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Acquisition of Behavioral Avoidance: Task-Irrelevant Conditioned Stimuli Trigger Costly Decisions

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Individuals avoid stimuli which are associated with aversive experience to preserve safety. However, behavioral avoidance also causes impairments and prevents the individual from attaining positive rewards. Little is known about the link between fear acquisition and the development of behavioral avoidance in the presence of potential rewards. Therefore, two experiments investigated the impact of fear conditioning on a subsequent gambling task. In an experimental group ($n = 30$) advantageous choices (higher reward probability) were linked to a fear-relevant stimulus that was associated with an aversive unconditioned stimulus (US) during fear conditioning (conditioned stimulus, CS+). A disadvantageous choice (lower reward probability) was, however, linked to a safe stimulus that was never associated with the US (CS−). In a control group ($n = 25$), fear conditioning was followed by a similar gambling task with novel stimuli. A second experiment focused on individual predictors of avoidant decisions ($n = 81$). Compared with the control group, individuals in the experimental groups avoided the advantageous CS + choice despite fewer gains. The predictor analysis further clarified that avoidant decisions were pronounced in highly trait anxious participants who exhibited higher fear responses. On the other hand, findings also indicated a reduction in absolute avoidance across the task. Combined, these findings demonstrate that fear conditioning can lead to avoidant decision making, especially in vulnerable individuals. The resulting costs parallel impairments caused by behavioral avoidance. Such an emotional decision-making style may be a link between aversive experience and the development of habitual pathological avoidance. Introducing rewards for approach, however, may counteract avoidant decisions.

Keywords: decision making, behavioral avoidance, fear conditioning, anxiety, experimental psychopathology, approach-avoidance conflict

Avoidance of fear-relevant stimuli is a characteristic behavior of patients with anxiety disorders (e.g., Craske, 1999; Dymond & Roche, 2009). Despite the central importance of behavioral avoidance for understanding the development and maintenance of anxiety disorders, there is little research on the underlying mechanisms of behavioral avoidance in humans. Past research on the underlying mechanisms of avoidance behavior specifically focused on responses toward single fear-relevant stimuli. In this regard, classical and instrumental conditioning studies showed that participants quickly learn to avoid an aversive unconditioned stimulus by performing a specific behavioral response to a warning signal (Delgado, Jou, Ledoux, & Phelps, 2009; Lovibond, Saunders, Weidemann, & Mitchell, 2008). Recent research also turned to more subtle or possibly automatic mechanisms of avoidance in fearful participants, as for example indicated by shorter viewing times of fear-relevant pictures (Mogg, Bradley, Miles, & Dixon, 2004; Tolin, Lohr, Lee, & Sawchuk, 1999), averting one's gaze from fear-relevant stimuli (Rinck & Becker, 2006), or the facilitation of avoidance-related action tendencies and motor responses by fear-relevant stimuli (Heuer, Rinck, & Becker, 2007; Rinck & Becker, 2007). Although this past research offered extensive insights into avoidance responses within a controlled laboratory setting, the sole focus on avoidance of a single stimulus may not be completely translatable to complex avoidance behavior and its pathological quality in anxiety disorder.

In complex situations, the selection of adaptive behavior is the key for human survival and well-being. Adaptive behavior protects the individual from harm but also enables it to obtain rewards (e.g., food, social contact, or secondary rewards such as money). In

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healthy individuals, avoidance, therefore, is functional if it prevents actual threat. In anxiety disorders, however, avoidance is more recurrent and persistent and not related to realistic threat to the patient (Barlow, 2002), and obtains a pathological quality as it causes severe impairments and costs for the individual (American Psychiatric Association, 2000).

The costs of avoidance are partly related to the loss of positive consequences for approach (Dymond & Roche, 2009). Situations avoided by anxious individuals usually contain incentives or rewards, which are missed due to avoidance (Kashdan, Elhai, & Breen, 2008). Anxious individuals are often explicitly aware of these benefits, even for their most feared situations (Kashdan et al., 2008), and, thus, are torn between the choice to approach or to avoid. A solution to this approach-avoidance conflict requires some kind of decision-making process to determine behavior. This decision conflict and the coexistent positive consequences may help to explain the variance in avoidance responses in individuals with comparable levels of fear and anxiety (Craske & Barlow, 1988; Rachman & Hodgson, 1974). In this regard, avoidance behavior can be conceptualized as a shift toward avoidant decisions, which represent a costly outcome of the approach-avoidance conflict. With respect to psychopathology, a shift toward avoidant decisions has, for example, been proposed for posttraumatic stress disorder (Stein & Paulus, 2009). Despite the immense relevance of the loss of potential rewards for the development of behavioral avoidance, past research has rarely accounted for such costs of avoidance.

Following this perspective, we recently used an established decision-making paradigm to investigate behavioral avoidance in spider fearful individuals (Pittig, Brand, Pawlikowski, & Alpers, 2014). Decision-making paradigms can combine fear- and reward-relevant stimuli and offer explicit choices between approach and avoidance of the fear-relevant stimuli. Importantly, such paradigms can account for the costs of avoidance, measured as fewer rewards or larger losses. In our study, participants had to make continuous decisions to maximize their overall gain. Advantageous choices for maximizing rewards were, however, associated with fear-relevant pictures of spiders. In comparison with nonfearful participants, spider fearful participants consistently avoided the fear-relevant pictures, which resulted in costs in task performance. These results document that fearful individuals suffer costs due to their avoidant decisions. However, little is known about potential learning mechanisms for these avoidant decisions.

The interaction of classical and operant conditioning has been a key toward understanding the development and maintenance of avoidance behavior (Bouton, 2007; Mowrer, 1960). Recent rodent research has further established the impact of classical fear conditioning on avoidance behavior (Bouton, Mineka, & Barlow, 2001; Craske et al., 2008; Mineka & Zinbarg, 2006). Animals and humans will rapidly learn and perform an avoidance response during fear conditioning to prevent presentation of an aversive unconditioned stimulus (US; Amorapanth, LeDoux, & Nader, 2000; Bouton, 2007; Delgado et al., 2009; Lovibond, Mitchell, Minard, Brady, & Menzies, 2009). Fear conditioning research also provided considerable evidence for elevated physiological fear responses (such as elevated skin conductance or startle responses) toward an aversive conditioned stimulus (CS+). However, the impact of fear conditioning and physiological fear responses on avoidance within an approach-avoidance conflict or on actual (decision) behavior has rarely been investigated. Furthermore, most studies have investigated avoidance of an US rather than the CS (Delgado et al., 2009; Lovibond et al., 2009). An aversive US (like an electrical shock) induces innate aversive unconditioned responses and, thus, avoiding the US is usually adaptive. Behavioral avoidance can also be seen in avoidance of fear-relevant stimuli or warning signals (i.e., a CS). Fear responding to and subsequent avoidance of such warning signals is also functional as it may prevent the occurrence of the US. However, persistent avoidance may resemble pathological behavior in the long run, if the fear-relevant stimulus is no longer associated with the US (i.e., during extinction). Such behavioral avoidance is clearly dysfunctional if approaching the fear-relevant stimulus would result in relevant rewards. To account for these features of behavioral avoidance in the development of avoidant decisions, we conducted two experiments in order to (a) investigate the impact of fear conditioning on subsequent decisions involving approach or avoidance of the CS+, and (b) investigate individual predictors of these avoidant decisions.

Experiment 1: Group Comparison

Experiment 1 investigated the impact of fear conditioning on subsequent decisions. During differential fear conditioning, a CS+ was paired with an aversive US, whereas a CS− was never paired with the US. A subsequent approach-avoidance conflict was modeled as a card game including two different options. The advantageous choice was associated with more frequent rewards, but also the aversive CS+. The disadvantageous choice was associated with the safe CS− and less frequent rewards (i.e., a less attractive choice from a rational perspective). Hence, fear-related avoidant decisions in the present task were indicated by fewer advantageous CS+ choices. Performance of the Experimental Group 1 was compared with a control group which underwent the same fear conditioning, but was presented with new material during decision making.

As the fear conditioning procedure involved presentations of aversive electrical stimulations, it may be associated with a stress response including elevated levels of stress hormones (Maren, 2001). Because previous research showed that general distress may influence subsequent decisions (for a review see Starcke & Brand, 2012), the control group underwent an identical fear conditioning procedure to establish comparable levels of general distress before decision making. However, for participants in the control group, the stimuli during decision making differed from those presented during fear conditioning in order to eliminate the specific effects of the prior CS contingencies. In other words, levels of general distress and picture type (females displaying neutral facial expressions) were kept constant to control for potential influences on avoidant decisions which may have interfered with specific effects of fear learning.

Furthermore, individual responses to fear conditioning were investigated as predictors for the strength of avoidant decisions (Loewenstein, Weber, Hsee, & Welch, 2001; Mineka & Zinbarg, 2006). In addition to self-reported discomfort and CS ratings, startle eyeblink and skin conductance (SCRs) responses during fear conditioning were assessed as potential predictors to account for different response levels in anxiety (Bouton, 2007; Lang, Greenwald, Bradley, & Hamm, 1993; Pittig, Arch, Lam, & Craske,

2013). Finally, individual trait variables were tested as potential predictors of avoidant decisions.

Method and Materials

Participants. Fifty-five undergraduate students at UCLA were randomly assigned to the experimental or control group (see below). Exclusion criteria were serious medical conditions, substance abuse/dependence, current or history of bipolar disorder, psychosis, or organic/traumatic brain damage, and current use of psychotropic medication. All participants provided written informed consent approved by the UCLA Internal Review Board. Table 1 shows demographic and questionnaire data. No significant differences were found for these data between the Experimental Group 1 and the control group, all ts < 1.7, all ps $> .10$.

Materials. Four pictures with neutral facial expressions of females were taken from the *NimStim* set of facial expressions (Adolph & Alpers, 2010; Tottenham et al., 2009). Two faces served as conditioned stimuli (CSs) during fear conditioning for all groups. These two CSs were also presented during the decision-making paradigm for the Experimental Group 1, whereas the other two novel faces were presented for the control group. During both phases, pictures were presented in exactly the same position and size (approximately 22° × 16° visual angle) and for the same duration.

The US was an electrical stimulus to the bicep muscle. Two disposable Ag/AgCl electrodes were placed at each end of the bicep of the nondominant arm. Each US consisted of five consecutive 4-ms stimulations (STMISOL; BIOPAC Systems, Inc.). Individual levels of US intensity were obtained using a work-up procedure. Participants were asked to rate US unpleasantness and discomfort (0 = *no unpleasantness or discomfort* and 100 = *extreme discomfort*) and instructed to "choose a level that is unpleasant and causing discomfort, but not painful." Afterward, participants were asked whether they could tolerate stimulations of such intensity throughout the experiment. If not, stimulation intensity was adjusted accordingly.

Procedure. All participants were informed that loud noises and unpleasant electrical stimulations would be administered. After informed consent, electrodes were attached and participants completed a questionnaire battery. Trait anxiety was assessed as the NEO anxiety facet of neuroticism using the International Personality Item Pool-NEO-PI-R (IPIP-N1; Goldberg et al., 2006). Potential group differences on the Beck Depression Inventory (BDI-II; Beck, Steer, Ball, & Ranieri, 1996) were controlled due to biased processing of rewards in depression (Eshel & Roiser, 2010; Mineka, Watson, & Clark, 1998). The Social Phobia Inventory (SPIN; Connor et al., 2000) controlled for potential effects of high and low socially anxiety to the facial expressions (Yoon & Zinbarg, 2008). After a subsequent 5-min baseline, individual US level were determined which was followed by fear conditioning and the decision-making paradigm.

Fear conditioning. Before conditioning, eight startle probes were presented (mean interprobe interval = 20 s) to minimize startle habituation confounds (Blumenthal et al., 2005). Fear conditioning consisted of two blocks including five trials of each CS, respectively. Order of the CSs was pseudorandomized with no more than two consecutive presentations of the same CS. In each trial, a CS was presented for 5 s and a startle probe was delivered 4.5 s after CS onset. To establish differential fear conditioning acquisition, presentation of the CS+ was followed by the US in four of five trials (i.e., 80% reinforcement). The CS− was never followed by a US. Continuous CS-UCS parings (100%) usually results in rapid acquisition, but also in rapid extinction in human participants (LaBar, Gatenby, Gore, LeDoux, & Phelps, 1998). Therefore, a partial reinforcement schedule was chosen to decrease extinction learning (Phelps, Delgado, Nearing, & LeDoux, 2004) and, thereby, allow us to examine the impact of fear acquisition in a test phase where no more US were presented (see Alpers, Ruhleder, Walz, Mühlberger, & Pauli, 2005). Trials were separated by inter-trial-intervals (ITIs) ranging from 20 s to 35 s. During five ITIs in each block, a startle probe was delivered with inter-probe-intervals of at least 15 s. During fear conditioning, SCRs and startle eyeblink responses were measured as physiological indices of fear acquisition. SCRs were calculated in the interval of 1 s–4.5 s after CS onset before the startle probe was delivered (see Physiological Assessment and Data Reduction section). Immediately after fear conditioning, participants completed the state version of the STAI (Spielberger, Gorsuch, Lushene, & Vagg, 1983) to assess self-reported state anxiety and were asked to rate both CSs for unpleasantness, fearfulness, arousal, and US expectancy (0 = *Not at all*; 10 = *Very*).

Conditioned stimulus card game. The goal of this computerized card game was to win as much virtual money as possible within 40 trials; an example is shown in Figure 1. For the Experimental Group 1, participants could freely choose between two decks in each trial (A). Selecting a deck always resulted in two subsequent feedbacks; a task-irrelevant presentation of one of the

Table 1
Demographic and Questionnaire Data

	Experimental 1 (n = 30)	Control (n = 25)	Experimental 2 (n = 81)	F or χ^2	p
Age	21.78 (3.60)	20.64 (4.42)	20.91 (2.71)	0.55[a]	.532
Sex = Female	22 (73%)	16 (65%)	60 (74%)	1.24[b]	.538
Trait anxiety (IPIP-N1)	28.83 (7.58)	26.04 (10.68)	29.38 (7.39)	1.63[a]	.200
Social anxiety (SPIN)	14.97 (9.75)	14.66 (11.86)	16.85 (10.37)	0.61[a]	.544
Depression (BDI)	6.38 (5.74)	7.07 (6.11)	7.02 (5.75)	0.15[a]	.863

Note. Means (and standard deviations) separately for groups. Experimental 1 and 2 = Participants encountering same facial cues is conditioning and decision-making phase in Experiment 1 and 2. n = Number of participants; IPIP = International Personality Item Pool-NEO-PI-R (Goldberg et al., 2006); SPIN = Social Phobia Inventory (Connor et al., 2000); BDI = Beck Depression Inventory (Beck et al., 1996).
[a] F score for $F(2, 133)$. [b] χ^2 score for $\chi^2(2, N = 136)$.

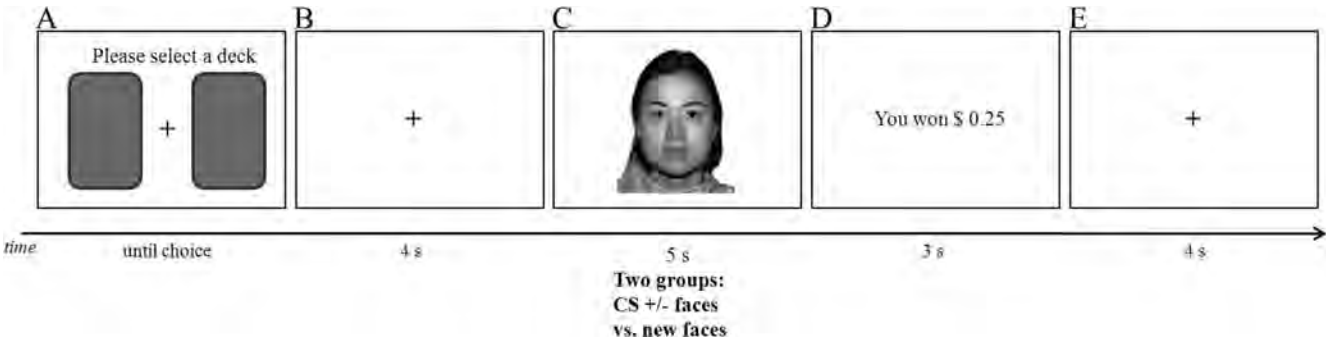

Figure 1. Example of a trial sequence of the conditioned stimulus card game. A selection screen (A) was presented until the participant selected one of the two decks. After a short break (B), one of the two facesIn the first block, the advantageous was shown (C). In the experimental groups the CS+ or CS− faces was presented depending on which deck was selected, whereas two novel faces were presented in the control group. Feedback presentation followed (D) and the next trial began after another short break (E). Pictures of facial expressions were taken from the NimStim set of facial expressions (Tottenham et al., 2009).

CSs followed by a task-relevant feedback if a fixed amount of virtual money was won ("You won $0.25") or not. Specifically, after a deck was selected, a fixation cross appeared for 4 s (B) and was followed by a 5 s presentation of the CS+ or CS− depending on which deck was chosen (C). Afterward, the gain-related feedback was presented for 3 s (D), followed by another 4 s break (E). Then, the next trial started and participants again had to choose between decks. This order of presentations was used to allow complete avoidance of the presentation of the CS+ (i.e., if a participant chose to never select the CS+ deck, the CS+ was never presented).

A selection from the advantageous deck was associated with a higher chance of winning a fixed reward (60% probability of winning $0.25). However, gain feedbacks were always preceded by a presentation of the aversive CS+. In contrast, selecting the disadvantageous deck was associated with a lower chance of winning (40% probability of winning $0.25) and gain feedbacks were always preceded by a presentation of the CS−.[1] Thus, the paradigm included one disadvantageous CS− deck (lower winning probability and presentation of the CS−) and an advantageous CS+ deck (higher winning probability and presentation of the CS+). Left–right location of the decks was counterbalanced and had no impact on task performance.

Card game performance of the Experimental Group 1 was compared with a control group. Procedures and contingencies were exactly the same for the control group with one critical difference; instead of the CS+ and CS−, novel pictures of neutral facial expressions were presented before the gain feedbacks. Whereas participants in the control group saw the same pictures as the Experimental Group 1 during fear conditioning, they saw different ones during decision making. Thus, only the Experimental Group 1, but not the control group, had prior fear conditioning experience with the pictures presented during decision making.

At the beginning, participants were not aware of the rules for rewards, CS presentation, or the duration of the task. Participants were instructed that they were about to play a card game with the goal of winning as much money as possible by selecting one card at a time from one of the two decks. Participants were also told that they could choose whichever deck they want and were absolutely free to switch from one deck to the other at any time. Finally, they were told that they may receive further USs. However, not a single US was presented during the card game.

In order to investigate if physiological fear responses from fear conditioning generalized to presentations of the CSs during the card game, SCRs were calculated in the interval of 1 s–4.5 s after CS onset in each card game trial. The fixation cross after each selection (see B in Figure 1) served as a break between selection of a deck and CS onset to prevent interference of selections of the decks and the calculation of SCRs. In addition, SCR electrodes were attached to the nondominant hand whereas they used their dominant hand for button presses. Finally, no startle probes were delivered during the card game.

Physiological Assessment and Data Reduction

Electrodermal activity (EDA) and an electromyogram (EMG) to record startle eyeblink were continuously recorded with BIOPAC instrumentation (MP150 Data Acquisition System for Windows; BIOPAC Systems, Inc.). Online data monitoring, acquisition, and analyses were done with AcqKnowledge software (AcqKnowledge 4.1 for Windows; BIOPAC Systems, Inc.). One disposable Ag/AgCl electrode on the left clavicle served as ground electrode. Participants were instructed to avoid gross movement. Such artifacts (e.g., larger movements, sneezing, etc.) were recorded by a research assistant who observed the assessment via one-way mirror from an adjacent room. Intervals containing artifacts were excluded from data analyses.

Skin conductance responses (SCRs). EDA was recorded with BIOPAC skin conductance instrumentation (sampling rate = 500 Hz) with a constant voltage of 0.5 V. Two disposable Ag/AgCl electrodes with electrodermal conducting gel were attached to the palmar surface of the middle phalanges of the second and third finger of the nondominant hand. High frequency noise was removed using a 2 Hz FIR lowpass filter. Afterward, a 0.05 Hz

[1] A pilot study including 12 healthy participants indicated that most participants (91.67%) were able to learn the advantageous choice using a 60% versus 40% winning probability.

high-pass filter was used to obtain phasic SCRs. SCRs were calculated as the maximum increase in skin conductance in the interval of 1 s–4.5 s after a facial stimulus was presented compared with a baseline of 2 s before onset (during both fear conditioning and the decision-making paradigm). A threshold of 0.02 Mirco-Siemens (μS) was used; all SCRs below this threshold were scored as zero response and included in the analyses (SCR magnitude). For range correction (Lykken & Venables, 1971), SCRs were divided by the largest SCR of each participant (SCR corrected = SCR raw/SCR maximum). Finally, the square root was taken to obtain normal distribution (Dawson, Schell, & Filion, 2007).

Startle eyeblink EMG. Startle EMG recording and analysis followed standard procedures (Blumenthal et al., 2005). Startle eyeblink EMG was recorded with two Ag/AgCl shielded electrodes (4 mm contact surface in diameter) filled with high-conduction gel (sampling rate = 2,000 Hz). Both electrodes were placed on the lower orbicularis oculi muscle (approximately 8 mm below the lower lid of the right eye) after cleaning the skin. One electrode was placed in the center and the other electrode approximately 10 mm lateral. EMG electrode impedance was held below 20 kOhm. Raw EMG data were filtered with a FIR bandpass filter (low frequency = 28 Hz, high frequency = 500 Hz), rectified, and smoothed using a time constant of 10 ms.

Startle probes were 100 dB(A) bursts of white noise with nearly instantaneous rise time and were delivered binaurally for 50 ms via headphones. Startle responses were scored as maximum peak amplitude within 21 ms–150 ms after startle probe onset subtracted by baseline EMG activity (averaged EMG activity in the interval of 200 ms before onset to 20 ms after onset). Trials in which EMG activity did not exceed two standard deviations compared with baseline were scored as zero and included in the analyses. All startle responses were visually inspected and single startle responses were rejected if: (a) observations indicated movement artifacts, (b) onset occurred prior to 21 ms after probe onset, or (c) spontaneous blinks occurred during the baseline interval (7.00% of trials were rejected). Raw response scores were transformed into *T* scores based on all valid startle responses for each participant. Two participants (3.6%) were excluded from startle analyses because there were no reliable startle responses.

Statistical Analyses

Fear conditioning. Fear conditioning data were analyzed to document (a) successful differential fear acquisition within both groups, and (b) the absence of significant differences in fear acquisition between groups. SCRs and startle responses were analyzed using a repeated measures 2 × 2 × 2 ANOVA with block (first vs. second block of fear conditioning) and CS (CS+ vs. CS−) as within subject factors and group (experimental vs. control) as the between subject factor. Follow-up *t* tests were used to specifically compare SCRs and startle responses of the CSs during the two blocks of fear conditioning and between groups. CSs ratings were analyzed using repeated measures 2 × 2 ANOVAs with CS (CS+ vs. CS−) as the within subject factor and group (experimental vs. control) as a between subject factor. In addition, groups were compared on US intensity, self-reported unpleasantness caused by the US and state anxiety after fear conditioning.

Avoidant decision making. The 40 trials of the card game were subdivided into four blocks of 10 trials, respectively. For each block a net score was calculated by subtracting the number of disadvantageous CS− choices from the number of advantageous CS+ choices (advantageous − disadvantageous). Thus, numbers above zero indicated more advantageous than disadvantageous choices (i.e., more gains were obtained). In the Experimental Group 1, a higher net score also indicated more frequent presentations of the CS+. Net scores were analyzed using a repeated measures 4 × 2 ANOVA with blocks (Block 1 to 4) as the within subject factor and group (experimental vs. control) as the between subject factor. In addition to comparing avoidant decisions between the experimental and control group (relative avoidance), absolute avoidance was analyzed by comparing the number of advantageous CS+ choices with the number of disadvantageous CS− choices within the Experimental Group 1. Furthermore, SCRs toward the CSs in the Experimental Group 1 and the novel faces in the control group were compared within single blocks using pairwise *t* tests to investigate if responding to the CS+ was significantly higher during the different blocks of the card game.

Finally, to investigate potential individual predictors, correlations between total net scores and net scores of the single blocks and fear conditioning responses (i.e., differential SCRs and startle responses to the CSs ([CS+] − [CS−]), state anxiety, and CS ratings) were calculated for the Experimental Group 1. Correlations were also calculated for differential SCRs during the first block of the card game ([CS+] − [CS−]), which served as index for fear response generalization during decision making. Finally, trait anxiety, and social anxiety were correlated with the net scores of the card game for analyses of the impact of individual trait variables.

Results

Fear conditioning.

Startle responses and SCRs during fear conditioning. SCRs and startle responses during the two fear conditioning blocks are shown in Figure 2. The results indicated significant fear acquisition for both groups. Specifically, the repeated measures ANOVA for SCRs yielded a significant interaction effect of Blocks × CS, $F(1, 53) = 14.78$, $p < .001$, partial $\eta^2 = .215$. Follow-up *t* tests indicated significantly higher SCRs to the CS+ compared with the CS− in the second block, $t(54) = 7.54$, $p < .001$. Although a difference was already present during the first block, $t(54) = 3.77$, $p < .001$, the differentiation between CS+ and CS− was significantly larger in the second block than the first block, $t(54) = 3.91$, $p < .001$. Startle analyses also yielded a significant interaction effect of Blocks × CS, $F(1, 51) = 8.76$, $p = .005$, partial $\eta^2 = .154$. Follow-up *t* tests showed a significantly higher response to the CS+ compared with the CS− in the second block, $t(52) = 4.07$, $p < .001$. However, this difference was not present in the first block, $t(52) = 0.71$, $p = .483$. In addition, the differentiation between CS+ and CS− was significantly larger during the second compared with the first block, $t(52) = 3.06$, $p = .004$. There were no main or interaction effects regarding the factor group for both SCRs and startle responses, all Fs < 1.7, all ps > .20.

Self-reported anxiety and CS ratings after fear conditioning. CS ratings and state anxiety of the two groups are shown in Table 2. All ANOVAs with repeated measures showed the same pattern of results with a significant main effect of CS, all *Fs*(1,

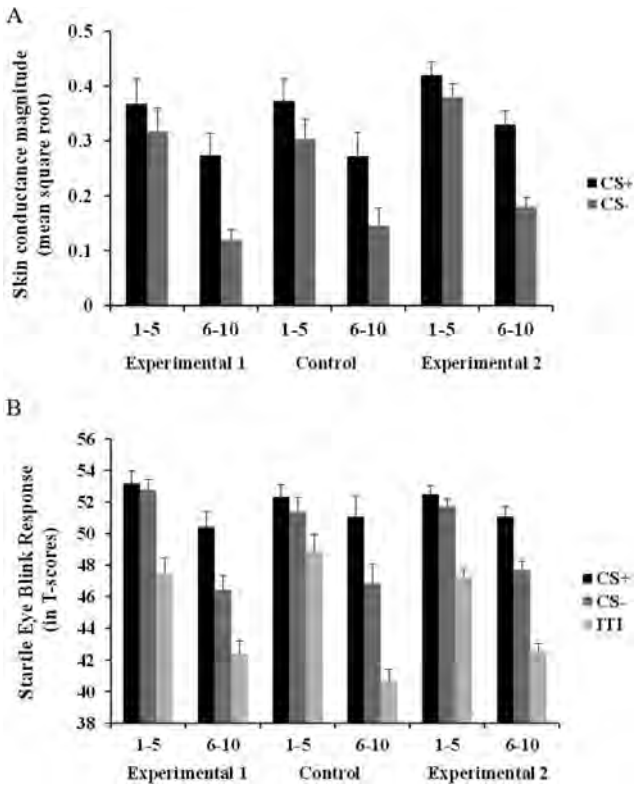

Figure 2. (A) Mean skin conductance responses (SCRs; as mean square root) and (B) startle eyeblink responses (in mean *T* scores) during fear conditioning separately for both blocks and groups (with standard errors of the mean). CS+ = conditioned stimulus associated with the US; CS− = conditioned stimulus never associated with the US; intertribal interval (ITI) = inter-trial-interval; Experimental 1 and 2 = Experimental Group from Experiment 1 and 2.

53) > 45.26, $p < .001$, partial $\eta^2 > .46$, but no significant group effect or interaction between Group × CS, all Fs < 2.8, all ps > .10. Follow-up t tests indicated significantly higher ratings for the CS+ compared with the CS− on all four scales: Unpleasantness, $t(54) = 7.00$, $p < .001$; fearfulness, $t(54) = 6.79$, $p < .001$; arousal, $t(54) = 6.82$, $p < .001$; and US expectancy, $t(54) = 13.03$, $p < .001$. In addition, there were no significant differences between groups in state anxiety (STAI-S, see Table 1), intensity of the US, $t(53) = -1.50$, $p = .139$, or US unpleasantness ratings, $t(53) = 1.25$, $p = .217$. In sum, the results of the self-reported and physiological data indicated successful fear conditioning in both groups with no significant differences in fear acquisition between groups.

Avoidance and fear responses during decision making. To verify comparable choices in the first trial (see Figure 3 A), nonparametric binomial tests were used. Results yielded no significant preference in the Experimental Group 1 (43% advantageous vs. 57% disadvantageous choices, $p = .57$) or the control group (32% advantageous vs. 68% disadvantageous choices, $p = .11$). Thus, without any information on contingencies in the first trial, both groups chose randomly.

Relative avoidant decisions (experimental compared with control group). The ANOVA[2] including the repeated net scores of the four blocks for both groups (see Figure 3 B) indicated that across both groups participants learned to make more advantageous choices; main effect of blocks, $F(3, 51) = 2.93$, $p = .036$, partial $\eta^2 = .052$. In addition, the overall net score was significantly lower in the Experimental Group 1 compared with the control group, main effect of group, $F(1, 51) = 7.20$, $p = .010$, partial $\eta^2 = .120$. No significant difference in the rate of learning was found between groups, Blocks × Group, $F(3, 51) = 0.42$, $p = .670$, partial $\eta^2 = .008$. Therefore, post hoc t tests yielded a significantly lower net score for the Experimental Group 1 in most blocks; Block 1, $t(53) = -3.23$, $p = .002$, Block 2, $t(53) = -2.10$, $p = .040$, and Block 4, $t(53) = -2.43$, $p = .019$, with a similar but nonsignificant trend in Block 3, $t(53) = -1.81$, $p = .077$. Finally, the overall monetary outcome was compared between both groups. The Experimental Group 1 gained less monetary reward (i.e., suffered costs) compared with the control group, $t(53) = -2.37$, $p = .022$. Thus, the Experimental Group 1 consistently showed relative avoidance of the CS+ throughout the task despite costs in card game performance.

Absolute avoidant decisions (CS+ compared with CS− choices). In the first block, the advantageous CS+ deck was chosen significantly less frequent within the Experimental Group 1, $t(29) = -2.21$, $p = .035$. However, this initial absolute avoidance gradually decreased and at the end both decks were selected equally often, $t(29) = -0.17$, $p = .870$. Thus, whereas relative avoidance remained constant throughout the task, absolute avoidance was pronounced at the beginning and absent by the end of the task.

Skin conductance responses during avoidant decisions. Mean SCRs to the CS+ and CS− (within the Experimental Group 1), as well as the two novel faces (within the control group) during the first block are shown in Figure 4. Within the Experimental Group 1, SCRs to the CS+ were significantly larger compared with the CS− in the first block of the card game, $t(51) = 2.50$, $p = .020$. In the first block, SCRs to the CS+ in the Experimental Group 1 were also significantly larger compared with one of the novel faces in the control group, $t(51) = 2.30$, $p = .026$, with a similar but nonsignificant trend compared with the second novel face, $t(51) = 1.81$, $p = .077$. For all other blocks, no differences between CSs and the novel faces were found, all ts < 0.82, all ps > .41. There were no significant differences between SCRs to CS− and the novel faces, all ts < 1.20, all ps > .28. In sum, elevated SCRs were only found in response to the CS+ in Block 1 and did not differ between the other pictures or in later blocks.

Individual predictors of avoidant decisions. In the Experimental Group 1, higher scores in trait anxiety, differential SCRs during conditioning and during the initial card game block, unpleasantness and fearfulness ratings of the CS+, and state anxiety after fear conditioning significantly predicted fewer advantageous CS+ choices (see Table 3). Most of the variables and the net scores were uncorrelated in the control group, all rs < −.24, all ps > .12. Only higher fearfulness ratings for the CS+ predicted fewer advantageous choices in Block 2, $r(25) = -.38$, $p = .029$, and Block 3, $r(25) = -.38$, $p = .033$. No significant correlations were found for any CS− ratings, all rs < −.23, all ps > .13.

[2] Greenhouse-Geisser corrected degrees of freedom and p values were used for the repeated measures ANOVA due to a violation of the sphericity assumption (Mauchly's $w = 0.55$, $\chi^2(5) = 30.80$, $p < .001$).

Table 2
State Anxiety and Conditioned Stimulus Rating Data

	Experimental 1 (n = 30)	Control (n = 25)	Experimental 2 (n = 81)	F	p
State anxiety (STAI-S)	45.93 (9.77)	42.52 (13.99)	47.40 (11.34)	1.57	.211
CS+ ratings:					
Unpleasantness	7.30 (2.37)	6.04 (2.98)	7.09 (2.56)	1.09[a]	.340
Fearfulness	6.30 (2.41)	5.48 (3.02)	6.37 (2.47)	0.53[a]	.593
Arousal	6.40 (2.84)	5.32 (3.57)	6.77 (2.55)	1.65[a]	.196
US expectancy	8.33 (1.67)	7.64 (2.58)	8.41 (1.46)	1.69[a]	.188
CS− ratings:					
Unpleasantness	4.70 (2.52)	3.74 (2.43)	4.68 (2.43)	0.69[a]	.502
Fearfulness	3.90 (2.56)	2.88 (2.65)	3.74 (2.34)	0.65[a]	.522
Arousal	4.07 (2.00)	3.52 (2.65)	4.09 (2.18)	1.75[a]	.180
US expectancy	2.53 (2.80)	1.48 (2.24)	2.41 (2.91)	1.14[a]	.322

Note. Means (and standard deviations) separately for groups. Experimental 1 and Experimental 2 = Participants encountering same facial cues is conditioning and decision-making phase in Experiment 1 and 2. n = Number of participants; STAI-S = State-Trait Anxiety Inventory-State version (Spielberger et al., 1983); CS+ = facial stimulus followed by US; CS− = facial stimulus not followed by US; US = unconditioned stimuli.
[a] F score for $F(2, 133)$.

To test which of the variables that significantly correlated with net scores explained independent variance, a backward stepwise multiple regression was used with total net score of the card game as dependent variable. The final model included two significant predictors; increased learning during fear conditioning as indexed by higher differential SCRs to the CS+ compared with the CS− during the second block of fear conditioning, $\beta = -.41$, $t(28) = -2.43$, $p = .023$, and trait anxiety, $\beta = -.40$, $t(28) = -2.40$, $p = .025$, which together explained a significant amount of variance in total net scores, corrected $R^2 = .33$, $F(2, 27) = 7.18$, $p = .004$.

Due to the strong effect of trait anxiety, avoidant decisions might be limited to highly trait anxious participants (i.e., group differences after fear conditioning might have been driven by highly trait anxious participants in the Experimental Group 1). In order to investigate if fear conditioning also resulted in avoidant decisions in participants with low trait anxiety, we compared total net scores of a subgroup with low trait anxiety (median split in the Experimental Group 1) with the control group. Result yielded significantly fewer advantageous choices in the low trait anxious subgroup, $t(38) = -2.31$, $p = .027$. Thus, fear conditioning generally resulted in avoidant decision, with particularly strong avoidance in highly trait anxious participant.

Exploratory analyses restricted to female participants. Given the higher prevalence of anxiety disorders in women compared with men (Craske, 2003) and their larger proportion in our samples, we explored potential effects of gender by reanalyzing our data only with female participants. In general, effects remained

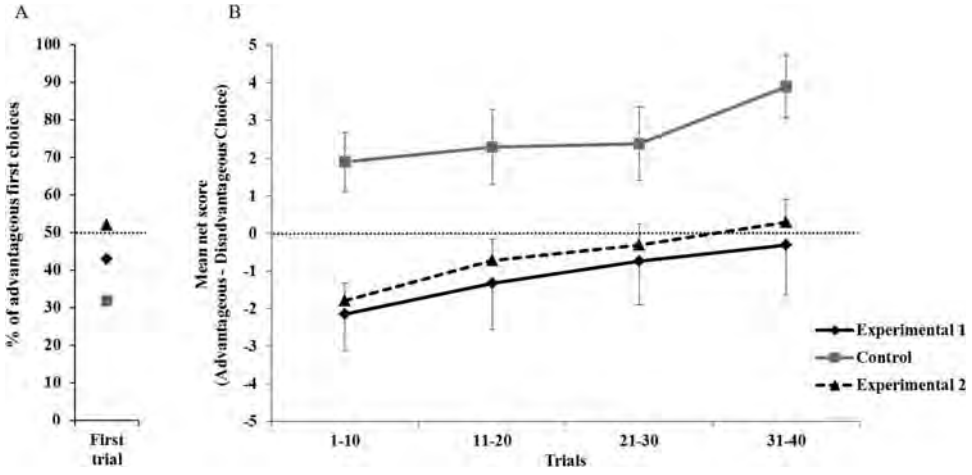

Figure 3. (A) Percentage of advantageous choices on the first trial for the experimental and Control Group. (B) Mean net scores (advantageous CS+ choices − disadvantageous CS− choices) for the experimental and control group divided into four blocks (with standard errors of the mean). Values above zero indicate that the advantageous CS+ deck was chosen more frequently than the disadvantageous CS− deck, Experimental 1 and 2 = Experimental Group from Experiment 1 and 2.

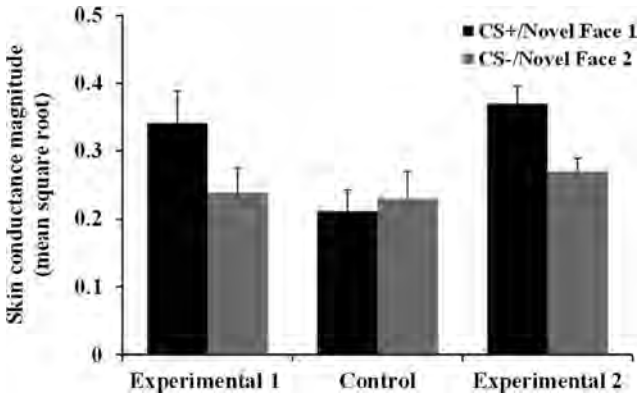

Figure 4. Skin conductance responses (SCRs; as mean square root) during the initial block of the card game (with standard errors of the mean). Experimental 1 and 2 = Experimental Group from Experiment 1 and 2; CS+ = conditioned stimulus associated with the US; CS− = conditioned stimulus never associated with the US, both novel faces were the faces presented in the control group.

stable. Female participants showed successful fear acquisition by means of significant differentiations between CS+ and CS− in SCRs, startle responses, and self-report ratings, all *t*s > 3.05, all *p*s < .005.

In terms of relative avoidance, the repeated measures ANOVA including the net scores of the four blocks also showed the same pattern of results with slightly larger effect sizes as in the complete sample: (a) a significant increase in advantageous choices; main effect of blocks, $F(3, 34) = 2.79$, $p = .044$, partial $\eta^2 = .072$; (b) a significantly lower overall net score for women in the Experimental Group 1 compared with women in the control group, main effect of group, $F(1, 34) = 6.21$, $p = .017$, partial $\eta^2 = .147$; and (c) there was no significant difference in the rate of learning between groups, Blocks × Group, $F(3, 34) = 0.92$, $p = .436$, partial $\eta^2 = .025$. Therefore, women in the Experimental Group 1 showed lower net scores in all blocks compared with women in the control group, all *t*s > 2.46, all *p*s < .020, except the last block, $t(36) = -1.66$, $p = .106$. In terms of absolute avoidant decisions, the advantageous CS+ deck was also chosen significantly less frequently by women in the Experimental Group 1, $t(21) = -3.66$, $p = .001$. However, initial absolute avoidance gradually decreased and at the end both decks were selected equally often, $t(21) = -0.30$, $p = .768$. Furthermore, although the differences in mean SCRs to the CS+ ($M = 0.29$, $SD = 0.22$) and CS− ($M = 0.20$, $SD = 0.15$), as well as the two novel faces (Novel Face 1: $M = 0.20$, $SD = 0.17$; Novel Face 2: $M = 0.18$, $SD = 0.15$) during the first block of the card game were equally large as compared with the whole sample, they did not reach significance due to the smaller sample size, all *t*s < 1.49, all *p*s > .14.

Furthermore, the patterns of correlations between the individual predictors of avoidant decisions remained in the same direction. Effect sizes among women remained similar for social anxiety, startle responses during condition, and SCRs during the first block of conditioning. However, effect sizes of the correlation tended to increase for SCRs during the first block of fear conditioning, ($-.49 < r < -.63$, all *p*s < .032), SCRs during the first block of the card game ($-.47 < r < -.55$, all *p*s < .039) as well as all self-reported responses after fear conditioning; state anxiety: $-.42 < r < -.52$, all *p*s < .054; US expectancy: $-.17 < r < -.36$, all *p*s > .092; CS+ unpleasantness: $-.37 < r < -.48$,

Table 3
Correlations Between Individual Trait Variables, Responses to Fear Conditioning, Generalization, and Card Game Performance

	Card game net scores				
	Block 1	Block 2	Block 3	Block 4	Total
Trait variables					
Trait anxiety (IPIP-N1)[a]	**−.38*** **(−.25*****)**	**−.40*** (−.20)	**−.42**** **(−.29*****)**	−.13 (−.16)	**−.38*** **(−.27*****)**
Social anxiety (SPIN)[a]	−.23 (−.13)	−.29 (−.02)	−.25 (−.18)	−.10 (−.01)	−.25 (−.09)
Physiological responses to fear conditioning					
SCRs					
([CS+] − [CS−]) Block 1[a]	−.02 (−.02)	−.02 (−.01)	−.03 (−.05)	−.16 (−.17)	−.07 (−.08)
([CS+] − [CS−]) Block 2[a]	−.18 **(−.29*****)**	**−.42**** **(−.23*****)**	**−.47*** **(−.25*****)**	**−.36*** **(−.24*****)**	**−.43**** **(−.30******)**
Startle eye blink responses					
([CS+] − [CS−]) Block 1[b]	.02 (−.15)	.14 (−.05)	.22 (−.07)	.17 (−.03)	.17 (−.09)
([CS+] − [CS−]) Block 2[b]	.01 **(−.24*****)**	.05 (−.12)	−.03 (−.17)	−.04 (−.13)	−.01 (−.19)
Self-reported responses after fear conditioning					
State anxiety (STAI-S)[a]	**−.33*** (−.19)	**−.45*** **(−.34******)**	**−.46**** **(−.27*****)**	−.17 (−.09)	**−.40*** **(−.27*****)**
US expectancy for CS+ [a]	.03 (−.04)	−.04 (−.15)	−.18 (−.21)	−.17 (−.08)	−.11 (−.15)
CS+ unpleasantness[a]	−.03 (−.06)	−.15 **(−.22*****)**	**−.31*** (−.16)	**−.34*** (−.10)	−.25 (−.17)
CS+ fearfulness[a]	−.22 (−.12)	**−.33*** **(−.31******)**	**−.35*** **(−.26*****)**	−.23 (−.03)	**−.33*** **(−.22*****)**
CS+ arousal[a]	−.02 (−.08)	−.13 **(−.29*****)**	−.22 **(−.26*****)**	−.29 (−.14)	−.20 **(−.23*****)**
SCRs during first block of the card game (Generalization)					
([CS+] − [CS−])[b]	**−.42*** **(−.39******)**	**−.37*** **(−.30*****)**	**−.33*** (−.14)	**−.42*** **(−.23*****)**	**−.42*** **(−.31******)**

Note. Correlations from Experiment 1 (and Experiment 2 in parentheses). Significant correlations are in boldface. STAI-S = State-Trait Anxiety Inventory-State version (Spielberger et al., 1983); IPIP = International Personality Item Pool-NEO-PI-R (Goldberg et al., 2006); SPIN = Social Phobia Inventory (Connor et al., 2000); SCRs = Skin conductance responses; CS+/CS− = facial stimulus followed/not followed by US; US = unconditioned stimuli.
[a] $n = 30$. [b] $n = 28$ due to missing values.
* $p < .05$. ** $p < .01$.

all $ps < .080$; CS+ fearfulness: $-.37 < r < -.46$, all $ps < .087$; CS+ arousal: $-.39 < r < -.54$, all $ps < .089$. In addition, correlations between trait anxiety and avoidant decisions failed to reach significance within female participants only, ($-.12 < r < -.30$, all $ps > .18$).

Discussion: Experiment 1

Past research has established the impact of classical fear conditioning on avoidance behavior (Bouton et al., 2001; Craske et al., 2008; Grillon, Baas, Cornwell, & Johnson, 2006; Lovibond et al., 2009; Mineka & Zinbarg, 2006), but did not account for decision conflicts in humans. To this end, the first experiment investigated whether fear conditioning results in avoidance of advantageous choices linked to an aversive CS+. Results, on the one hand, yielded consistently fewer advantageous CS+ choices in the Experimental Group 1 compared with the control group. These relative avoidant decisions of the CS+ persisted despite costs in task performance (indicated by less overall gain) and the absence of the aversive event (US). On the other hand, absolute avoidance of the CS+ compared with the CS− was most pronounced during initial decisions, but gradually decreased across the task. Thus, these findings showed strong initial avoidance followed by (partial) extinction of this behavioral avoidance across participants in the Experimental Group 1.

In addition, the Experimental Group 1 showed elevated fear responses to the CS+ during initial choices, which indicates generalization of fear responses to these initial trials. Importantly, groups did not differ on trait variables (trait and social anxiety, depression) and showed equally successful fear conditioning. Combined, these results provide supporting evidence for a causal role of fear conditioning for the development of avoidant decision making. These decisions closely reflect the costs and impairments of behavioral avoidance.

Furthermore, results yielded multiple predictors of avoidant choices. In particular, increased learning during fear conditioning as indexed by higher differential SCRs predicted stronger individual avoidance. In addition, higher individual levels of trait anxiety incrementally predicted pronounced avoidant decisions above and beyond fear conditioning responses. These latter findings may indicate a specific deficit in extinction of behavioral avoidance in highly trait anxious individuals despite the nonoccurrence of the US and the related rewards during the decision-making task. Although these results offer first insights into individual predictors of avoidant decisions and a potential deficit in vulnerable individuals, Experiment 1 was not specifically designed to test for individual predictors and, given the stepwise regression approach, it remains unclear if the results are only valid for the specific sample (Cohen, 2003). Therefore, Experiment 2 focused on detailed investigation of individual predictors.

Experiment 2: Regression Analysis

The aim of Experiment 2 was to specifically address the question of individual predictors for the strength of avoidant decisions. Experiment 1 provided evidence that both trait anxiety and elevated emotional responding during conditioning predicted subsequent avoidance. Recent research has emphasized the role of trait anxiety as a vulnerability factor for the development of anxiety disorders (Bienvenu et al., 2001, 2004; Brown & Rosellini, 2011; Mineka et al., 1998). Individual emotional responses to aversive experience (such as SCRs during fear conditioning) represent an index for the individual's stress response. Thus, initial findings regarding potential predictors may be interpreted within the framework of a vulnerability-stress perspective for the development of behavioral avoidance (Bouton et al., 2001; Mineka et al., 1998; Mineka & Zinbarg, 2006). Specifically, the individual level of trait anxiety, as a vulnerability factor, may moderate the strength of the association between fear responding during conditioning and subsequent avoidant decisions. Following this assumption, a new sample was recruited and a confirmatory regression analyses was used to specifically test a moderator effect of trait anxiety on the association between fear conditioning and avoidant decisions.

Method

Participants and procedures. Power analyses indicated that to reach 80% power, a medium effect size required 77 participants. Eighty-one students at UCLA participated and provided written informed consent to procedures approved by the UCLA Internal Review Board. Demographic and questionnaire data of the new sample (referred to as Experimental Group 2) are shown in Table 1. All procedures were the same as in Experiment 1 with the exception of no control group.

Statistical analyses. The analyses followed those from Experiment 1. In addition, the new Experimental Group 2 was compared with both groups of Experiment 1. No significant differences between the new group and both previous groups were found for age, sex, trait anxiety, social anxiety, or depression (see Table 1). The main focus was a stepwise hierarchical linear regression based on the exploratory findings from Experiment 1. In Step 1, differential SCRs to the CS + compared with CS− during conditioning and trait anxiety were entered. In Step 2, the interaction effect was entered to test the vulnerability-stress model in terms of a moderator model (Brown & Rosellini, 2011). Before building the regression model, all included variables were centered at their mean to reduce multicollinearity.

Results

Fear conditioning.

Startle responses and SCRs during fear conditioning. SCRs and startle responses of the Experimental Group 2 are shown in Figure 2. In Experiment 2, 9% of the startle trials were rejected. In addition, one participant (1.1%) was excluded from analyses due to absence of any startle response. Finally, SCR measures of one participant were excluded due to recording errors. For SCRs, the repeated measures ANOVA including only the Experimental Group 2 yielded a significant interaction effect of Blocks × CS, $F(1, 79) = 35.09$, $p < .001$, partial $\eta^2 = .308$. Follow-up t tests within the Experimental Group 2 yielded significantly higher SCRs to the CS+ compared with the CS− in the first block, $t(79) = 3.31$, $p = .001$, and the second block, $t(79) = 10.07$, $p < .001$, with a larger differentiation between CS+ and CS− in the second block than the first block, $t(79) = 5.92$, $p < .001$. For startle responses of the Experimental Group 2, the interaction of Blocks × CS was significant, $F(1, 79) = 6.75$, $p = .011$, partial

$\eta^2 = .081$. Follow-up *t* tests within the Experimental Group 2 showed a significantly larger response to the CS+ compared with the CS− in the second block, $t(79) = 3.97$, $p < .001$, but not in the first block, $t(79) = 1.09$, $p = .278$, and with a larger differentiation between CS+ and CS− during the second than the first block, $t(79) = 2.60$, $p = .011$. ANOVAs including all three groups showed no significant main or interaction effects regarding group, all *F*s < 1.6, all *p*s > .22.

Self-reported anxiety and CS ratings after fear conditioning. CS ratings and state anxiety of the Experimental Group 2 are shown in Table 2. Significantly higher ratings for the CS+ compared with the CS− were found on all four scales: unpleasantness, $t(80) = 8.33$, $p < .001$; fearfulness, $t(80) = 8.36$, $p < .001$; arousal, $t(80) = 9.41$, $p < .001$; and US expectancy, $t(80) = 15.87$, $p < .001$. ANOVAs showed no significant differences in CS ratings, state anxiety, intensity of the US, or US unpleasantness among the three groups. In sum, results indicated successful fear conditioning in the new Experimental Group 2 with no differences compared with both previous groups.

Avoidance and fear responses during decision making. The first choice and net scores of the four blocks are shown in Figure 3. Results did not show a significant preference on the first trial in the Experimental Group 2 (52% chose the advantageous CS+ deck vs. 48% chose the disadvantageous CS− deck, $p = .738$).

Relative and absolute avoidant decisions. The repeated measures ANOVA including only the Experimental Group 2 yielded a significant effect of blocks, $F(3, 78) = 2.96$, $p = .039$, partial $\eta^2 = .036$, indicating that participants in the Experimental Group 2 learned to make more advantageous choices. The repeated measures ANOVA including all three groups yielded a significant effect of Group, $F(2, 133) = 4.49$, $p = .013$, partial $\eta^2 = .063$, but no significant interaction effect, $F(3, 132) = 0.21$, $p = .961$, partial $\eta^2 = .006$. Follow-up Scheffé tests showed a significantly lower total net score for the Experimental Group 2 compared with the control group, $p = .032$, but not the Experimental Group 1, $p = .80$. Thus, the Experimental Group 2 also consistently showed relative avoidance of the CS+ compared with the control group despite costs in card game performance. In terms of absolute avoidance, the advantageous CS+ deck was chosen significantly less frequent in the first block within the Experimental Group 2, $t(80) = -2.34$, $p = .022$. However, this initial absolute avoidance again decreased and at the end both decks were selected equally often, $t(80) = 0.65$, $p = .520$. Thus, results replicated the findings of Experiment 1 with consistent relative avoidance constant throughout the task, but diminishing absolute avoidance.

Skin conductance responses during avoidant decisions. Mean SCRs to the CS+ and CS− (within experimental groups), as well as the two novel faces (within the control group) during the first block are shown in Figure 4. Within the Experimental Group 2, SCRs to the CS+ were significantly larger compared with the CS− in the first block, $t(79) = 4.00$, $p < .001$. This was not the case for all remaining blocks, all *t*s < 1.6, *p*s > .10. In addition, SCRs to the CS+ in the Experimental Group 2 were significantly larger compared with both novel faces in the control group, Novel Face 1: $t(102) = 4.04$, $p < .001$; Novel Face 2: $t(102) = 3.05$, $p = .004$, but not to the CS+ in the Experimental Group 1, $t(107) = 0.63$, $p = .532$. Thus, both experimental groups showed elevated SCRs to the CS+ in the first block of the card game. There were no significant differences between SCRs to CS− in the Experimental Group 2 compared with the CS− in the Experimental Group 1 or the novel faces in the control group, all *t*s < 1.70, all *p*s > .08. In sum, results regarding the decision task for the Experimental Group 2 replicated results of Experiment 1.

Individual predictors and the vulnerability-stress model. Following exploratory analyses of Experiment 1, correlations between the individual predictors and avoidant decisions for Experiment 2 are shown in parentheses in Table 3. In Step 1, higher scores for differential SCRs during the second block of fear conditioning, $\beta = -.27$, $t(78) = -2.54$, $p = .013$, and for trait anxiety, $\beta = -.23$, $t(78) = -2.13$, $p = .037$, significantly predicted lower total net scores and explained a significant amount of variance, corrected $R^2 = .14$, $F(2, 77) = 6.14$, $p = .003$. In Step 2, differential SCRs yielded a similar effect, $\beta = -.28$, $t(78) = -2.72$, $p = .008$, whereas the effect of NEO anxiety was marginal, $\beta = -.18$, $t(78) = -1.71$, $p = .092$. The interaction of fear conditioning and trait anxiety significantly predicted total net scores, $\beta = -.23$, $t(78) = -2.10$, $p = .039$, and significantly increased the explained variance in total net scores, corrected $R^2 = .20$, $F(1, 76) = 4.42$, $p = .039$.[3]

To illustrate the interaction effect, the Experimental Group 2 was subdivided into low, medium, and high trait anxiety (27 participants in low and medium, 26 participants in the high anxious subgroup; see Figure 5). Differential SCRs did not predict total net scores in the low trait anxiety, $\beta = .08$, $t(25) = 0.41$, $p = .687$, corrected $R^2 < .01$, and the medium trait anxiety subgroup, $\beta = -.25$, $t(25) = -1.30$, $p = .204$, corrected $R^2 = .06$. However, higher differential SCRs predicted lower total net scores in the high trait anxiety subgroup, $\beta = -.54$, $t(24) = -3.15$, $p = .004$, explaining a significant portion of variance in total net scores, corrected $R^2 = .29$, $F(1, 24) = 9.90$, $p = .004$.

Analogously to Experiment 1, we compared total net scores of participants with low and medium trait anxiety from Experiment 2 with the control group of Experiment 1 to investigate if fear conditioning also resulted in avoidant decisions in these two groups. Result yielded significantly fewer advantageous choices in low trait anxious, $t(50) = -2.07$, $p = .044$, as well as medium trait anxious participants, $t(50) = -2.09$, $p = .042$. Thus, fear conditioning again resulted in avoidant decision in low and medium trait anxious participants, with enhanced avoidance in highly trait anxious participant.

General Discussion

While there is general agreement that avoidance is relevant for the development and maintenance of anxiety disorders, decisions between approach and avoidance have not received adequate attention. Using a novel decision paradigm to model an approach-avoidance conflict, we provide first evidence that fear conditioning leads to subsequent avoidant decisions that result in costs. These costs may be seen as laboratory analogue of the impairments caused by avoidance behavior.

[3] Assumptions for regression analyses were examined visually with scatterplots and histograms of individual predictors and error values. Multicollinearity analyses indicated a lack of significant multicollinearity problems (all tolerances > .94, all VIFs < 1.1). The Durbin-Watson statistic (= 2.17) indicated no correlation among the residuals. The largest Cook's distance (= .08) indicated no serious outliers.

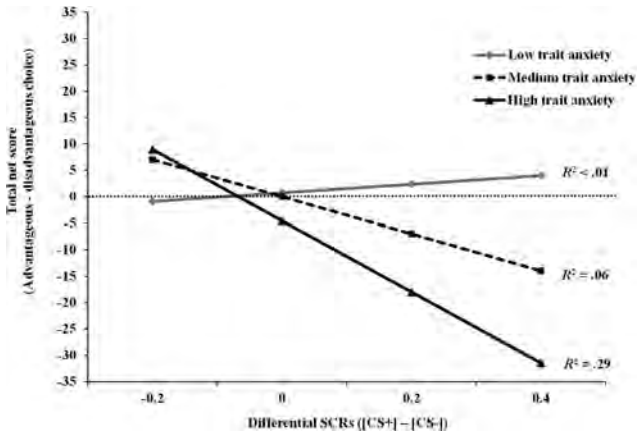

Figure 5. Regression association between total net score in the card game and differential skin conductance responses to the CS+ compared with the CS− during conditioning for individuals with low, medium, and high scores on trait anxiety on the International Personality Item Pool-NEO-PI-R (Goldberg et al., 2006). SCRs = Skin conductance responses.

Impact of Fear Conditioning on Subsequent Approach-Avoidance Decisions

Since the two-factor theory was proposed (Mowrer, 1960), the interaction of classical and operant conditioning is seen as one key factor in the development of avoidance behavior. Results of this study provided first evidence for such a mechanism in the development of avoidant decisions. The experimental groups in both experiments showed sustained relative avoidance of advantageous choices, which were associated with the fear-relevant CS+. These avoidant decisions resulted in task-related costs. Importantly, the first default choice was random in all groups and avoidant decisions only occurred after first experience with the consequences. As groups did not differ in trait or social anxiety, depression or responses to fear conditioning, avoidant decisions cannot be explained by a heightened response to fear conditioning or higher trait vulnerability within a specific group. The results, therefore, suggest that fear conditioning may be one contributing factor to the development of irrational decisions, which are motivated by preventing a confrontation with a fear-relevant stimulus although this resulted in costs.

These findings extend recent fear conditioning research. Specifically, past research showed that individuals acquire an behavioral response during fear conditioning to avoid presentation of an US (Delgado et al., 2009; Lovibond et al., 2009) and demonstrate behavioral avoidance of contexts previously associated with unpredictable USs (Grillon et al., 2006). In the present study, avoidant decisions were, however, related to an aversive conditioned stimulus (the CS+). Although presentation of the US might have been expected during the decision-making task, not a single US occurred during these decisions. Furthermore, our results expand previous conditioning studies by accounting for potential rewards of approach. In line with a recent study on avoidant decisions in highly fearful individuals (Pittig et al., 2014), the current findings indicate that individuals chose to avoid fear-relevant stimuli, even if these decisions result in costs. As US and reward contingencies were uncertain during early decisions, initial avoidance of the CS+ may still be seen as a functional behavioral response to prevent the potential occurrence of the US, irrespective of a lower probability to attain uncertain rewards. Thus, these avoidant decisions parallel a costly outcome of a real-life decision conflict and may be an intermediate step between aversive experience and the acquisition of habitual (pathological) avoidance.

On the other hand, our findings also indicated a reduction in absolute avoidance within both experimental groups. Whereas the CS+ deck was initially selected significantly less frequently, this absolute avoidance vanquished at the end. This reduction may be related to extinction of fear by means of exposure during later decisions because no further aversive experience was made. In support, elevated fear responses toward the CS+ were only present during initial decisions. Another explanation for the reduction in absolute avoidance may be the introduction of rewards for approaching a fear-relevant stimulus. These findings may provide experimental evidence for treatment strategies which target sources of reward for approach to compete with the fear reduction inherent in avoidance. An example for this alternative focus is acceptance–commitment therapy (Hayes, Strosahl, & Wilson, 2003; Yovel & Bigman, 2012). Even if extinction of fear was the pivotal mechanism, exposure experience may have been facilitated by a motivation to approach rewards. Thus, although it is hard to disentangle the role of rewards and fear extinction in the present study, results across the whole experimental groups indicated an extinction of absolute avoidant decisions. The present design may, therefore, be useful to investigate these mechanisms in more detail and serve as a laboratory design for experimental treatment research.

Vulnerability-Stress Model of Avoidant Decisions

Findings from both experiments indicated that higher trait anxiety and enhanced differential SCRs during conditioning predicted pronounced avoidant decisions. Although fear conditioning resulted in avoidant decisions in low and medium trait anxious participants, most pronounced avoidance of the advantageous CS+ choice was found in highly trait anxious individuals. Within this subgroup, differential fear responding accounted for nearly 30% of the variance in decisions. Higher trait anxiety is generally agreed to represent a trait vulnerability to anxiety disorders (Bienvenu et al., 2001, 2004; Brown & Rosellini, 2011; Mineka et al., 1998). Elevated aversive learning that generalizes to subsequent decisions may represent an elevated stress response due to aversive learning. Thus, our findings may be linked to a vulnerability-stress perspective (Bouton et al., 2001; Mineka et al., 1998; Mineka & Zinbarg, 2006). Specifically, a genetic vulnerability for anxiety disorders may be mediated by personality variables such as higher trait anxiety (Hettema, Neale, & Kendler, 2001; Hettema, Prescott, Myers, Neale, & Kendler, 2005) and can serve to potentiate the intensity of fear conditioning (Hettema, Annas, Neale, Kendler, & Fredrikson, 2003; Levey & Martin, 1981; Zinbarg & Mohlman, 1998). Our findings of pronounced behavioral avoidance in highly trait anxious individuals suggest that vulnerability factors such as trait anxiety may also facilitate long-term avoidant decisions after aversive learning, even in the absence of a repetition of the aversive event and at the risk of reduced rewards. These findings, thus, extends the described perspective of a vulnerability-stress model. The facilitation of avoidant decisions may be linked to a

deficit in extinction of behavioral avoidance in highly trait anxious individuals, which may result in the recurrent and persistent avoidance behavior which characterizes anxiety disorders.

Vulnerability-stress models including the role of fear conditioning have been proposed for almost every anxiety disorder (Hofmann, Alpers, & Pauli, 2009; Mineka et al., 1998; Mineka & Zinbarg, 2006). The sample in the current study, however, consisted of healthy individuals, not screened for specific anxiety disorders or vulnerabilities. Yet, fear conditioning resulted in avoidant decisions. Individuals who are at risk or have already developed an anxiety disorder will most likely exhibit even higher levels of vulnerability (Zinbarg et al., 2010). Hence, aversive experience may even yield a more pronounced impact in individuals at risk for or suffering from anxiety disorders.

Generalization of Fear Responses and Translation into Behavior

Both experimental groups showed elevated fear response to the CS+ during initial decisions as indicated by higher SCRs. These initial fear responses predicted decisions throughout the entire decision-making task. Aversive learning during conditioning, thus, generalized to initial decisions and predicted long-term avoidance. Contrary to SCRs, differential startle responses to the CS+ and CS− during fear conditioning, however, did not predict avoidant decisions. Both responses can be indicators for aversive learning, but can be related to different stimulus properties. SCRs are specifically modulated by the level of negative or positive arousal (Lang et al., 1993), whereas startle responses are more strongly modulated by valence (Lang, Cuthbert, & Bradley, 1998). Thus, the impact of fear conditioning on avoidant decisions may be specifically related to differences in negative emotional arousal triggered by the CSs and not their valence.

Recent decision-making theories provide a useful framework for these findings (Bechara, Damasio, Tranel, & Damasio, 1997; Loewenstein et al., 2001). Most important, previous emotional experience, including conditioning experience, may bias decisions and subsequent behavior, if emotional responses are activated during decisions (Loewenstein et al., 2001). Somatic marker theory suggests that such emotional responses during decisions can act as (physiological) markers or gut feelings (Damasio, Tranel, & Damasio, 1991). These markers can label different choices as more or less favorable depending on previous experience. SCRs have frequently been described as such markers (Bechara, Damasio, Damasio, & Lee, 1999; Brand, Grabenhorst, Starcke, Vandekerckhove, & Markowitsch, 2007; Goudriaan, Oosterlaan, de Beurs, & van den Brink, 2006), although not without criticism (Dunn, Dalgleish, & Lawrence, 2006). In addition, false feedback of elevated fear responses during conditioning led to stronger subsequent responding, which was more resistant to extinction (Davey, 1987). False feedback of missing physiological responses, on the other hand, was shown to result in subsequent approach of a fear-relevant stimulus (Valins & Ray, 1967). For avoidant decisions in the present study, a conditioned response (CR) activated by presentations of the CS+ may have operated as such a marker. The CR, as a consequence of an advantageous CS+ choice, may have been incorporated as a threat marker, which led to a subsequent negative labeling of the advantageous choice.

Alternatively to such a physiological explanation, explicit threat expectancies may be a more parsimonious explanation for the avoidant decisions we observed (Lovibond, 2006; Lovibond et al., 2008). Avoidant decisions may be based on explicit expectancies about the occurrence of the US after choosing the advantageous CS+ deck (and its omission if selecting the CS− deck). Although there were no significant correlations between US expectancy ratings after fear conditioning and subsequent avoidant decisions, our experiments were not designed to directly test threat expectancies as a potential mediator of avoidant decisions. Thus, future research should directly assess online measures of US expectancy during the card game trials (e.g., see Lovibond, Davis, & O'Flaherty, 2000).

Irrespective of the exact underlying mechanisms of avoidant decision making, the interaction of fear responses and trait anxiety suggests that these processes may be pronounced in vulnerable individuals. This may suggest that highly anxious individuals rely more on emotional information during decision making than nonanxious individuals, even if they experience similar distress. Similarly, highly anxious, but not healthy individuals tend to show stronger emotional reasoning, that is, they tend to use their own fear responses as invalid evidence about the actual danger of a situation (Arntz, Rauner, & van den Hout, 1995). In combination with these emotional reasoning processes, an emotional decision-making style may represent an underlying mechanism of avoidance behavior and contribute to a deficit of behavioral extinction.

Limitations and Future Research

As the present study tried to establish a new paradigm to investigate behavioral avoidance, it comprises some limitations, which may encourage future research. First, the present experimental model of avoidant decision making has face validity for specific, but not all fear-relevant situations. In some situation, anxious individuals may already be familiar with the likelihood and contingencies of specific benefits of a fear-relevant situation (e.g., a flight phobic who does not board the airplane will know that the destination is desirable to reach). However, in other situations individuals may know that these situations potentially provide benefits but the exact contingencies and gains are usually uncertain (a person with stage fright may or may not be applauded for his presentation). In this regard, our task aimed to model situations with a remaining uncertainty about reward contingencies. Future studies should be designed to address characteristics of other fear-relevant conflict situations (e.g., explicit knowledge about the contingencies). Future research should also evaluate predictive, construct, and diagnostic validity of the present paradigm as a model of psychopathology (Vervliet & Raes, 2012).

Second, as mentioned above, the present study used a control group with identical fear conditioning experience in order to control for levels of general distress before the ensuing decision making task. We switched to previously unknown faces during the card game in order to establish a control condition with the same kind of stimulus material. An alternative approach may be to compare a fear conditioning group with an associative learning group, in which the CS+ is associated with a neutral stimulus. Although this comparison would not account for possible influ-

ences of general distress, it would not require a switch of stimuli across tasks.

Third, gender distribution was not balanced across conditions in Experiment 1 and, thus, the present study was not designed to test the impact of gender on avoidant decision making. Exploratory analyses showed that nearly all effect sizes remained stable or increased if analyses were run for women only. The tentatively stronger associations between physiological and self-reported responses to fear conditioning and avoidant decisions in women may hint at elevated avoidance responses after aversive experience in women compared with men. Higher behavioral avoidance in women has been linked to lower extinction rates due to less reinforcement to confront developmentally fear-relevant stimuli in girls versus boys (McLean & Anderson, 2009). This differential learning of how to cope with fear may generalize to novel fear learning and subsequent avoidance or, alternatively, elevated avoidance responses may represent a more fundamental mechanism for the gender-related prevalence for anxiety disorders. However, these conclusions remain speculative as the present study did not allow for a direct comparison of men versus women.

Fourth, the present study used pictures of female facial expressions as stimuli during both task. Recent findings suggest that women show poorer encoding, memory, and recognition for male compared with female faces, whereas men do not show this gender bias (Lovén, Herlitz, & Rehnman, 2011; Lovén, Svärd, Ebner, Herlitz, & Fischer, 2013). Thus, using female faces in a conditioning paradigm may have optimally enhanced memory and recognition of the corresponding faces in the experimental group. Future research should also present male faces as CSs and may investigate the effects of same- and opposite-sex pairing. Given the social nature of these stimuli, present results also cannot be generalized to nonsocial stimuli, such as prepared fear-relevant stimuli (e.g., spiders or snakes) or arbitrary stimuli (e.g., geometrical shapes), which are frequently used in fear conditioning research, but there is now evidence that they also influence decision making (Pittig et al., 2014).

Fifth, startle responses to the CSs during fear conditioning did not consistently predict subsequent avoidance. Given the differences in physiological arousal to the CSs, it seems likely that CSs would also prompt different startle responses, but startle modulation is difficult to anticipate based on other indicators of arousal (Alpers, Adolph, & Pauli, 2011). Thus, a definite conclusion on the predictive power of individual startle responses in comparison to SCRs will require direct assessment of both variables during the decision-making task. Furthermore, SCRs during fear conditioning were analyzed in the interval of 1 s–4.5 s after CS presentation. Past research on fear conditioning suggested that a later interval may be a better measure of the CR, if the CS–US interval is sufficiently long (first vs. second interval response, see, e.g., Dengerink & Taylor, 1971; Stewart, Stern, Winokur, & Fredman, 1961), although recent investigations did not support this (Pineles, Orr, & Orr, 2009). Future research may prolong CS presentation and investigate the predictive power of later SCRs for avoidant decisions.

Sixth, the present experiments used virtual rewards as incentives for approaching the fear-relevant CS+ option. Because participants in both experiments showed increasing selection rates of the advantageous decks across the task, it seems likely that they responded to the hypothetical gains. This suggests that participants were indeed motivated to maximize their overall gains and accept the increased presentation of the fear-relevant stimulus. This interpretation is further supported by past research showing that hypothetical rewards can be validly generalized to everyday life (Locey, Jones, & Rachlin, 2011). Most importantly, research using similar gambling tasks, for example the Iowa Gambling task, usually do not grant true monetary rewards (e.g., Bechara et al., 1999, 1997; Mueller, Nguyen, Ray, & Borkovec, 2010; van den Bos, Houx, & Spruijt, 2006). Some studies directly compared virtual with real rewards and found no difference in decision making (Bowman & Turnbull, 2003; Jenkinson, Baker, Edelstyn, & Ellis, 2008). Finally, the present design was specifically developed to establish a conflict between the motivation to avoid a presentation of the CS+ and the motivation to obtain long-term gains. Thus, the present design cannot completely separate the specific contribution of each motivational aspect on initial choices and learning during the task. Future research can be designed to replicate these findings and compare different gradients of rewards conditions (e.g., with 80% reward probability or a higher amount of reward), which may help to dismantle the specific contribution of reward.

Conclusion

In sum, the present findings show that fear conditioning can result in avoidant decision making, particularly in anxious individuals. The extent of individual avoidance was predicted by an interaction of trait anxiety and responses to fear conditioning. This learning of avoidant decision making may be a crucial link between aversive experience and the development of habitual avoidance behavior in anxiety disorders.

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