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The influence of state anxiety on the acquisition and extinction of fear

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ABSTRACT

Objective: Fear conditionability has been found to be elevated in samples with high trait anxiety or anxiety disorders. Since these studies provide circumstantial evidence for a causal link between anxiety and conditionability we examined fear conditionability after experimental induction of anxiety in two experiments.

Method: In **Experiment 1**, 60 participants were randomized to one of two film conditions inducing an anxious or happy emotional state. They subsequently underwent a differential conditioning acquisition procedure. Two pictures of faces served as conditioned stimuli (CS+ and CS–), and an electric stimulus served as aversive unconditioned stimulus (US). In **Experiment 2**, after similar acquisition procedure as used in **Experiment 1**, 90 participants watched one of three films (anxious, neutral, happy) prior to an extinction procedure. In both studies, skin conductance response (SCR) served as measure of fearful responding.

Results: Conditioning was successful in both studies. In **Experiment 1**, the anxious group exhibited decreased SCRs to both CS+ and CS– during acquisition. In **Experiment 2**, during extinction SCRs to both CSs were highest in the anxious group, intermediate in the neutral, and lowest in the happy group.

Discussion: State anxiety did not enhance conditionability during acquisition or reduce the extinction procedure. However, individuals in an anxious state show less responding during fear learning, but more responding during unlearning. Thus, our results suggest that state anxiety changes the sensitivity with which individuals react to stimuli presented in different contexts.

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1. Introduction

Fear conditionability refers to the individual ability to learn the association of a neutral (conditioned) stimulus (CS) with an aversive (unconditioned) stimulus (US) and/or the ability to extinguish this association. Individuals with enhanced fear conditionability typically show stronger conditioned responses (CR) to the conditioned stimuli (CSs) during the acquisition and/or extinction (Orr et al., 2000).

Enhanced fear conditionability has been put forward as a potential etiological factor for the development of anxiety disorders, because it could explain why upon exposure to fearsome incidents only some individuals develop pathological fears, whereas others show an adaptive fear response (Orr et al., 2000). To establish enhanced conditionability in patients with anxiety disorders experimentally, patients and healthy controls typically undergo a classical conditioning paradigm, in which one CS is

paired with an US during the acquisition phase (the CS+) and another CS is not (the CS–). During a subsequent extinction phase, both CSs are presented without the US (e.g., Blechert, Michael, Vriends, Margraf, & Wilhelm, 2007; Michael, Blechert, Vriends, Margraf, & Wilhelm, 2007). Such studies have revealed encouraging evidence for enhanced conditionability – and slowed extinction in particular – in patients with different anxiety disorders relative to healthy control samples. Such cross-sectional patient studies do, however, not establish the causality between anxiety (disorders) and enhanced conditionability since it remains unclear if enhanced fear conditionability is an etiological precursor of the disorder or an epiphenomenon of the active disease process. Further, such studies do not clarify which mechanism increases conditionability in patients with anxiety disorders.

Differences in conditionability between anxiety patients and healthy controls may be the result of stable temperament factors that are partially heritable. Several studies have shown that individuals high in trait anxiety show more rapid and stronger aversive conditioning (e.g., see Levey & Martin, 1991, for an early review; Zinbarg & Mohlman, 1998). Recently Barrett and Armony (2008) compared healthy subjects with high versus low trait anxiety and found higher anxiety responses only during extinction in high trait

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anxious participants. Also Otto et al. (2007) found an association between conditionability and subsyndromal characteristics of anxiety disorders such as worry and anxiety sensitivity (Otto et al., 2007). Thus, both high trait anxiety as well as being diagnosed with an (subsyndromal) anxiety disorder may operate as facilitators of conditioning.

Studies relating clinical anxiety and/or trait anxiety to conditionability only provide circumstantial evidence that anxiety per se is a mechanistic (or causal) factor for increased conditionability. A third variable, such as neurotransmitter system differences between groups or personality variables may be responsible for the observed differences. Only experimental variation of a factor in a randomized design can establish a causal link between this factor and the outcome (Kraemer et al., 1997). Thus, to convincingly test if anxiety itself is a facilitator of conditioning, anxiety/fear needs to be experimentally manipulated before conditioning effects are measured. To our knowledge, only one study related to this question has been conducted. Jackson, Payne, Nadel, and Jacobs (2006) induced stress with a social anxiety stressor 1 h before a conditioning paradigm. Only in men, stress exposure increased conditioned responding (measured by skin conductance response, SCR) during acquisition and extinction (Jackson et al., 2006). Interpretability of study results is limited, however, since the 1 h interval between the stressor and the conditioning had resulted in reported anxiety having decreased to normal at the start of the conditioning task. Clearly, to test the influence of anxiety on conditionability anxiety needs to be induced immediately before conditioning starts.

Taking these considerations into account, we investigated the influence of state anxiety on conditionability in healthy subjects in a differential fear conditioning paradigm. We tested the assumption that anxiety enhances fear conditioning during acquisition and particular reduces extinction. Due to the temporary nature of experimentally induced emotional states (Gilet, 2008) it appeared necessary to study their effects separately for acquisition and extinction. In Experiment 1, subjects were randomized to one of two film conditions inducing an anxious or happy emotional state. They subsequently underwent a conditioning acquisition procedure. In Experiment 2, subjects watched one of three films (anxious, neutral, happy) following a similar acquisition phase, and immediately preceding an extinction phase. In both studies two pictures of faces served as conditioned stimuli (CS+ and CS–), and an aversive electric stimulus served as unconditioned stimulus (US). SCR served as the dependent variable since it is the best-established outcome measure of fear in human fear conditioning studies.

2. Experiment 1: acquisition of conditioned fear

Experiment 1 investigated fear conditionability in subjects with either an anxious or a happy induced emotional state during the acquisition phase of a differential fear conditioning paradigm. According to previous results indicating enhanced conditionability in (subsyndromal) anxiety we expected higher conditionability in the anxious compared to the happy emotional state.

2.1. Method

2.1.1. Participants

Female participants were recruited at the faculty of psychology of the University of Basel. We included only women, as the meta-analysis of Westermann, Spies, Stahl, and Hesse (1996) has shown that emotional state induction can be achieved more reliably in women compared to men. Participants were psychology undergraduates recruited using advertisements on websites and pin

boards of the University of Basel. The advertisement described that the study was about human decision making and judging. Seventy-nine women (age range 18–40 years, $M = 23.0$, $SD = 4.6$) provided written consent for participation in the study. Data from the first 10 participants were discarded since the intertrial intervals proved too short for sufficient recovery of the skin conductance levels, requiring adjustment of the procedure. Data from another 5 participants were lost due to equipment malfunctioning. Finally, 7 participants were electrodermal nonresponders and therefore excluded from the analyses. Of the 55 women who were included in the analyses 28 were randomly assigned to the anxiety state group and 27 to the happiness state group. Participants underwent the 1-h protocol in exchange for course credits. Table 1 displays data on demographics, psychometric data and characteristics of the conditioning task of the two groups. No significant differences were found between groups in age ($t = 0.43$), psychopathology (trait anxiety, $t = 0.60$; social anxiety, $t = 1.25$; and depression, $t = 0.24$), or the objective strength and subjective intensity as well as startling properties of the electric stimulus (US; $\chi^2 = 7.21$; $t = -0.144$; and $t = 0.93$, respectively), nor for contingency awareness ($\chi^2 = 1.06$).

2.1.2. Procedure

2.1.2.1. Selection of the CS+, CS– and control stimulus. Participants were assessed individually. After informed consent was obtained, the electrodes for psychophysiological measurement were attached (see Apparatus and physiological recordings section below). Then participants were invited to watch a set of 60 color pictures of neutral human faces (30 male) on a computer screen one by one by clicking the mouse. All photographs (256 colors, 640×480 pixel resolution, 13×19 cm size, viewing distance 1 m) were presented against a black background on a 19 inch Monitor (100 Hz refresh rate). Then they watched the pictures again and evaluated them on a valence and arousal Likert-type, 21-point scale ($-100 =$ 'very unpleasant', $0 =$ 'neutral', $+100 =$ 'very pleasant'; and $-100 =$ 'very calming', $0 =$ 'neutral', $+100 =$ 'very arousing'). The experimenter used these ratings to select appropriate CS+, CS–, and control stimuli (see below for the selection procedure).

2.1.2.2. Adjustment of the electric stimulation (US). After picture ratings electrodes for the electric stimulation were attached to participants' right forearm. Together with the experimenter, participants increased the intensity of the electric stimulation to a level that they described as being "unpleasant and demanding some effort to tolerate". Between 3 and 6 electric stimuli were applied to arrive at the final intensity. After a 5-min adaptation period, a rating dial was introduced. The rating dial was a linear slider on which a visual analogue scale was affixed; the lower

Table 1
Descriptive data of participants and conditioning parameters in Experiment 1.

	Mood	
	Anxious <i>N</i> = 28	Happy <i>N</i> = 27
Age in years, <i>M</i> (<i>SD</i>)	22.3 (3.6)	22.8 (5.5)
STAI-trait anxiety, <i>M</i> (<i>SD</i>)	36.6 (7.8)	38.0 (6.9)
Social interaction anxiety scale, <i>M</i> (<i>SD</i>)	19.2 (9.9)	23.0 (8.9)
Beck depression inventory, <i>M</i> (<i>SD</i>)	7.2 (6.8)	7.7 (5.7)
Electrical stimulus intensity (%)		
1 mA	7	0
2 mA	25	11
5 mA	61	59
10 mA	7	30
Subjective US-intensity, <i>M</i> (<i>SD</i>)	3.18 (0.39)	3.04 (0.34)
Subjective US-startle, <i>M</i> (<i>SD</i>)	3.40 (0.79)	3.59 (0.80)
Contingency awareness %	100	96

Note: STAI = Spielberger state-trait anxiety scale.

anchor label was –100 and the upper label was +100. Participants then gave a retrospective rating of US aversiveness (anchor labels: –100 = *very slightly unpleasant* to +100 = *extremely unpleasant/painful*; no anchor label for 0).

2.1.2.3. Happy and anxious state induction. To induce either an anxious or happy emotional state, participants watched one of two 10-min films.² This type of procedure has been shown to be effective in eliciting different emotional states in most people (Gerrardshesse, Spies, & Hesse, 1994; Gross & Levenson, 1995; Philippot, 1993; Westermann et al., 1996). Preceding the film participants filled out 4 paper-and-pencil visual analogue scales with the anchors ‘absolutely not anxious’ – ‘very anxious’, ‘absolutely not happy’ – ‘very happy’, ‘absolutely not negatively aroused’ – ‘very negatively aroused’³ and ‘absolutely not positively aroused’ – ‘very positively aroused’. We emphasized that we were only interested in how they felt at this very moment and that they should answer as spontaneously as possible. Participants were briefly informed about the content of the following film and asked to watch the film on the monitor while the sound was delivered through headphones. We supervised subjects’ compliance with the instruction to carefully watch the film using a video camera. All subjects complied well with the instruction. Immediately after the film participants filled out the 4 visual analogue scales again.

2.1.2.4. Conditioning task. While participants were watching the film the experimenter prepared the stimulus material for the conditioning task. The experimenter selected the pictures that were rated as most neutral by the participant. These were randomly assigned to serve as CS+ and CS–. Pictures were presented using a customized script written in E-Prime (Psychology Software Tools, Inc., Pittsburgh, PA, USA). The experimenter entered into the script which pictures were assigned as CS+ and CS–.

The E-Prime program was started and the conditioning task commenced with the instructions that two pictures of faces would be presented repeatedly, and only one of them would be accompanied by the electric stimulus. The conditioning task consisted of an acquisition phase, in which each the CS+ and CS– were presented eight times. CS duration was 8 s, and intertrial interval was 18 ± 2 s (determined at random). Each CS+ was immediately followed at stimulus offset by a 500-ms US. The CS– stimulus was always presented without subsequent US. Following the acquisition phase, the contingency awareness was assessed for the CS+, the CS–, and the control stimulus by asking the participants which of the three pictures was paired with the US.⁴

2.1.3. Apparatus and physiological recordings

The experiment took place in a temperature-controlled, fully lit, sound-attenuated room electrically connected to an adjacent control room in which the experimental apparatus was located. An electrical stimulator (constant current unit, Biopac Systems, Inc., Goleta, CA) was used to deliver the US via Ag/AgCl electrodes at the right lower arm. Stimulus delivery and physiological data acquisition were controlled by two computers that used E-Prime and *Acknowledge* software (Biopac Systems, Inc., Goleta, CA).

We recorded physiological channels and rating dial information using the Biopac MP150 system at a sample rate of 1000 Hz. We obtained skin conductance (SC) using 11-mm inner diameter Ag/AgCl electrodes filled with isotonic electrode paste. Electrodes were placed on the middle phalanx of the index and middle fingers of the left hand. Respiration (belt around the thorax) and movement (accelerometry sensor on the shoulder) were measured to enable detection and exclusion of spurious skin conductance responses (SCRs).

2.1.4. Data reduction and statistical analyses

2.1.4.1. SCR. Physiological data reduction was conducted using a customized system of computer programs (ANSLAB, available at the University of Basel). An SCR was calculated by subtracting the average SC level (SCL) for the 2 s immediately before CS onset from the maximum SCL recorded between 8 s after CS onset and CS offset. The body movement and respiration channels were displayed in parallel to the SC channel. SCRs, caused by deep inhalations or large trunk movement, were excluded from the analyses.

2.1.5. Statistical analyses

A manipulation check for emotional state induction was conducted using a General Linear Model (GLM) for repeated measures. The within-subject factor Emotion Type consisted of the four emotion scales (anxious, negatively aroused, happy, and positively aroused). The within-subject factor Time consisted of the measurement points before and after the emotional state induction. The between-subject factor Group consisted of the emotional state groups (happy versus anxious). A significant Group \times Time interaction for the combined scale (disregarding emotion type) and for each scale separately would indicate that the emotional state induction worked well. To specify which means are significantly different from one another, we performed Post-hoc Tukey’s tests.

For the analysis of SCRs during acquisition we used a random coefficient model (Singer & Willett, 2003), a type of mixed effects model. Mixed effects models are recommended for the analysis of psychophysiological repeated-measures data since they handle missing data effectively and are more efficient and parsimonious (Baijella, Sloan, & Heitjan, 2000).⁵ The model included CS-type (CS+, CS–) and Trial (eight trials for each CS-type) as within-subjects factors and Emotion State (happy versus anxious) as between-subjects factor. The factor Trial contained a linear and a quadratic trend component allowing for a curvilinear relationship between SCR and trial number, which was expected since during acquisition the SCR for CS+ usually increases in the first trials and then slowly decreases (due to habituation). The SCR for CS– usually decreases across all trials. The model also included random coefficients for intercept and slope thereby allowing each individual to have his/her own linear and quadratic trajectories. A significant interaction effect between Trial, CS-type and Emotion State would indicate a difference in conditionability. SCR values were square root transformed to better meet model assumptions. An alpha level of 0.05 determined statistical significance.

2.2. Results

2.2.1. Emotional state induction

The main and interaction effects of anxiety, negative arousal, happiness and positive arousal ratings before and after the emotion state induction of both groups are presented in Table 2. For the

² The frightening film included a part of the horror film “Shining” (Kubrik, 1980) or “Night watch” (Bornedal, 1998). The happy film included parts of different films (e.g., “When Harry Met Sally” (Reiner, 1989), “Rowan Atkinson, Live” (Schlamme, 1995), “Jungle Book” (Reitherman, 1967)).

³ In the German and Swiss language the term “aroused” can have positive and negative connotations. We used the words “aufgeregt” for negative arousal and “beschwingt” for positive arousal.

⁴ Before the contingency awareness test, the participants also rated the CS+, the CS– and the control stimulus for valence. These results are not presented, but can be given on request.

⁵ For the tests of fixed effects, the denominator degrees of freedom are not integers. This is because these statistics do not have exact F distributions. The values for denominator degrees of freedom are obtained by a Satterthwaite approximation (SPSS Inc., 2005).

Table 2

Statistics for anxiety, negative arousal, happiness, and positive arousal ratings for the two film groups before and after the emotional state induction (ESI) in Experiment 1.

	Group				Group	Time	Group × Time
	Anxious		Happy				
	Before ESI	After ESI	Before ESI	After ESI			
	M (SD)	M (SD)	M (SD)	M (SD)			
Anxiety	32.36 (22.92)	51.75 (18.84)	36.78 (23.18)	24.15 (19.96)	5.11*	1.71	38.29***
Negative arousal	45.11 (22.69)	61.43 (20.84)	53.04 (24.00)	46.11 (26.08)	2.92	0.42	17.85***
Happiness	32.00 (22.29)	38.64 (16.24)	57.41 (15.47)	73.90 (13.86)	74.93***	11.71***	1.87
Positive arousal	45.21 (16.94)	32.46 (17.10)	49.04 (19.98)	67.04 (20.65)	18.44***	1.26	43.08***

* $p < 0.05$, *** $p < 0.001$.

scales anxious, negative aroused and positive aroused the expected interactions between the factors Group and Time were significant, indicating successful emotional state induction. For the happy emotional state, there were significant main effects for the factors Group and Time. The happiness group was happier than the anxious group at both time points. Since skin conductance level (SCL) is frequently correlated with SCRs we compared the SCLs of both emotional state groups after emotional state induction. There were no differences between the two groups in baseline SCL on the first acquisition trial (anxious group $M = 9.17 \mu\text{S}$, $SD = 3.83$; happy group $M = 10.74 \mu\text{S}$, $SD = 3.98$; $t = 1.49$, $p = 0.14$).

2.2.2. SCR

Observed means of CS+ and CS− across the eight trials of the acquisition are presented in Fig. 1. For acquisition we found a significant interaction effect between the quadratic term of trial and CS-type ($t(737) = 4.30$, $p < 0.001$), because differences between CS+ and CS− were smaller at the beginning trials and at the last trials of the acquisition phase compared with the intermediate trials of this phase (see Fig. 1). For the happy emotional state this interaction was thereby more pronounced as shown by the significant three-way interaction between CS-type, Trial and Emotion State ($t(738) = 2.20$, $p = 0.028$). There was also a significant interaction between CS-type and Emotional State ($t(737) = 4.05$, $p = 0.044$) with differences between the two emotional states being more pronounced for CS+ compared to CS−, indicating that the happy emotional state group showed enhanced discrimination between the CSs compared to the anxious group. In addition, there were significant main effects for all three independent variables pointing to a decrease in SCR across trials ($t(53) = -8.13$, $p < 0.001$), and to higher SCR values for CS+ than CS− ($t(735) = -13.08$, $p < 0.001$), and the happy than anxious emotional state ($t(53) = -3.46$, $p < 0.001$), respectively.

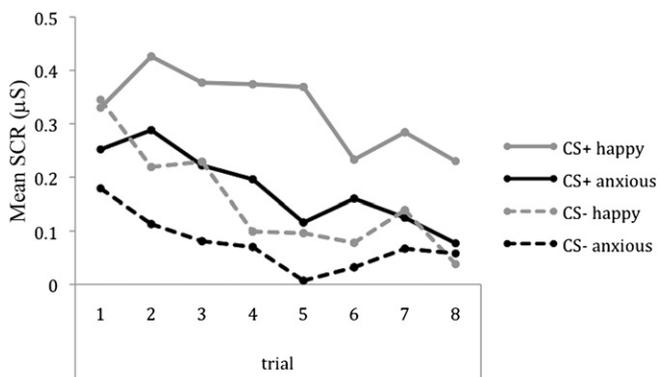


Fig. 1. Mean SCRs (in μS) for CS+ and for CS− during the acquisition phase for the happy and anxious emotional state groups in Experiment 1.

2.3. Discussion

Experiment 1 revealed a significant effect of the film emotion induction on SCRs during the fear acquisition procedure. However, unexpectedly, an anxious emotional state was not associated with increased conditionability (i.e. higher SCRs to CS+ than CS− trials), but rather it was associated with lower CRs for both conditioned stimuli and decreased discriminative learning. This result seems to contradict a recent meta-analysis that showed enhanced conditionability during acquisition in anxiety patients (Lissek et al., 2005). This difference between our results and the results of the meta-analysis of Lissek et al. (2005) might be explained by the different conditioning design of most of the studies included in this meta-analysis. Those studies used a single CS design that differs from differential conditioning paradigms used in many human conditioning studies, and which was also used in Experiment 1. Further, other previous research that employed similar conditioning procedures to our study either comparing anxiety patients to healthy controls (Hermann, Ziegler, Birbaumer, & Flor, 2002; Michael et al., 2007; Orr, Metzger, & Pitman, 2002; Peri, Ben-Shakhar, Orr, & Shalev, 2000; Pitman & Orr, 1986) or healthy samples with high trait anxiety versus low trait anxiety (Barrett & Armony, 2008) did not find group differences in conditionability during the acquisition phase (fear learning), only during the extinction phase (fear unlearning). Whereas, these studies did not find any differences in fear learning, the present study found decreased fear learning in anxious participants and significant lower SCR in an anxious state.

How can our main effect of the emotional state on the SCRs be explained? Basoglu et al. (1997) found that torture victims, who knew about an impending trauma (e.g., what kind of torture techniques would be used), who had torture experience, or who trained stoicism techniques were less likely to develop post-traumatic stress disorder than those, who did not have this kind of “psychological preparedness” for aversive events. Such psychological preparedness is based, in part, on evidence of animal studies that prior exposure to controllable stressors reduced fear conditioning. Indeed, Baratta et al. (2007) showed that rats that were initially exposed to escapable shocks showed subsequently reduced fear conditioning both to a context and to a discrete CS relative to groups receiving no prior shocks. According to the psychological preparedness theory, it might be possible that participants who watched the fear-inducing film may have applied emotion regulation strategies such as diverting their attention or cognitive reappraisal (Gross & Thompson, 2007) that reduced the negative impact of this film on their emotional well being. The use of these strategies may have carried over to the conditioning part of the experiment, thus ‘immunizing’ these participants to some degree against the fear-inducing effects of the US and reducing their UR.

Moreover, we found that participants in a positive mood showed stronger discrimination between the CS+ and the CS−.

Given that fear learning is considered to be a highly adaptive response to aversive events that ensures survival in changing and novel environments (LeDoux, 1995), our results indicate that a positive emotional state may improve this adaptive response and enhance conditionability. Further, decreased SCRs to both CSs might still predict enhanced anxiety and avoidance. For example, Grillon (2002) found that deficits in discrimination between the CS+ and CS– during acquisition were associated with increased signs of anxiety after one week and even after one month.

Based on the contention that a positive mood enhances conditionability, it can further be assumed that a positive emotional state should promote extinction effects as well. Or in other words, if an anxious state decreases fear learning, it might also decrease fear unlearning. Thus, in line with the results of Experiment 1 and in line with existing findings of slower extinction (and not enhanced acquisition) in patients with an anxiety disorder or high trait anxiety, we expected that individuals in a positive emotional state would show enhanced extinction and individuals in an anxious state would show deficits in extinction. Therefore, in Experiment 2 we investigated the influence of an anxious emotional state on extinction.

3. Experiment 2

Based on our assumptions that in Experiment 1 the positive emotional state improved the adaptive response to aversive events (LeDoux, 1995), and that patients with anxiety disorders mostly show slowed extinction rather than enhanced fear acquisition (e.g., Michael et al., 2007), we hypothesized that an anxious state is associated with stronger CRs during extinction compared to a happy or neutral emotional state. To investigate this we induced the emotional state between an acquisition and extinction phase of a similar differential conditioning paradigm as was used in Experiment 1. To increase the conclusiveness of the design we included a neutral emotional state group.

3.1. Method

3.1.1. Participants

Recruitment procedures were similar to Experiment 1. Participants were recruited at the faculty of psychology of the University of Basel. The advertisement described that the study was about human decision making and judging. Participants received course credits for participation. Ninety-four women provided written consent for participation in the study. Data from 7 participants were removed from analyses owing to technical failures. Of the 87 participants included in the analyses, 30 were randomly assigned to the anxiety state group, 30 to the happiness emotional state group and 27 to the neutral emotional state group. Descriptive data are presented in Table 3. No significant differences were found between groups in age ($F = 2.09$), psychopathology (trait anxiety, $F = 0.57$; social anxiety, $F = 0.06$; depression, $F = 0.55$), or the strength and subjective intensity and startling properties of the electric stimulus ($\chi^2 = 4.54$; $F = 0.38$; $F = 0.05$, respectively), nor in contingency awareness ($\chi^2 = 1.09$).

3.1.2. Procedure

3.1.2.1. Selection of the CS+, CS–, and control stimulus. The procedure for selection of pictures was identical to the one described in Experiment 1, except for the number of pictures that the participant could select from. The 16 most neutral pictures of Experiment 1 were used for Experiment 2. The procedure of adjustment of the electric stimulation (US) was identical to the one of Experiment 1.

Table 3

Descriptive data of participants and conditioning parameters in Experiment 2.

	Mood		
	Anxious	Neutral	Happy
	N = 30	N = 27	N = 30
Age, M (SD)	23.6 (4.4)	23.6 (5.0)	21.5 (2.4)
STAI-Trait anxiety, M (SD)	47.23 (3.30)	47.74 (3.19)	46.87 (2.79)
Social interaction anxiety scale, M (SD)	18.07 (10.35)	19.03 (9.53)	18.78 (12.69)
Beck depression inventory, M (SD)	10.07 (7.79)	8.85 (5.06)	8.30 (6.75)
Electrical stimulus intensity (%)			
0.5 mA	10	4	7
1 mA	20	30	27
2 mA	37	44	47
5 mA	27	15	10
10 mA	7	7	10
Subjective US-intensity, M (SD)	56.70 (1.44)	54.41 (1.00)	53.92 (1.40)
Subjective US-startle, M (SD)	61.51 (1.77)	59.92 (1.81)	60.96 (2.03)
Contingency awareness (%)	100	96	97

Note: STAI = Spielberger State-Trait Anxiety Scale.

3.1.2.2. Conditioning task. The conditioning task commenced with the instructions that two pictures would be presented repeatedly, and one of them would occasionally be accompanied by the electric stimulus. Participants were informed that a short film would be presented during this task. The conditioning task consisted of a habituation, an acquisition, and an extinction phase. In the habituation phase, both the CS+ and CS– were presented 3 times. In the acquisition and extinction phase, both the CS+ and CS– were presented 6 times. CS duration was 8 s, and the intertrial interval was 18 ± 2 s (determined at random). During acquisition, each CS+ was immediately followed at stimulus offset by a 500-ms US. Otherwise, all stimuli were presented alone.

The films for inducing the happy, anxious, or neutral emotional states were presented between the acquisition and extinction phase. This procedure and the films were identical to the ones described in Experiment 1. The film “Epidermiszellkultur” (translation “epidermis cell culture”, Thiele, 1987) was used for the neutral emotional state induction. During the film the electrodes were unattached. After the extinction phase the participants were debriefed and dismissed.

3.1.3. Statistical analyses

Analyses for emotional state induction are identical to the statistical analyses in Experiment 1. For the analysis of SCRs during the habituation and acquisition we used a mixed effects model with CS-type (CS+, CS–) and Trial (3 habituation trials and six acquisition trials for each CS) as within-subject factors and emotional state (happy, anxious, and neutral) as between-subjects factor. No significant effects involving the emotional state groups were expected. For the extinction phase, we used the same random coefficient model as in Experiment 1 with CS-type (CS+, CS–) and Trial (6 extinction trials) as within-subject factors and Emotion State (happy, anxious, and neutral) as between-subject factor. However, we also included the last SCR values of the acquisition phase for each CS type as covariate (see results in Section 2.2.2.). For Emotion State we did not perform an omnibus test for unspecific differences among the three levels but instead tested for a more specific contrast suggesting a linear change of the outcome across emotional states in the order happy, neutral, anxious. In contrast to Experiment 1, this model included only a linear trend component, as for extinction no quadratic effect was expected (SCR for CS+ is expected to decrease linearly). An alpha level of 0.05 determined statistical significance.

Table 4

Statistics for anxiety, negative arousal, happiness, and positive arousal ratings for the three film groups before and after the emotional state induction (ESI) in Experiment 2.

	Group						Group	Time	Group × Time
	Anxious		Neutral		Happy				
	N = 30		N = 30		N = 27				
	Before ESI	After ESI	Before ESI	After ESI	Before ESI	After ESI			
	M (SD)	M (SD)	M (SD)	M (SD)	M (SD)				
Anxiety	31.52 (22.99)	43.72 (26.46)a	29.64 (21.07)	7.19 (17.09)b	24.94 (18.92)	10.86 (14.04)b	12.20***	11.20***	19.64***
Negative arousal	43.75 (24.50)	55.98 (24.70)b	43.63 (18.07)	28.81 (19.05)a	43.61 (23.75)	24.13 (19.60)a	7.55***	6.31*	11.51***
Happiness	49.23 (20.44)	33.54 (18.51)b	46.91 (21.85)	72.59 (18.64)a	49.42 (22.65)	43.49 (21.62)b	7.88***	0.47	41.24***
Positive arousal	31.43 (19.99)	29.25 (22.13)b	32.54 (20.58)	56.21 (21.19)a	41.42 (21.93)	32.11 (24.42)b	3.00	3.85*	19.358***

* $p < 0.05$, *** $p < 0.001$.

a, b: different letters denote significant differences between groups with post hoc Tukey-HSFigure legends.

3.2. Results

3.2.1. Emotional state induction

The main and interaction effects of anxiety, negative arousal, happiness and positive arousal ratings before and after the emotional state induction for both groups are presented in Table 4. For all rating scales the expected interaction between the factors Group and Time were significant, indicating successful emotional state induction. Similar to Experiment 1 there were no differences in SCL between groups after emotion induction.

3.2.2. SCR

No significant effects were found for CS-type or Emotion State during habituation. Regarding acquisition, a significant interaction between the factors CS-type and Trial ($F(5, 582) = 2.84, p = 0.015$) indicated successful conditioning with participants differentiating between CS+ and CS- during acquisition. As expected, no main or interaction effects emerged that involved emotional state group (see Fig. 2). Although not significant at the end of acquisition the group that was induced in an anxious state after acquisition, showed stronger SCR to the CS+ and higher differentiation between the CS+ and CS-. Therefore we included the SCRs of the last acquisition trial of each CS-type as a covariate in the following analysis.

Fig. 3 displays the observed SCR values for CS+ and CS- across trials during the extinction phase. There was a significant interaction between CS-type and Trial ($F(1,816) = 10.05, p = 0.002$): SCR values, which were higher for CS+ than for CS- at the beginning of the extinction phase, decreased in both CS types, eventually reaching comparable extinction levels (floor effect). A main effect for Emotion State ($F(1,85) = 5.16, p = 0.026$) revealed that, averaged across both CS-types and all trials, SCR values linearly increased from happy to neutral to anxious (see Fig. 3). Other interactions were not significant ($p > 0.5$ for all tests performed).⁶

3.3. Discussion

Contrary to our prediction, the anxious group did not show reduced extinction. However, we found that compared to happy participants, participants in an anxious state showed stronger SCRs to both CSs at the beginning and during the whole phase of extinction. Thus, in general, an anxious state enhances responding to both CSs. This implies that anxious individuals show enhanced sensitivity to all stimuli that were previously presented in an aversive context rather than reduced extinction to a fear cue that

was paired with an aversive event. Considered from a more practical point of view, the data suggest that anxious individuals need more extinction trials than individuals in a happy or neutral emotional state to reduce their responding to cues from aversive contexts.

4. General discussion

The present two experiments investigated the influence of state anxiety on fear conditionability. We examined if women with state anxiety differ from women with state happiness (or a neutral emotional state) in their CRs to both paired and unpaired stimuli during the acquisition phase and during the extinction phase of a fear conditioning procedure. The most intriguing finding of these experiments is that state anxiety decreased conditionability during acquisition and enhanced responding to both CSs during extinction. Thus, although individuals in an anxious state showed less responding during fear learning, they showed elevated fear responses to both CSs during the entire phase of extinction and thus would need more extinction trials to reach the same response level as individuals in a neutral or happy emotional state.

The present absence of enhanced conditionability during acquisition in state anxiety fits well to the findings of others that

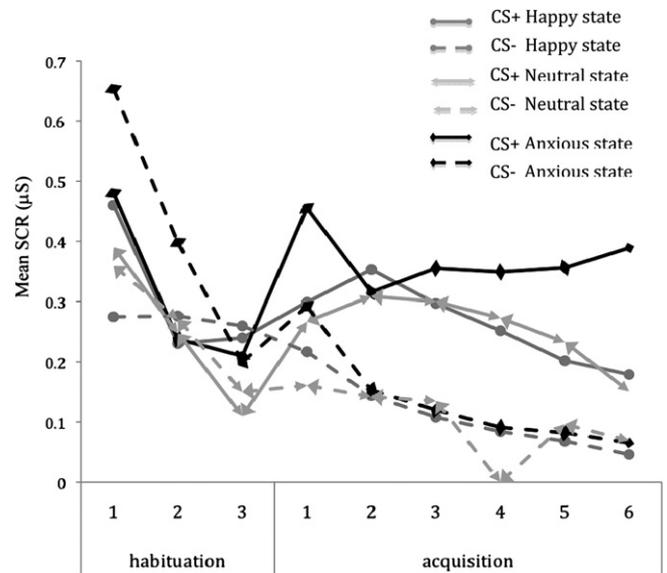


Fig. 2. Mean SCRs (in µS) for CS+ and for CS- during the habituation and acquisition (before emotional state induction) for the anxious, neutral, and happy emotional state groups in Experiment 2.

⁶ The same pattern of results was obtained when the SCRs of the last acquisition trial of each CS-type were not included as a covariate.

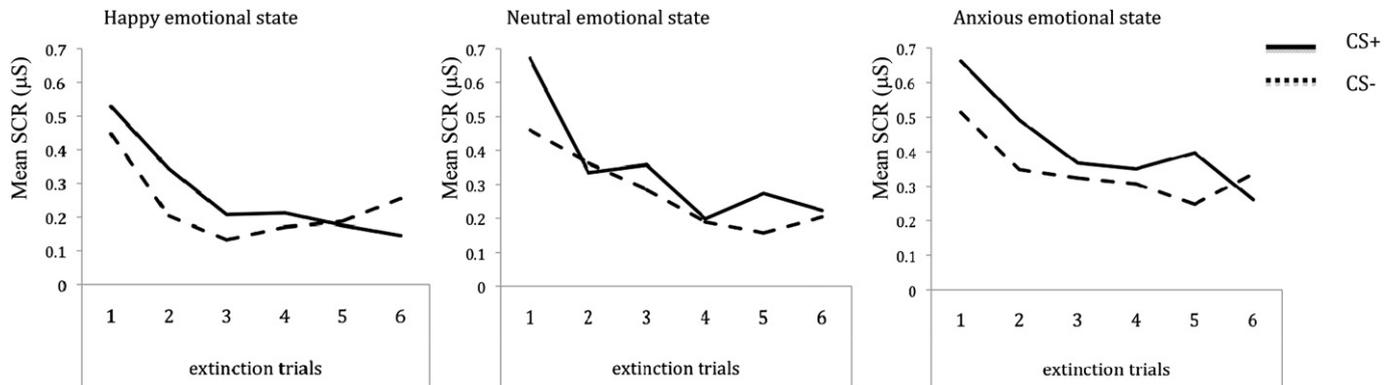


Fig. 3. Mean SCRs (in μS) for CS+ and for CS- during the extinction phase for the happy, neutral, and anxious emotional state groups in Experiment 2.

also did not find enhanced conditionability during acquisition but reduced extinction in patients with anxiety disorders or samples with high trait anxiety (Barrett & Armony, 2008; Blechert et al., 2007; Hermann et al., 2002; Michael et al., 2007; Orr et al., 2002; Peri et al., 2000; Pitman & Orr, 1986; Wessa & Flor, 2007). Moreover, the current finding that individuals with state anxiety still show stronger fear responding to both CSs at the end of extinction in a differential fear conditioning paradigm is in line with two previous studies that found larger responses to unpaired and paired cues during extinction in anxious individuals (Peri et al., 2000; Wessa & Flor, 2007). Yet the present study is the first to demonstrate enhanced responding effects of anxiety during extinction for both CSs using an experimental manipulation of state anxiety.

Our result of enhanced responding to both CS-types in an anxious mood indicates that an individual in an anxious state would need more extinction trials (or exposure sessions) to reach the same effect as individuals in a neutral or happy emotional state. This interpretation is plausible given several studies revealing an association between the onset of anxiety disorders and a stressful period in the individual's life (Last, Barlow, & O'Brien, 1984; Magee, 1999; Marks, 1987; Martensdottir, Svensson, Svedberg, Anderberg, & Von Knorring, 2007; Munjack, 1984). Individuals who experience stressful life events at the time of the aversive experience will have relatively enduring elevated background anxiety levels that may attenuate the normal recovery process through higher responsivity to cues associated with aversive contexts, which might increase the period of recovery compared to individuals without stressful life events, resulting in the worst case in a full-blown Anxiety Disorder.

Our results do not clarify the exact mechanism explaining the relationship of state anxiety and responding during an extinction phase. Theoretically, an anxious state may have effects on the processing of threatening information potentially important for a conditioning procedure. Davey and Matchett (1994) found increased CR strength during extinction following US rehearsal in participants with high state anxiety. Thus, anxiety could increase rehearsal of the US that in turn could enhance CRs during extinction.

Further, an anxious state has been associated with the selective processing of emotional or threatening material (Butler & Mathews, 1983; Mathews & Macleod, 1994). Our finding of enhanced responding to the CS+ as well as to the CS- might reflect a general overestimation of danger, which may reflect an association between an anxious state and the interpretation of ambiguous events as threatening (Eysenck & Mogg, 1992).

Although increased processing of threatening information might explain the enhanced responding during extinction, skin conductance as an indicator of fear as a dependent variable does not exclude a general arousal effect. However, skin conductance is

a standard measure in human fear conditioning. Further from our point of view, the hypothesis of a general arousal effect through the film seems unlikely. First, there were no differences in skin conductance levels between the groups during the baseline of the first trial of acquisition in Experiment 1. Second, after using the same films for the emotion induction in Experiment 1 and Experiment 2, the SCRs main effects showed an opposite effect; anxious participants showed lower SCRs in Experiment 1 and higher SCRs in Experiment 2. For happy participants the opposite happened (higher SCRs in Experiment 1 and lower SCRs in Experiment 2). Third, the neutral group of Experiment 2, which had not seen any arousing film, showed intermediate SCRs compared to the anxious and happy group. Therefore, we assume that our findings do not simply represent a shift in general electrodermal reactivity due to the emotion induction. However, to be more conclusive about the effect of emotional state on higher responding during extinction, future research should include startle responses during a control condition (i.e. in the absence of any CS).

The present results have to be interpreted in the light of the following limitations. In Experiment 1 we included no habituation phase, as the effect of an emotional state induction is rather short (e.g., Gilet, 2008; Isen & Gorgoglione, 1983) and we wanted to make sure that the induced state anxiety would last until the end of the acquisition phase. However, it would be more valid to test the effect of state anxiety on the general SCR during a habituation phase as well. In both experiments the participants were women. Jackson et al. (2006) found that in men stress exposure facilitated fear conditioning. In line with our results, women in the most stressful condition showed lower CRs than controls to both the CS+ and CS- during acquisition and early extinction, and higher CRs to the CS+ only during extinction. These differences were not significant in the study of Jackson et al. (2006). Thus, testing the interaction of sex, emotional state and conditioning is needed.

Future studies may also investigate the influence of a combination of positive and negative emotional states on the different processes of acquisition and extinction of fear. For example, an experiment with two emotional state inductions (randomized emotional states), before the acquisition and before the extinction phase, would specify the influence of emotional state on the process of adaptability in fear conditioning during the different phases of learning and unlearning. Such a design would also test if state anxiety functions as a context variable so that possible renewal effects (i.e. Vansteenwegen et al., 2005) could be examined. Further, at this point it is not clear if our findings of state anxiety on conditioning are specific for anxiety or if they relate to a more general negative emotional state. Future experiments should therefore also include sad and/or angry emotional states.

Finally, as laboratory and clinical studies have repeatedly demonstrated a strong correspondence between CRs and beliefs/expectancies during extinction (e.g., US expectancy, for an overview see Lovibond, 2004), it can be assumed that the emotional state influences not only the CR but also thus far unknown cognitive processes.

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