal evidence for delayed fear extinction in adolescence and young adulthood. *Scientific Reports*, *9*(7748).

Olsson, A., Carmona, S., Downey, G., Bolger, N., & Ochsner, K. N. (2013). Learning biases underlying individual differences in sensitivity to social rejection. *Emotion*, *13*(4), 616–621.

Otto, M. W., Pollack, M. H., Gould, R. A., Worthington III, J. J., McArdle, E. T., Rosenbaum, J. F., & Heimberg, R. G. (2000). A comparison of the efficacy of clonazepam and cognitive-behavioral group therapy for the treatment of social phobia. *Journal of Anxiety Disorders*, *14*(4), 345-358.

Pejic, T., Hermann, A., Vaitl, D., & Stark, R. (2013). Social anxiety modulates amygdala activation during social conditioning. *Social Cognitive and Affective Neuroscience*, *8*(3), 267–276.

Pittig, A., Boschet, J. M., Glück, V. M., & Schneider, K. (2020a). Elevated costly avoidance in anxiety disorders: Patients show little downregulation of acquired avoidance in face of competing rewards for approach. *Depression and Anxiety*, (October).

Pittig, A., Schulz, A. R., Craske, M. G., & Alpers, G. W. (2014). Acquisition of behavioral avoidance: Task-irrelevant conditioned stimuli trigger costly decisions. Journal of Abnormal Psychology, 123(2), 314–329.

Pittig, A., Wong, A. H. K., Glück, V. M., & Boschet, J. M. (2020b). Avoidance and its bi-directional relationship with conditioned fear: Mechanisms, moderators, and clinical implications. *Behaviour Research and Therapy*, *126*,103550.

Rabinak, C. A., Mori, S., Lyons, M., Milad, M. R., & Phan, K. L. (2016). Acquisition of CS-US contingencies during Pavlovian fear conditioning and extinction in social anxiety disorder and posttraumatic stress disorder. *Journal of Affective Disorders*, *207*(June 2016), 76–85.

Ranta, K., Kaltiala-Heino, R., Pelkonen, M., & Marttunen, M. (2009). Associations between peer victimization, self-reported depression and social phobia among adolescents: the role of comorbidity. *Journal of adolescence*, *32*(1), 77-93.

Rapee, R. M., & Heimberg, R. G. (1997). A cognitive-behavioral model of anxiety in social phobia. *Behaviour Research and Therapy*, *35*(8), 741–756.

Rattel, J. A., Miedl, S. F., Blechert, J., & Wilhelm, F. H. (2017). Higher threat avoidance costs reduce avoidance behaviour which in turn promotes fear extinction in humans. Behaviour Research and Therapy, 96,37–46.

Reichenberger, J., Porsch, S., Wittmann, J., Zimmermann, V., & Shiban, Y. (2017). Social fear conditioning paradigm in virtual reality: Social vs. electrical aversive conditioning. *Frontiers in Psychology*, *8*(NOV), 1–15.

Remes, O., Brayne, C., van, d. L. R., & Lafortune, L. (2016). A systematic review of reviews on the prevalence of anxiety disorders in adult populations. *Brain and Behavior*.

Ruscio, A. M., Brown, T. A., Chiu, W. T., Sareen, J., Stein, M. B., & Kessler, R. C. (2008). Social fears and social phobia in the United States: results from the National Comorbidity Survey Replication. *Psychological medicine*, *38*(1), 15.

Sosic, Z., Gieler, U., & Stangier, U. (2008). Screening for social phobia in medical in-and outpatients with the German version of the Social Phobia Inventory (SPIN). *Journal of Anxiety Disorders*, *22*(5), 849-859

Tinoco-González, D., Fullana, M. A., Torrents-Rodas, D., Bonillo, A., Vervliet, B., Pailhez, G., … Torrubia, R. (2015). Conditioned Subjective Responses to Socially Relevant Stimuli in Social Anxiety Disorder and Subclinical Social Anxiety. *Clinical Psychology and Psychotherapy*, *22*(3), 221–231.

van Ameringen, M., Mancini, C., & Farvolden, P. (2003). The impact of anxiety disorders on educational achievement. *Journal of anxiety disorders*, *17*(5), 561-571.

van Uijen, S.L., Leer, A., Engelhard, I.M., 2018. Safety behavior after extinction triggers a return of threat expectancy. *Behav. Ther.* (N. Y.) 49, 450–458.

Vervliet, B., & Indekeu, E. (2015). Low-cost avoidance behaviors are resistant to fear extinction in humans. Frontiers in Behavioral Neuroscience, 9.

Wake, S., van Reekum, C. M., Dodd, H., & Morriss, J. (2020). The Impact of Intolerance of Uncertainty and Cognitive Behavioural Instructions on Safety Learning. *Cognitive Therapy and Research*.

Whisman, M. A., Sheldon, C. T., & Goering, P. (2000). Psychiatric disorders and dissatisfaction with social relationships: Does type of relationship matter?. *Journal of abnormal psychology*, *109*(4), 803.

Whiting, S. E., Jenkins, W. S., May, A. C., Rudy, B. M., Davis III, T. E., & Reuther, E. T. (2014). The role of intolerance of uncertainty in social anxiety subtypes. *Journal of Clinical Psychology*, *70*(3), 260-272.

Wong, Q. J. J., & Rapee, R. M. (2016). The aetiology and maintenance of social anxiety disorder: A synthesis of complimentary theoretical models and formulation of a new integrated model. *Journal of Affective Disorders*, *203*, 84–100.

Availability of Data

Original data created in support of the findings reported in this thesis have been deposited on the Open Science Framework.

Chapter 2:

DOI 10.17605/OSF.IO/SR7ZW

Chapter 4:

DOI 10.17605/OSF.IO/EWRQK

Appendices

1. Questionnaire Measures

1.1 Social Phobia Inventory

Social Phobia Inventory (SPIN)

Participant Number: _____ Date: _____

Age: _____ Nationality: _____

What is your ethnic origin?

☐ Black ☐ White ☐ Asian / Pacific Islander

☐ Hispanic / Latino ☐ Mixed ☐ Other, please state: _____

Please read each statement and select a number; 0,1,2,3 or 4 which indicates how much the statement applied to you over the past week. There are no right or wrong answers. Do not spend too much time on any one statement. This assessment is not intended to be a diagnosis. If you are concerned about your results in any way, please speak with a qualified health professional.

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

1	I am afraid of people in authority	0	1	2	3	4
2	I am bothered by blushing in front of people	0	1	2	3	4
3	Parties and social events scare me	0	1	2	3	4
4	I avoid talking to people I don't know	0	1	2	3	4
5	Being criticised scares me	0	1	2	3	4
6	I avoid doing things or speaking to people for fear of embarrassment	0	1	2	3	4
7	Sweating in front of people causes me distress	0	1	2	3	4
8	I avoid going to parties	0	1	2	3	4
9	I avoid activities in which I am the centre of attention	0	1	2	3	4
10	Talking to strangers scares me	0	1	2	3	4

11	I avoid having to give speeches	0	1	2	3	4
12	I'd do anything to avoid being criticised	0	1	2	3	4
13	Heart palpitations bother me when I am around people	0	1	2	3	4
14	I am afraid of doing things when people might be watching	0	1	2	3	4
15	Being embarrassed or looking stupid are among my worst fears	0	1	2	3	4
16	I avoid speaking to anyone in authority	0	1	2	3	4
17	Trembling or shaking in front of others is distressing to me	0	1	2	3	4

1.2 Intolerance of Uncertainty Scale

Intolerance of Uncertainty Scale

Date: _____ **Participant Number:_____**

You will find a series of statements that describe how people may react to the uncertainties of life. Please use the scale to describe to what extent each item is characteristic of you. Using the scale below, choose the number that describes you best.

Not at all characteristic of me				*Highly characteristic of me*
1	**2**	**3**	**4**	**5**

_____ 1) Uncertainty stops me from having a firm opinion.

_____ 2) Being uncertain means that a person is disorganized.

_____ 3) Uncertainty makes life intolerable.

_____ 4) It's not fair that there are no guarantees in life.

_____ 5) My mind can't be relaxed if I don't know what will happen tomorrow.

_____ 6) Uncertainty makes me uneasy, anxious, or stressed.

_____ 7) Unforeseen events upset me greatly.

_____ 8) It frustrates me not having all the information I need.

_____ 9) Uncertainty keeps me from living a full life.

____ 10) One should always look ahead so as to avoid surprises.

_____ 11) A small unforeseen event can spoil everything, even with the best of planning.

_____ 12) When it's time to act uncertainty paralyzes me.

_____ 13) Being uncertain means that I am not first rate.

_____ 14) When I am uncertain I can't go forward.

_____ 15) When I am uncertain I can't function very well.

_____ 16) Unlike me, others always seem to know where they are going with their lives.

_____ 17) Uncertainty makes me vulnerable, unhappy, or sad.

_____ 18) I always want to know what the future has in store for me.

_____ 19) I hate being taken by surprise.

_____ 20) The smallest doubt stops me from acting.

_____ 21) I should be able to organize everything in advance.

_____ 22) Being uncertain means that I lack confidence.

_____ 23) I think it's unfair that other people seem sure about their future.

_____ 24) Uncertainty stops me from sleeping well.

_____ 25) I must get away from uncertain situations.

_____ 26) The ambiguities in life stress me.

_____ 27) I can't stand being undecided about my future.

1.3 State-Trait Anxiety Inventory

SELF-EVALUATION QUESTIONNAIRE

STAI Form Y-2

Name_____Date_____

DIRECTIONS

A number of statements which people have used to describe themselves are given below. Read each statement and then circle the appropriate number to the right of the statement to indicate how you *generally* feel.

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