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Social anxiety and cognitive expectancy of aversive outcome in avoidance conditioning

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ABSTRACT

Fear conditioning studies have shown that social anxiety is associated with enhanced expectancy of aversive outcome. However, the relation between cognitive expectancy and social anxiety has never been tested in avoidance conditioning paradigms. We compared 48 low (LSA) and high socially anxious individuals (HSA) on subjective expectancy of aversive outcome during an avoidance conditioning task. Displays of neutral faces were coupled with an aversive outcome (US): a shout and a shock. Participants could avoid the US by pressing a correct button from a button box. First, HSA showed higher US expectancy than LSA during the initial phase of avoidance conditioning, supporting the view that socially anxious individuals have an expectancy bias when social situations are ambiguous. Second, when the avoidance response became unavailable, LSA showed lower US expectancy than HSA, suggesting that low socially anxious individuals are prone to a positive bias when perceived threat is high. A lack of such positive bias in socially anxious individuals may lead to higher susceptibility to safety behavior interpretations. Together, these findings support the role of cognitive processes in avoidance conditioning and underscore the relevance to encounter avoidance learning when studying social anxiety.

Introduction

Social Anxiety Disorder (SAD) is one of the most prominent mental disorders (Bögels & Tarrier, 2004). It is the most frequent anxiety disorder and the third most common mental disorder in the population (Kessler et al., 1994). SAD is characterized by fear and avoidance of social interaction and evaluation (Hofmann & Bögels, 2006).

Cognitive mechanisms may play an important role in the development and the maintenance of social anxiety (e.g., Clark & Wells, 1995; Rapee & Heimberg, 1997). There is substantial evidence for the presence of information processing biases in social anxious individuals. For instance, heightened self focused attention, selective retrieval of negative past social events and biased interpretation of social events in a negative way have been observed in SAD (for a review, see Hirsch & Clark, 2004). These cognitive biases may lead to overestimations of social threat in social situations and to behavioral processes in the form of overt avoidance and safety behaviors (Clark & Wells, 1995). As a negative consequence, these dysfunctional behaviors may make a feared outcome more likely to occur. For example, a social phobic who hardly speaks in social situations may receive less positive feedback from others. In addition, avoidance of social situations decreases the opportunity to disconfirm negative beliefs (Salkovskis, 1991). Phobics tend to attribute the nonoccurrence of an expected aversive outcome to their safety behaviors. Avoidance and safety behaviors not only prevent the person from potential achievement, but also disallow progression in anxiety reduction: it prevents exposure to feared situations and, hence, prohibits extinction of the phobic fear. For these reasons, avoidance and safety behaviors are considered a major maintaining factor of anxiety (Barlow, 2002; Clark & Wells, 1995; Salkovskis, 1991).

Despite the crucial role of avoidance behavior, research in the field of social anxiety has been mainly focused on fear learning and not on avoidance learning. In this study, we used an avoidance learning paradigm to compare avoidance conditioning in high (HSA) and low socially anxious (LSA) participants. The main purpose was to test whether HSA would show higher expectancy of aversive outcome during avoidance conditioning. In addition, we tested whether HSA would show prolonged aversive outcome expectancy even in the absence of aversive outcome during an extinction like procedure.

Several studies, using fear conditioning and extinction paradigms, have found higher levels of conditioned responding during acquisition and delayed extinction of conditioned fear among

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anxious patients in contrast with healthy controls (e.g., Grillon & Morgan, 1999; Orr et al., 2000; Pitman & Orr, 1986). A few of these studies concerned fear conditioning in social phobics (Hermann, Ziegler, Birbaumer, & Flor, 2002; Schneider et al., 1999; Veit et al., 2002). For example, using a differential aversive Pavlovian conditioning paradigm, Hermann et al. (2002) found that social phobics had an overall higher subjective arousal, enhanced unconditioned stimulus (US) expectancy during acquisition, especially for the nonreinforced conditioned stimuli (CS), and a delayed extinction of conditioned skin conductance response. These results are consistent with cognitive theories suggesting that cognitive biases play a role in the development and maintenance of emotional disorders (Beck & Clark, 1997; Heinrichs & Hofmann, 2001; Mathews & MacLeod, 1994).

However, little is known about avoidance conditioning in relation to social anxiety. In fact, little research on avoidance learning has been conducted in humans. Nevertheless, new theories of avoidance learning have been proposed recently that may be crucial for our understanding of avoidance in SAD.

It is speculated that avoidance behavior can function as a negative occasion setter (De Houwer, Crombez, & Baeyens, 2005), because avoidance learning involves a so called 'feature negative discrimination': the CS is followed by the US when feature X is absent, whereas CS is not followed by the US when feature X is present. Regarding this, the crucial points in studies on avoidance learning are identical to those in studies on negative occasion setting. The only difference is that feature X is a behavior in the former and a second CS in the latter. Using a contingency judgment experiment, De Houwer et al. (2005) showed that avoidance behavior indeed shares several functional properties with a negative occasion setter, such as the ability to modulate conditioned responding to stimuli, resistance to counterconditioning and selective transfer of modulation.

Another contemporary theory that also accounts for the actual performance of the avoidance response is proposed by Lovibond (2006). Using recent developments in conditioning research and clinical psychology, Lovibond (2006) developed an integrated expectancy based model. This model, intended to apply to human avoidance learning, is based on Pavlovian conditioning, Instrumental conditioning, propositional knowledge of learned contingencies and an interaction of avoidance and anxiety mediated by expectancy of aversive outcome. This model is described as a cognitive model of anxiety in which performance of an avoidance response reduces expectancy of an aversive outcome and thereby reduces anxiety. This cognitive expectancy model is supported by evidence from a lab based paradigm of human avoidance learning (Lovibond, Saunders, Weideman, & Mitchell, 2008). Although the paradigm was successfully used to study the cognitive accounts of avoidance, it has not been applied to study the relation with social anxiety yet.

We used a modified version of the human avoidance learning paradigm (Lovibond et al., 2008) to test the cognitive expectancy account of avoidance in social anxiety. Following Lovibond and colleagues, we measured change from baseline skin conductance level (dSCL) as an autonomic measure of anxiety and on line subjective expectancy of US (Lovibond, 1992). We adapted the paradigm by using social CS and US, since the use of ecologically more valid stimuli might enhance discrimination of HSA and LSA (Lissek et al., 2007). In addition, we implemented a subsequent extinction like procedure to the paradigm containing aspects of exposure therapy with decreased safety behavior (Wells et al., 1995): encounter a feared situation (CS associated with US) with the believe that a feared outcome would occur (expectation of US), while performance of safety behaviors (avoidance response) is prohibited. Because avoidance was unavailable and the US was absent in this procedure, participants would not attribute the nonoccurrence of the feared outcome (no US) to the safety behavior (avoidance response).

Allover, we expected that acquisition of the avoidance response would reduce US expectancy that would lead to reduced anxiety (Lovibond et al., 2008). For HSA we formulated three specific hypotheses: First, based on the previously found expectancy bias in social phobics (Hermann et al., 2002; Veit et al., 2002), we predicted HSA to show an enhanced US expectancy compared to LSA in the first stage of avoidance learning, when the functionality of the avoidance response still needs to be proven. Second, because avoidance of (negative) social stimuli is a main feature of social anxiety (e.g., Barlow, 2002; Clark & Wells, 1995), we predicted that HSA would be faster in learning the effects of avoidance. Third, based on previous findings on extinction (e.g., Hermann et al., 2002), we predicted HSA to show delayed extinction (i.e., relatively diminished decrease in US expectancy and dSCL compared to LSA) during the extinction like procedure, in which the CS (initially followed by US) was presented without the availability of avoidance response and the US. Similar hypotheses counted for the dSCL, although discrimination in skin conductance measures has frequently failed to be found in anxious participants (Del Ben et al., 2001; Grillon & Ameli, 2001).

Methods

Participants

A total of 22 low socially anxious (LSA; 16 male; mean age 21.55, SD 3.76) and 26 high socially anxious (HSA; 8 male; mean age 19.42, SD 1.96) individuals participated in this experiment for financial reward or course credit. The participants (all students of Leiden University) consecutively enrolled in this study and group division was based on their score on the brief version of the Fear of Negative Evaluation Scale (BFNE; Leary, 1983) through median split procedure. The LSA (mean 1.55, SD 1.30) differed significantly from HSA (mean 18.08, SD 9.77) in mean score on the BFNE ($F(1, 46)$ 61.82, $p < 0.001$). Exclusion criteria were: any psychiatric disorder on AXIS I, including substance abuse, not corrected visual impairments, any clinical significant physical impairment or medical disease and use of medication.

Materials

The BFNE measures the degree to which apprehension at the prospect of being negatively evaluated is experienced. Because of better psychometric properties, 12 straightforwardly formulated items were used instead of the original set of items containing four reversed scored items (e.g., Carleton, McCreary, Norton, & Asmundson, 2006). Respondents are required to rate the degree to which each item fits them on a five point scale (0 not at all, 1 a little, 2 fairly, 3 good, 4 very good). The questionnaire showed good internal consistency and construct validity (e.g., Collins, Westra, Dozois, & Stewart, 2005).

Apparatus and stimuli

Two desktop computers were used for this experiment. The first computer presented the avoidance conditioning task and recorded the participant's responses using E Prime version 1.1 software. The second computer registered the SCL throughout the experiment with a sample rate of 500 samples/s using Acqknowledge software (Biopac System Inc.). Measurements were acquired through a Galvanic skin response amplifier (GSR100C) and a Biopac data acquisition system (mp150 Windows).

Participants were tested singly in a dim lit room. The instructor controlled the experiment from a separate room. The participant and the instructor were able to communicate through an intercom. Three different pictures of neutral male faces served as CSs and were presented on a 17 inch color TFT computer screen approxi mately 30 inch in front of the participant. The CSs were approxi mately 5 inch × 6 inch large and appeared in the center of the screen in front of a black background. Instructions were given on the same screen. On the table in front of the screen a response box with four buttons and a mouse were situated. The four buttons could illuminate individually. With the mouse, participants gave US expectancy ratings on each trial by moving the mouse cursor from a fixed starting point (left side top of the screen) to a visual analogue scale (center of the screen), which appeared on the screen. The scale represented the chance of the occurrence of an US and ranged from 0 to 100 (0 no US, 100 definitely an US). Participants wore headphones that played white noise at about 70 dB headphones during the experiment to increase arousal and reduce habituation.

The stimuli in this experiment were socially relevant. CSs were 3 pictures of male faces with neutral expressions selected from the Karolinska Directed Emotional Faces (Lundqvist, Flykt, & Öhman, 1998). The US consisted of a combination of a critical vocalization and an electric shock of 100 ms duration. The critical vocalization consisted of a male voiced shout 'Get lost!' ('Rot op!' in Dutch) at approximately 90 dB and was presented through headphones. The electric shock was added to induce an additional shock effect and to make the US more aversive. The shock electrodes were attached to the thumb of the non dominant hand. Skin conductance was measured through disposable electrodermal activity electrodes (Biopac 100/PK EL507 10) attached to the second and third fingers of the non dominant hand.

Procedure

After arrival of the participant, the experimenter reminded that the experiment involved delivery of loud noise and shouts and administration of electric shocks and that they would have the right to terminate the experiment at any time. If participants agreed to participate, they were asked to sign an informed consent.

Participants were instructed to wash their hands with soap and water before fitted with the electrodes. They were asked to complete the BFNE. After completion of the questionnaire, they were led through a work up procedure to select a 'definitely uncomfortable, but not painful shock level'. Shock levels were limited to 1.0 and 5.0 mA to minimize group differences.

Prior to the conditioning task, the participants were asked to read the instructions presented on the screen. Subsequently, the experimenter gave a verbal explanation of the task. Participants were told that on each successive trial a face as CS would appear for 5 s, followed by a 10 s delay, followed by either a critical vocaliza tion and shock as US or no US. They were informed that one or more buttons on the response box might be lighted up during CS presentation and they had to press a lit button, when this was the case. Only one of the four buttons would prevent the US and it would be the same button throughout the experiment. Participants were instructed to give a rating during the 10 s delay after the CS disappearance to indicate their US expectancy. This rating was given by placing the mouse cursor on a visual analogue scale from 0 to 100 (0 no aversive stimuli expected, 100 aversive stimuli expected) presented on the computer screen. Participants were instructed to use their dominant hand for the responses and ratings to avoid movement artifacts in the skin conductance measures.

The experimenter gave clear instructions, so that the partici pants knew that they were required to learn explicitly which face(s) would lead to an US and which response button could cancel the US. If the participants indicated that everything was clear, they were asked to put on the headphones and the avoidance condi tioning task was started. The design of the task is shown in Table 1 and outlined below. The three CSs, designated A to C, were allocated to the three different neutral male faces. Since there were three different faces, there were six different combinations of allocation possible. This combination of allocation and the correct button was randomly chosen for each participant. Within each phase, trial order was random except that there were no more than two consecutive presentations of the same stimulus type. The trial procedure was as follows. Each trial started with a resting period with a duration varying randomly between 25 s and 45 s with a mean of 35 s. After this period, a CS would be presented. During the CS presentation, two out of the four response buttons illumi nated, except for in the Pavlovian phase. In avoidable trials, the illuminated buttons always included the correct avoidance button, whereas in unavoidable trials the correct avoidance button was unavailable. When a lit button was pressed, the button lights went off and the response was recorded. The CS was always presented for the full 5 s, so button presses did not terminate CS presentation. After CS termination, during the 10 s delay, an instruction appeared on the screen asking the participants to rate their US expectancy. After the 10 s delay, the US would either occur or not. The design per phase was as follows:

1. In the *Pavlovian phase*, all CSs were presented with A and B followed by the US and C not followed by the US. No response buttons illuminated in this phase. Thus, participants were not required to make a button response in this phase.
2. In the *Instrumental phase*, there were six 'avoidable' A(+) trials on which A was presented with two response buttons illumi nated (including the correct 'avoidance' button). If the partici pant pressed the correct avoidance button, no US would be presented; otherwise US would follow. In this phase, partici pants also received two 'unavoidable' trials in which CSs (1 A+ trial and 1 B+ trial) were presented with two response buttons illuminated, without the correct avoidance button. Finally, the participant also received two 'safe' C trials, in which C was illuminated with two buttons, without correct avoidance button, followed by no US.
3. In the *Test phase,* occurrence of transfer was tested: transfer of the instrumental response on stimulus A to the other trained predictor (B) of US. Both A and B were tested with the correct avoidance button available (A(+) and B(+)) and with the correct avoidance button unavailable (A+ and B+) to test the impact of avoidance availability on US expectancy and arousal.

Table 1
Design of experiment.

Phase			
Pavlovian	Instrumental	Test	Extinction
A+ (2)	A(+) (6) A+ (1)	A+ (1) A(+) (1)	A− (4)
B+ (2)	B+ (1)	B+ (1) B(+) (1)	B+ (2)
C− (4)	C− (2)	C− (1)	C− (2)

A CS1.
B CS2.
C CS3.
+ Aversive stimuli.
− No aversive stimuli.
(+) Avoidable aversive stimuli.
(*N*) *N* trials (randomly presented with no more than two consecutive presentations of same stimulus type).

Since the availability of the correct avoidance button in B(+) trials was required, new button combinations were also introduced for A+, A(+), B+ and C trials in order to equate the novelty.

4. During the *Extinction phase* the trained predictor, A, of a US was presented without the US following (A). In these trial types, two response buttons other than the correct avoidance response button were illuminated. Thus, the correct avoidance button was unavailable. The participant also received unavoidable B+ trials and safe C trials.

All four phases followed each other without any indication being given to participants that there would be any changes.

Data scoring and transformation

Following Lovibond et al. (2008), acquisition of the avoidance response was defined by a criterion of at least two consecutive correct responses on the A(+) trials during the acquisition phase. The skin conductance measure was the change in mean skin conductance level from the 5 s pre CS baseline period to the final 5 s of the post CS delay period (dSCL). The final 5 s of the post CS delay period was found to be most sensitive for distinguishing between various trial types (Lovibond et al., 2008). dSCL data was log transformed as follows, log (post CS score + 1) log (baseline score + 1) to minimize individual differences and normalize the distribution. Expectancy ratings (0 100) from participants were recorded by the computer.

Statistical analysis

For each phase, we performed repeated measures analysis of variance (ANOVA) on both US expectancy ratings and dSCL, with Group as between subjects factor and Stimulus type or Trial as within subjects factor (Girden, 1992). We used the same a priori contrasts (Difference and Polynomial) for US expectancy and dSCL to examine within subjects, and within subjects by between subjects interaction effects. First, we inspected the main effects of the within subjects factors, to see whether we were successful in replicating the results of Lovibond et al. (2008) by using a modified version of their paradigm. Secondly, pertaining to our specific hypotheses for HSA, we were interested in whether these effects would differ between HSA and LSA showed by the interaction effects. If an interaction effect was found, post hoc comparisons were performed using Bonferroni correction to control for type I errors. Additionally, we performed an ANOVA for the single A+ trial in the Instrumental phase, to test whether HSA and LSA would differ when the avoidance response became unavailable. All analyses were performed using SPSS for Windows, version 14.0.

Results

Avoidance acquisition and shock level

All 48 participants reached the criterion of two consecutive correct avoidance responses during the Instrumental phase. For the first trial in the Instrumental phase, 2 of the LSA and 2 of the HSA failed to press an illuminated button (all were on A(+) trials). The percentage of participants who made the correct response on each of the 6 A(+) trials was 59, 82, 96, 100, 100,100 for LSA, and, 62, 89, 96, 100, 100, 100 for HSA. The number of the A(+) trials before reaching the acquisition criterion did not differ between LSA (mean 2.68, SD 0.89) and HSA (mean 2.42, SD 0.86; $F(1,46)$ 1.045, p 0.312).

The mean shock levels (mA) chosen did not differ between LSA (mean 3.59, SD 1.76) and HSA (mean 2.96, SD 1.69; $F(1, 46)$ 1.59, p 0.213).

Expectancy ratings

The US expectancy data were combined across both groups, and the mean US expectancy rating for each trial over all phases were calculated. These mean US expectancy ratings in Fig. 1 show the learning effects over time for all stimulus types. Overall, the US expectancy ratings tracked the experimental contingencies. Fig. 2 displays the mean expectancy ratings only for stimulus type A for each group separately. Differences in US expectancy ratings between HSA and LSA were found in the Instrumental phase.

Pavlovian phase

To examine whether HSA and LSA differed in differentiation of the threat stimuli (A+ and B+) and the safe stimulus (C), subjective expectancies were averaged within this phase separately for each stimulus type and entered in a Group (LSA, HSA) × Stimulus type (A+, B+ vs. C) ANOVA. A significant main effect of Stimulus type indicated clear discrimination between the threat stimuli (A+ and B+) and the safe stimulus (C ; $F(1, 46)$ 269.62, $p < 0.001$). To test whether HSA and LSA differed in acquisition of the safe stimulus C across the four successive trials, a Group (LSA, HSA) × Trial (1, 2, 3, 4) ANOVA was conducted. The expectancy ratings decreased over trials (1 4) for C ($F(3, 44)$ 53, 41, $p < 0.001$; linear trend: $F(1, 46)$ 147.81, $p < 0.001$). No Group × Stimulus type and Group × Trial interaction effects were found in this phase (all $p > 0.5$), indicating that HSA and LSA learned the contingencies equally well.

Instrumental phase

To examine whether the previous acquired differentiation between threat (A+, B+) and safe (C) stimuli generalized to the Instrumental phase, a Group (LSA, HSA) × Stimulus type (A+, B+ vs. C) ANOVA was performed. Only participants (LSA: N 19; HSA: N 17) who experienced at least one correct avoidance response on A(+) trials, before exposed to A+ and B+, were included in this analysis to make sure that all participants in the analyses new that 'absence of the possibility to press the avoidance button indicates threat'. A significant main effect of Stimulus type indicated the

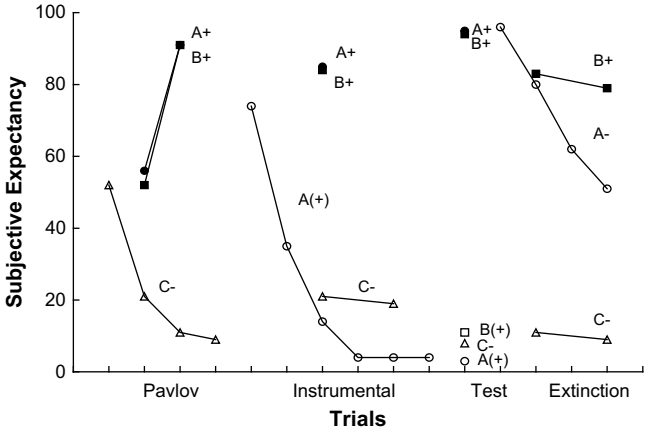

Fig. 1. Mean expectancy ratings for each trial over all phases. These mean expectancy ratings were combined across both groups. The expectancy ratings reflect clear learning effects over the phases. Note that the mean ratings on the A+ and B+ trials in the Instrumental phase are only based on the data of the subjects who had experienced one successful avoidance in the A(+) trial previously. For the meaning of the letters and symbols see footnote Table 1.

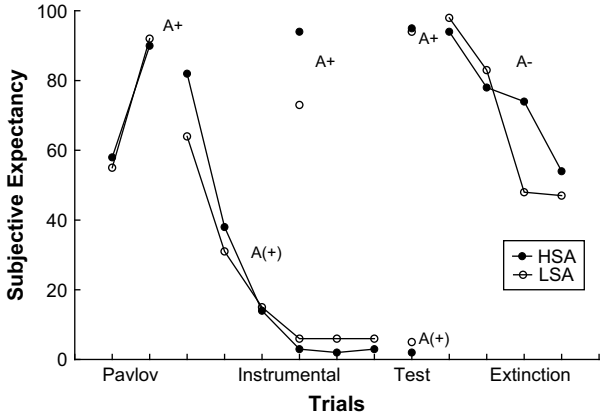

Fig. 2. Mean expectancy ratings for stimulus A for LSA and HSA separately. The figure shows differential US expectancy ratings for high and low socially anxious subjects in the instrumental and extinction phase. Note that the mean rating for both the HSA and LSA on the single A+ trial in the Instrumental phase is only based on the data of the subjects who had not only experienced one successful avoidance in the A(+) trial, but also that threat was still present as evidenced by a B+ trial (for the meaning of the letters and symbols see footnote Table 1).

learned contingency from the Pavlovian phase ($F(1, 34)$ 83.88, $p < 0.001$). No Group × Stimulus type interaction effect was found for this contrast (p 0.297).

To test whether HSA and LSA differed in avoidance acquisition (A(+) stimulus type) across the six successive trials, a Group (LSA, HSA) × Trial (1, 2, 3, 4, 5, 6) ANOVA was computed. A significant main effect for Trial indicated that the expectancy ratings declined over the trials (1 6) for A(+) to a very low level ($F(5, 42)$ 76.87, $p < 0.001$; linear trend: $F(1, 46)$ 236.62, $p < 0.001$). Importantly, there was a significant Group × Trial interaction effect ($F(5,42)$ 2.582, p 0.040; linear trend: $F(1,46)$ 6.137, p 0.017). Post hoc comparisons of the two groups on mean expectancy ratings using Bonferroni correction yielded a significantly higher US expectancy for the first A(+) trial in HSA (mean 82, SD 20) compared to LSA (mean 64, SD 24; $F(1, 46)$ 7.72, p 0.0078 < 0.05/6). For the five subsequent trials, HSA did not differ from LSA in US expectancy ($p > 0.05/6$). In fact, expectancy ratings starting at Trial 4 remained at the same level in subsequent trials for both HSA and LSA, suggesting a floor effect in learning.

Because the first A(+) trial was not always the first trial in the Instrumental phase for all participants, we conducted an additional ANOVA comparing HSA and LSA on expectancy ratings for the first trial of the Instrumental phase to account for potential sequential effects. The condition on this first trial was the same for all participants, because this trial always contained an A cue (A(+) or A+) and it was the first opportunity to press a button. Thus, all participants did not know which of the buttons the correct avoid ance button was. Participants, who failed to press a button, were excluded, because not pressing any button would 'definitely' lead to the US assuming the previously learned contingency (A US). Again, HSA (N 24) showed higher US expectancy on this first trial as compared to LSA (N 22; $F(1, 42)$ 6.879, p 0.012).

To explore whether the opportunity to press a button in this first trial led to lower US expectancy compared to the US expectancy for A+ (no opportunity to press a button) at the end of the Pavlovian phase, an ANOVA with Trial (last A+ in Pavlovian vs. first trial in Instrumental) as within subjects factor was performed for both HSA and LSA separately. Participants, who failed to press an illu minated button were excluded: LSA (N 20) showed a lower US expectancy in the first trial in the Instrumental phase as compared to the last A+ trial in the Pavlovian phase ($F(1, 19)$ 24.091, $p < 0.001$), whereas the HSA (N 24) did not show this decrease (p 0.301).

To investigate whether HSA and LSA showed differences in US expectancy when the avoidance response became unavailable (the single A+ trial, the knowledge that 'the avoidance response became unavailable' was crucial, in particular under conditions where US threat was still present. Therefore, first an ANOVA of the US expectancy for the single A+ trial was performed for those who experienced one correct avoidance response on the A(+) trial before being exposed to the A+ trial. This resulted in a trend towards a higher US expectancy for HSA (N 17; mean 92, SD 20) as compared to LSA (N 19; mean 77, SD 24; $F(1, 34)$ 4.030, p 0.053). Second and most critically, we con ducted the same analysis for those, who had not only experienced that the A(+) trial could be successfully avoided, but also that threat of US was still present (as evidenced by a B+ trial): HSA now showed a significantly higher US expectancy for A+ (N 11; mean 94, SD 13) as compared to LSA (N 7; mean 73, SD 27; $F(1, 16)$ 5.043, p 0.039).

In sum, the results suggest that HSA and LSA learned the avoidance response equally well. However, a higher US expectancy in HSA as compared to LSA was found for (1) the first trial, in which a response button was available, and (2) the trial in which the correct avoidance response became unavailable for the first time.

Test phase

In order for a learned avoidance response to transfer, we first tested whether the learned avoidance response was present in the first place. A Group (LSA, HSA) × Stimulus type (A(+) vs. A+) ANOVA revealed a significant main effect for Stimulus type indi cating a much lower US expectancy for A(+) compared to A+ ($F(1, 46)$ 968.60, $p < 0.001$). To test the transfer of this effect of learned avoidance from A(+) to the B(+) stimulus type, a Group (LSA, HSA) × Stimulus type (B(+) vs. B+) ANOVA was performed. A significant main effect for Stimulus type indicated lower US expectancy for B(+) compared to B+ ($F(1, 46)$ 321.78, $p < 0.001$).

Although Group (LSA, HSA) × Stimulus type (A(+) vs. B(+)) ANOVA showed that expectancy ratings on the B(+) test trial were not as low as for the trained A(+) trial type ($F(1, 46)$ 5.53, p 0.023), a Group (LSA, HSA) × Stimulus type A (A(+) vs. A+) × Stimulus type B (B(+) vs. B+) ANOVA showed that the Stimulus type A × Stimulus type B interaction comparing the size of the A+ vs. A(+) difference with the B+ vs. B(+) difference was nonsignificant ($F(1, 46)$ 2.818, p 0.100), indicating successful transfer of the avoidance response from stimulus A to B.

To test the discrimination between avoidable and unavoidable trials in general, a Group (LSA, HSA) × Stimulus type (the average of US expectancy of (+) vs. +) ANOVA was conducted. As expected, a significant main effect for Stimulus type indicated the learned effects of the avoidance response ($F(1, 46)$ 911.07, $p < 0.001$). No significant Group × Stimulus type interaction effects were found pertaining to all contrasts (all $p > 0.5$), indicating that transfer of the learned avoidance response to stimulus B took place for both HSA and LSA similarly. US expectancy for the safe stimulus C remained very low for both groups.

Extinction phase

As for the A+ trial in the Test phase, the expectancy rating for the first A trial in the Extinction phase started relatively high, indicating the learned effects of the avoidance response. To evaluate extinction, we calculated a Group (LSA, HSA) × Trial (1, 2, 3, 4) ANOVA. A significant main effect for Trial revealed an extinction process across the 4 trials ($F(3, 44)$ 33.43, $p < 0.001$; linear trend: $F(1, 46)$ 73.28, $p < 0.001$), as the US expectancies clearly declined over the A trials (1 4). We found a marginal

Group × Trial interaction effect ($F(3, 44)$ 2.473, p 0.074)[1]. To explore this marginal effect, comparisons of the mean expectancy ratings of the two groups, showed higher US expectancy for the third A trial in HSA (mean 74, SD 32) compared to LSA (mean 48, SD 42; $F(1, 46)$ 5.841, p 0.020). No differences in US expectancy were found on the other 3 A trials between HSA and LSA (all $p > 0.5$).

To test whether the acquired differentiation between B+ and C stimuli remained in the Extinction phase for both groups, a Group (LSA, HSA) × Stimulus type (B+ vs. C) ANOVA was performed. The US expectancy remained significantly higher for the B+ trials compared to the safe stimulus C ($F(1, 46)$ 261.59, $p < 0.001$). No Group × Stimulus type interaction effect was found for this contrast ($p > 0.5$).

Skin conductance

First, HSA and LSA were compared on their baseline SCL (mean SCL over 5 s pre CS baseline period), because higher baseline SCL would make the change in SCL (dSCL) 'look smaller'. There was no significant difference between the groups on baseline SCL ($F(1, 46)$ 0.132, p 0.718). Subsequently, the same analyses for dSCL were done as for US expectancy. We found a similar pattern of learning effects for the Pavlovian, Instrumental and Test phases in dSCL as in US expectancy, although no significant group differences were found. Large individual differences in skin conductance, as well as habituation over trials could have attributed to nonsignificant group differences (Bradley, Lang, & Cuthbert, 1993). The changes in dSCL over all phases are displayed in Fig. 3 as was done for US expectancy in Fig. 1. The dSCL for all stimulus type A trials are shown for each group separately in Fig. 4.

Pavlovian phase

The dSCL to the threat stimuli (A+ and B+) were higher than to the safe stimulus C ($F(1, 46)$ 8.71, p 0.005). The dSCL decreased over trials (1 4) for C ($F(3, 44)$ 4.16, p 0.011; linear trend: $F(1, 46)$ 8.89, $p < 0.05$). There was a trend towards a Group (LSA, HSA) × Trial (1, 2, 3, 4) interaction ($F(3, 44)$ 2.369, p 0.083). To explore this marginal effect, comparisons of the two groups on dSCL showed only a marginally higher dSCL on the first C trial for the HSA as compared to LSA (p 0.127).

Instrumental phase

The dSCL to the unavoidable trials (A+ and B+) was higher than to the safe trial C ($F(1, 34)$ 7.682, p 0.009). For the first A(+) trial, dSCL started high and decreased rapidly across the 6 training trials ($F(5, 42)$ 8.22, $p < 0.001$; linear trend: $F(1, 46)$ 38.97, $p < 0.001$). There were no significant interaction effects (all $p > 0.5$).

ANOVA for the single A+ trial for those, who experienced one correct avoidance response on the A(+) trial before exposed to the A+ trial, showed no difference in dSCL between HSA and LSA. The same was found for the analysis on those, who had not only experienced that the A(+) trial could be successfully avoided, but also that threat of US was still present as evidenced by a B+ trial (all $p > 0.5$). Remarkably, dSCL for the first A(+) trial and the A+ trial in this phase appeared relatively higher compared to all other trials of the task.

[1] We performed a Group (LSA, HSA) × Order1 (first B+) × Order2 (second B+) × Trial (1, 2, 3, 4) ANOVA to test whether an order effect of B+ could have influenced the marginal effect. This revealed no significant interaction effects of Order 1 and Order 2 with Group and Trial (all $p > 0.5$), indicating that the sequence effect of B trials did not influence our results.

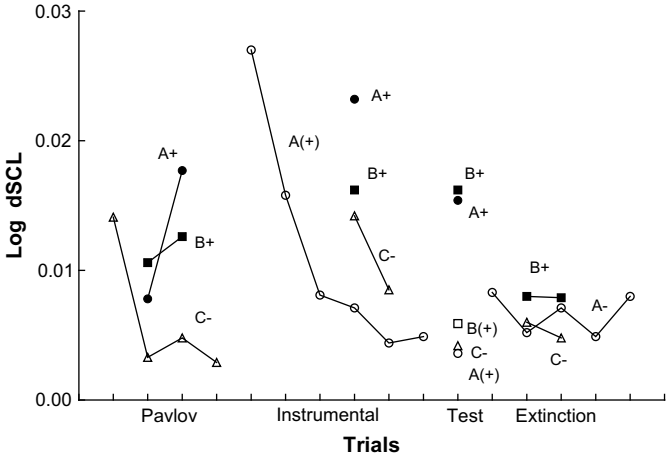

Fig. 3. Log transformed differences of skin conductance levels from baseline (dSCL) for each phase. The dSCL reflects clear learning effects over the first three phases. Note that the mean ratings on the A+ and B+ trials in the Instrumental phase are only based on the data of the subjects who had experienced one successful avoidance in the A(+) trial previously (for the meaning of the letters and symbols see footnote Table 1).

Test phase

The learned avoidance response was clearly reflected by dSCL ($F(1, 46)$ 11.91, p 0.001). Transfer of the avoidance response effect to stimulus B(+) was also evident in the observed dSCL for both HSA and LSA, with a much lower dSCL for B(+) compared to B+ ($F(1, 46)$ 7.97, p 0.007). No significant difference in dSCL was found for B(+) compared to A(+) ($F(1, 46)$ 1.28, p 0.263). dSCL was found to discriminate highly for the unavoidable trials (A+ and B+) and the avoidable trials (A(+) and B(+)) ($F(1, 46)$ 16.00, $p < 0.001$). There were no significant interaction effects (all $p > 0.5$).

Extinction phase

There were no significant main effects pertaining to Stimulus type or Trial and no significant Group × Stimulus type or Group × Trial interaction effects (all $p > 0.1$). Noteworthy, dSCL for all trials in this phase were very low, presumably partly due to large

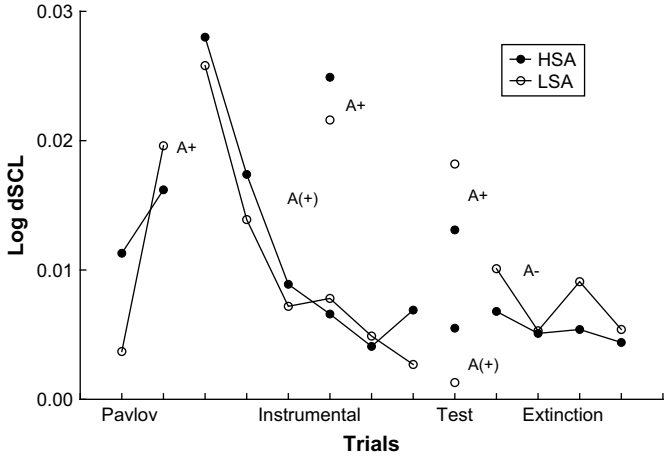

Fig. 4. Log transformed differences of skin conductance levels from baseline (dSCL) for stimulus A for LSA and HSA separately. The figure shows that dSCL was especially high for the first A(+) trial and the A trial in the Instrumental phase as these trials contained novel aspects: illumination of buttons and unavailability of the correct avoidance response button for A(+) and A+ respectively. Note that the Log dSCL for both the HSA and LSA on the single A+ trial in the Instrumental phase is only based on the data of the subjects who had not only experienced one successful avoidance in the A(+) trial, but also that threat was still present as evidenced by a B trial (for the meaning of the letters and symbols see footnote Table 1).

individual differences and habituation to the conditioning task (Bradley et al., 1993).

Discussion

The current study has successfully replicated the major premises of the Integrated expectancy based model by Lovibond et al. (2008). We modified Lovibond's avoidance conditioning paradigm using social instead of non social stimuli for testing low (LSA) and high socially anxious (HSA) individuals. Consistent with previous findings, we found a decrease in US expectancy and dSCL during avoidance learning and transfer of avoidance response in both LSA and HSA. In addition and most crucial, our modified avoidance paradigm successfully discriminated between LSA and HSA.

First, we found that US expectancy was greater in HSA as compared to LSA for the first trial, wherein a button response was available (Instrumental phase). Crucially, LSA showed a marked lower US expectancy in this trial as compared to the previous A+ trial in the Pavlovian phase (in which no button response was available yet), whereas HSA did not. For this trial, participants did not know which response allowed successful avoidance of the US. Given that participants were informed that one out of the four buttons was the correct avoidance button, the best available contingency information would be: a smaller chance for the US to occur after pressing any button (since there was a 0.25 chance of hitting the correct button). From this perspective, it is remarkable that HSA's US expectancy for this trial remained equally high as in the end of the Pavlovian phase. This finding is consistent with evidence that cognitive interpretation bias (i.e., a more negative interpretation of stimuli) in anxious individuals is maximal under conditions of ambiguous threat (e.g., Chan & Lovibond, 1996). HSA showed such cognitive bias, when a new situation (i.e., the availability of a button response) created an ambiguous contingency. This interpretation is consistent with theories proposing that expectancies are based on (1) present available information, and (2) prior beliefs (Alloy & Tabachnik, 1984; Chater & Oaksford, 2008). In an ambiguous situation, people rely primarily on their own expectations using generalized knowledge, thus resulting in a maximal cognitive bias in anxious participants.

Although this finding may suggest a cognitive interpretation bias in HSA, we cannot rule out that the group difference was affected by a positive bias in the LSA. A positive bias in LSA is particularly evident by our second finding. When the avoidance button became unavailable in the Instrumental phase (A+), HSA showed a marginally higher US expectancy as compared to LSA. This difference between HSA and LSA became more pronounced (and significant) when participants not only had the knowledge that 'the avoidance response became unavailable' (after the experience of an avoidable A(+) trial), but also when they had experienced that threat of US was still present as evidenced by a B+ trial. Interestingly, this result suggests a more accurate estimate of the actual contingency in HSA than in LSA. Since the participants were instructed that it is always the same response button that prevents the US, individuals who experienced an avoidable A(+) trial, would logically have known that avoidance is impossible in an A+ trial (due to the acquired CS US contingency in the Pavlovian phase and the unavailability of the correct response button), and therefore would have expected the US. Lower estimations in LSA suggest a positive bias: they made a more positive interpretation (at least to some extent) that the A cue was no longer as dangerous. Our results are consistent with notions by Taylor and Brown (1988), suggesting that a positive bias can serve as a protection to the self esteem and mental health, and that healthy individuals particularly show positive biases in situations of perceived threat. Our data show that HSA lack such positive bias, which is in line with literature suggesting that social anxiety is associated with an absence of positive thinking (e.g., Hirsch & Mathews, 2000). Such lack of positive bias leads to vulnerability to development and maintenance of psychopathology (Taylor & Brown, 1988).

The fact that the subjective US expectancy for the A+ trial in the Test phase did not differ between LSA and HSA any more, suggests that 1 A+ trial (presented in the Instrumental phase) was needed to 'convince' the LSA about the effectiveness of the avoidance response and that it is necessary to rely on the avoidance response for not receiving the US. This result suggests that, compared to LSA, a lack of positive bias in HSA may lead to higher susceptibility to safety behavior interpretations. This finding is not only relevant for the interpretation of the role of safety behaviors, it is also relevant for learning theories supporting the role of avoidance conditioning in social anxiety.

Finally, we investigated the relationship between social anxiety and extinction like processes. Although previous research showed that anxiety predicted delayed extinction (e.g., Hermann et al., 2002), we only found a marginal effect for a delay in extinction in HSA. This could be related to the use of a non clinical group of high socially anxious participants. Another explanation is that our design was not a 'regular' CS alone extinction procedure, because it included threatening B+ trials and aspects of decreased safety behavior.

Following Lovibond et al. (2008), we measured skin conductance as an indicator for anxiety. Since expectancy has been shown to be a mediator of anxiety (Lovibond et al., 2008), expectancy was hypothesized to reflect the degree of anxiety. Although HSA and LSA differed in expectancy ratings, we failed to find any group differences on dSCL. Skin conductance is a measure for autonomic arousal (not anxiety per se) and is found particularly sensitive to stimulus significance and novelty (Bradley et al., 1993). The absence of difference between HSA and LSA in dSCL for the first trial for which a button response was required, could be partly due to the novelty of button illumination and the requirement to press a button, that could have led to heightened skin conductance for both HSA and LSA. A similar reason might account for the single A+ trial in the Instrumental phase. This trial likely elicited enhanced skin conductance in both HSA and LSA because the avoidance response became unavailable. This is supported by the elevated dSCL for both the first A(+) trial and the A+ trial in the Instrumental phase compared to other trials in other phases (see Figs. 3, 4). Future studies should use more valid and accurate measures of anxiety, such as fear potentiated startle (Bradley et al., 1993).

To our knowledge, this is the first study addressing avoidance learning and cognitive expectancy in relation to social anxiety. We replicated and extended the findings of Lovibond et al. (2008) by showing that the avoidance learning paradigm using social stimuli successfully differentiates high socially anxious from low socially anxious individuals. It is important to note, that these findings should be replicated using a priori selected groups and also allowing studying sex differences.

Despite this limitation, the present findings stress the importance to conduct further research on cognitive processes in social anxiety that play a role in avoidance learning. Social avoidance is the major maintaining factor in SAD. It prohibits exposure to social situations and therewith extinction of the social fear. The present findings concerning cognitive interpretation bias in HSA encourages research on directional relation of interpretation bias and anxiety and the training of interpretation biases (Salemink, Van den Hout, & Kindt, 2006, 2007). Future studies should explore whether similar mechanisms may play part in other anxiety disorders, such as post traumatic stress disorder or specific phobia. One therapeutic implication of our findings is that cognitive and behavioral treatments for anxiety might benefit from not only including

procedures aimed at altering negative beliefs, but also procedures directed at the generation of positive inferences, especially under conditions of high threat perception.

In conclusion, this study successfully replicated previous findings with a modified avoidance paradigm using social stimuli. The paradigm also successfully differentiated between HSA and LSA. First, HSA showed *higher* US expectancy than LSA when high uncertainty about successful avoidance or ambiguity of a situation was present. This suggests a cognitive interpretation bias in high socially anxious individuals under the condition of ambiguous threat. Second, when the avoidance response became unavailable, LSA showed *lower* US expectancy than HSA, particularly under high threat perception. This suggests a positive bias in low socially anxious individuals. A lack of such positive bias in high socially anxious individuals may lead to higher susceptibility to safety behavior interpretations. Together, these findings support the role of cognitive processes in avoidance conditioning and social anxiety and underscore the relevance to encounter avoidance learning in studying social anxiety.

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