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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 the threat extinction phase, elevated social anxiety was associated with increased avoidance behaviour to threat 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

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 Pavlovian threat conditioning and extinction paradigms that incorporate an operant learning phase (Dymond, 2019; Dymond & Roche, 2009; Vervliet & 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 & Quirk, 2012). Within avoidance conditioning paradigms, an avoidance conditioning phase is typically presented between threat acquisition and threat extinction phases. 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 learning and avoidance behaviours remain after the occurrence of Pavlovian threat extinction procedures (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 & Engelhard, 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 the process of extinction learning (Morriss et al., 2018; Van Uijen, Leer & Engelhard, 2018; Vervliet & Indekeu, 2015), with the use of socially relevant stimuli and an extended threat extinction 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 conditioning and 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 threat extinction 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-). Given the findings of previous work that demonstrate that elevated social anxiety is associated with the increased tendency to generalise conditioned fear across threat to safety cues (Ahrens et al., 2014; Hermann et al., 2002; Sachs et al., 2003), we predicted that during the avoidance conditioning phase, 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).

Methods

Preregistration

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

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; Sexual Orientation: 65 Heterosexual, 7 Sexual Minorities (lesbian, bisexual, asexual, demisexual, 8 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 = 79. Due to non-responding in SCR (typically 5-10% of sample), we aimed to collect 8 more participants than the total suggested sample size to uphold good statistical power. The total sample size aim for the current study was therefore *n* = 87[1].

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[1] Preregistered power analysis stated that we would recruit 87 participants. In line with this however, data collection had to be terminated prematurely due to the Covid-19 outbreak in the UK. Thus, a new power analysis was conducted using the same parameters as the original analysis to calculate the power of the study due to the recruitment of 80 participants, instead of 87. The following parameters were used: effect size, f = 0.53 (converted from n^2= 0.22), α error probability = 0.01, total sample size = 80, number of groups = 2 (CS+, CS-), numerator df = 2, number of covariates = 4 (SPIN, IU, Trait Anxiety, BFNES). Given the sample of 80 participants included in the analysis of expectancy ratings data, the power of this analysis (1-β error probability) = .95, to detect an effect size of f = 0.53. Given the sample of 78 participants included in the

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

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

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analysis of physiological and avoidance response data, the power of this analysis (1-β error probability) = .94 to detect an effect size of f = 0.53.

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 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.

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 sustain the effect of conditioning into the avoidance conditioning and threat extinction phase (Leonard, 1975; Livneh & Paz, 2012), and to allow the examination of the conditioned response during threat acquisition without the confound of the US. 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 a CS+ paired trial 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.

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. 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]

SPIN scores, IUS scores and STAI-T scores were significantly positively correlated with one another, with the smallest correlation between SPIN scores and STAI-T scores, $r(80) = 0.57$, and the largest correlation between IUS scores and STAI-T scores, $r(80) = 0.72$. The correlation between SPIN scores and IUS scores was $r(80) = 0.60$. All correlations were at the $p < .001$ level.

SPIN, IUS, and STAI-T scores were not significantly associated with any of the following demographic variables: Age [SPIN, $r(79) = -0.07$, $p = .54$; IUS, $r(79) = 0.14$, $p = .24$; STAI-T, $r(79) = 0.17$, $p = .14$], Ethnicity (White, Non-White, not-specified) [SPIN, $F(2,77) = 2.21$, $p = .12$; IUS, $F(2,77) = 1.53$, $p = .22$; STAI-T, $F(2,77) = 2.83$, $p = .07$], or Sexual Orientation (Heterosexual, Sexual Minority, not-specified) [SPIN, $F(2,77) = 1.64$, $p = .20$; IUS, $F(2,77) = 1.98$, $p = .15$; STAI-T, $F(2,77) = 1.30$, $p = .28$].

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

[2] As recommended by a reviewer, we checked for associations between BFNE scores and avoidance responses towards the CS+ and CS- during avoidance conditioning and the avoidance test phase when BFNE scores were entered into the model alone and with IU and STAI-T scores. During avoidance conditioning, BFNE scores were not associated with avoidance responses when entered into the model alone, [Stimulus x BFNE, $F(1,78) = 0.9$, $p = .35$], however, when controlling for variance accounted for by IU and STAI-T the Stimulus x BFNE interaction became significant suggesting specificity, [Stimulus x BFNE, $F(1,78) = 4.48$, $p = .04$]. During the avoidance test phase, there was not an association between BFNE and avoidance responses when BFNE scores were entered into the model alone, [Stimulus x BFNE, $F(1,78) = 1.65$, $p = .20$], or with IU and STAI-T scores, [Stimulus x BFNE, $F(1,78) = 1.43$, $p = .24$]. These analyses were not preregistered on OSF.

avoidance phase (avoidance acquisition and avoidance test), i.e., total number of avoided trials divided by the total number of CS+ or CS- trials.

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.

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.

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).

Results

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, $r(78) = 0.04$, $p = .75$.

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 1].

There was no significant difference in US expectancy 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, $F(1, 165.16) = 275.69$, $p < .001$, 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 $F = 2.20$, or US expectancy ratings post-acquisition, max $F = 1.49$, when entered into the model alone, or with IU and trait anxiety scores.

Avoidance Conditioning

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

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, $F(1,78) = 5.36$, $p = .02$; SPIN, $F(1, 78) = 0.95$, $p = .33$]. To follow up this significant interaction, the effect of stimulus at higher and lower levels of SPIN was examined at + and – 1 SD above and below the mean SPIN score. 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, mean difference = 0.27), p < .001, relative to individuals with lower SPIN scores: CS+ (M = 0.82, SE = 0.05), CS- (M = 0.34, SE = 0.07; mean difference = 0.48), p < .001, see Figure 3. Further, follow-up correlation analyses were conducted to examine the relationship between SPIN scores and avoidance responses towards the CS+ and the CS- separately. There was a marginal positive correlation between SPIN scores and avoidance responses towards the CS-, $r(78) = 0.20$, $p = .07$, but not towards the CS+, $r(78) = -0.06$, $p = .61$.

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 $F = 2.91$.

Threat Extinction

During threat extinction, SCR was significantly higher to the CS+ compared to the CS- during early, p < .001, and late, p = .002, threat extinction [Stimulus, $F(1, 306.84) = 32.38$, p <.001, see Table 1 and Figure 2]. Further, SCR magnitude significantly reduced between early and late threat extinction towards the CS+, p = .02, but not the CS-, p = .3, [Time, $F(1, 306.84) = 5.42$, p =.02, see Table 1 and

Figure 2]. There was not a significant stimulus x time interaction for SCR magnitude during threat extinction [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 threat extinction, max $F = 0.82$.

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 1].

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, $F(1,78) = 4.52$, $p = .04$]: To follow up this interaction, the effect of stimulus at higher and lower levels of SPIN was examined at + and – 1 SD above and below the mean SPIN score. There was a significant difference between avoidance responses toward the CS+ and CS- at higher SPIN scores (CS+: $M = 0.63$, $SE = 0.08$; CS-, $M = 0.43$, $SE = 0.08$, mean difference = 0.2), $p = .001$, and at lower SPIN scores (CS+, $M = 0.36$, $SE = 0.08$; CS-, $M = 0.22$, $SE = 0.08$, mean difference = 0.14), $p = .03$, see Figure 3. Further, follow-up correlation analyses were conducted to examine the relationship between SPIN scores and avoidance responses towards the CS+ and the CS- separately. There was a significant positive correlation between SPIN scores and avoidance responses towards the CS+, $r(78) = 0.25$, $p = .03$, but not towards the CS-, $r(78) = 0.18$, $p = .12$.

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 $F = 1.99$.

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 1 and Figure 2].

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 $F = 0.15$.

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 threat extinction , 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 1].

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 threat extinction , after the avoidance test phase and after the re-extinction phase (see Table 2 and Figure 4).

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 $F = 1.18$.

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 of avoidance. 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 threat extinction and re-extinction phases, 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 during a threat extinction phase (Morriss et al., 2018; Van Uijen et al., 2018; Vervliet & Indekeu, 2015).

During the avoidance conditioning phase, 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. 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 towards conditioned threat (CS+) cues, indicating persistent avoidance behaviour following threat extinction. This finding implies that elevated social anxiety predicts the maintenance of maladaptive avoidance behaviour after the occurance of a threat extinction phase. 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 threat extinction, after the avoidance test phase and after 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 was present both when entered into the model alone 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 threat extinction 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 extinction of the conditioned response was not complete at the end of a threat extinction phase as a limitation of their study. In an attempt to prevent a similar effect, we increased the number of threat extinction 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 threat extinction, 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 previous 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 cannot determine to what extent the observed findings are related to the social nature of the CS+ (i.e., neutral facial expressions) and part of the US (i.e., negative verbal feedback). This question should be explored further within future work that examines the relationship between social anxiety and avoidance responses towards socially relevant and socially irrelevant CS and US. In the current study we employed a second socially irrelevant US (i.e., an electric shock) alongside the negative verbal statement and 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 of avoidance, 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. Therefore, we chose to include the shock alongside the verbal statement to ensure that the US was sufficiently threatening as 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+). Further, we reasoned that specificity of effects of social anxiety, over and above other measures of anxiety (i.e., IUS and STAI-T), would most likely be carried by the social element of the US.

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.

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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.

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