Evaluative conditioning affects the subsequent acquisition of differential fear conditioning as indexed by electrodermal responding and stimulus evaluations

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Evaluative learning affects fear conditioning

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Abstract

It is currently unclear whether the acquisition of negative stimulus valence in evaluative and fear conditioning paradigms is interrelated or independent. The present study used a transfer paradigm to address this question. Three groups of participants were trained in a picture-picture evaluative conditioning paradigm before completing acquisition of differential fear conditioning using graphical shapes as conditional stimuli (CSs). In group Congruent, the shape used as CS+ (paired with the US during fear conditioning) was paired with negative pictures whereas the shape used as CS- (presented alone during fear conditioning) was paired with positive pictures. In group Incongruent the shape used as CS+ was paired with positive pictures whereas the shape used as CS- was paired with negative pictures. In group Different, different shapes were employed in evaluative and fear conditioning. Acquisition of differential electrodermal responses emerged within fewer acquisition trials in groups Congruent and Different than in group Incongruent. Transfer of evaluative learning across paradigms was evident only after removal of participants who failed to display evaluative conditioning. The current research indicates that stimulus valence acquired during evaluative conditioning transfers to fear conditioning and will differentially affect the acquisition of fear learning as indexed by subjective evaluations and electrodermal responses. The findings suggest that evaluative and fear conditioning are not independent.

Key words: Evaluative conditioning; fear conditioning; skin conductance; stimulus valence.

1. Introduction

Evaluations of, and emotional responses to, events we encounter in our environment are critical in determining our behavior (Fridja, 1986; Lang, Bradley, & Cuthbert, 1997). We approach events and situations evaluated as pleasant and avoid events and situations evaluated as unpleasant or that evoke negative emotions such as fear (Fanselow & Poulos, 2005). Given their importance, much research effort has been expended on understanding how such evaluations are acquired and can be altered. This reflects a wide range of intentions – from a desire to enable individuals to realize their full potential by not avoiding events or situations that hold no realistic danger (e.g. Zbozinek, & Craske, 2017) to the intent to render certain products more desirable to boost sales (e.g., Tsiotsou, Alexandris, & Cornwell, 2014). Much of this research has utilized learning paradigms based on Pavlovian learning, such as in evaluative conditioning or fear conditioning.

Evaluative conditioning (for a review see Hofmann, De Houwer, Perugini, Baeyens, & Crombez, 2010) refers to the acquisition of likes or dislikes by a neutral stimulus (conditional stimulus, CS) after pairing with an a-priori liked or disliked stimulus (unconditional stimulus, US). Evaluative conditioning is a very robust phenomenon that has been observed across a number of different stimulus modalities (see Hofmann et al., 2010) and is most frequently assessed in picture-picture paradigms, in which pictures previously evaluated as neutral (geometric shapes, faces, or cartoon characters) are paired with a-priori valenced pictures (emotional faces or pleasant and unpleasant pictures from the International Affective Picture System; Lang, Bradley, & Cuthbert, 2008). Frequently, different CS pictures are paired with positive or negative US pictures respectively to observe the acquisition of likes and dislikes simultaneously. Evaluative conditioning is usually assessed using self-report and implicit measures of stimulus evaluation such as implicit association tests or affective priming (for a review see Fazio & Olson, 2003) as the latter are regarded as less vulnerable to demand characteristics. Some studies have attempted to utilize physiological measures, but results are mixed most likely because the

level of emotional arousal transferred to the CSs in evaluative conditioning is insufficient to drive physiological responses such as skin conductance or blink startle modulation (see for instance Mallan, & Lipp, 2007; Mallan, Lipp, & Libera, 2008).

In human fear conditioning, a-priori neutral (visual, acoustic, tactile stimuli) and unpleasant stimuli (high intensity electro-tactile, loud noises or screams) are paired in order to induce a mild apprehension and aversion to the CSs that is regarded as a laboratory analogue of fear (Lipp, 2006; Lonsdorf et al., 2017). Differential conditioning involving two CSs, one paired with the US (CS+) and the second presented alone (CS-), is the most frequently used paradigm. Physiological measures such as skin conductance or blink startle modulation are the primary dependent variables, although self-report and implicit measures have been employed as well (Luck & Lipp, 2015). Research using human fear conditioning has seen a resurgence in recent years mainly due to its perceived relevance to inform the design of more effective clinical interventions to reduce fear and anxiety (Scheveneels, Boddez, Vervliet, & Hermans, 2016; Waters, LeBeau, & Craske, 2016).

In spite of the procedural and conceptual similarities, research on evaluative and fear conditioning has progressed largely independently with outputs published in different literatures (although it should be noted that the meta analysis on evaluative conditioning by Hofmann et al., 2010, includes fear conditioning studies that reported self-report data). This may, in part, reflect on past claims that evaluative conditioning is distinct from other forms of human Pavlovian learning (Baeyens, & De Houwer, 1995; Gawronski & Bodenhausen, 2018). In particular, evaluative conditioning was said not to require participants' awareness of the CS-US contingency (Baeyens, Eelen, & van den Bergh, 1990), not to be subject to extinction (Baeyens, Crombez, van den Bergh, & Eelen, 1988), and not affected by manipulations of the CS-US contingency (Baeyens, Hermans, & Eelen, 1993). More recent work, however, has provided little support for the first two claims. Pleyers, Corneille, Luminet, and Yzerbyt (2007) demonstrated convincingly that what appears to be evaluative conditioning without

awareness reflects on the effects of aware contingencies that are overlooked in absence of an item based analysis. Nevertheless, the discussion of learning without awareness continues in the evaluative (e.g. Stahl, Haaf, & Corneille, 2016)) and fear conditioning literatures (e.g., Raio, Carmel, Carrasco, & Phelps, 2012; but see Purkis & Lipp, 2001; Lovibond & Shanks, 2002). Extinction of evaluative learning has been shown repeatedly (e.g., Luck & Lipp, in press, who not only showed extinction of evaluative conditioning, but also demonstrated that evaluative conditioning is subject to relapse), but there is also evidence to question these findings (e.g., Gawronski, Gast, & De Houwer, 2015). Less work seems available on the question of whether evaluative conditioning is sensitive to manipulations of the CS-US contingency or may be affected only by the contiguity of the two stimuli (Hofmann et al., 2010).

When assessing similarities or differences between two phenomena, two different approaches seem feasible. The first focusses on dissociations, i.e., the same experimental manipulation having different effects on evaluative and fear conditioning, and has been the preferred approach to date (see for instance Dunn & Kirsner, 1988). The second focusses on similarities that can be observed in transfer paradigms which assess, for instance, whether emotional learning in one paradigm will facilitate or hinder emotional learning in the second. The absence of transfer would provide some indication that evaluative and fear conditioning paradigms tap distinct processes. If evaluative conditioning is mediated by a learning mechanism that is distinct from that which mediates fear learning, then prior acquisition of a dislike to the CS+ and a like to the CS- should not affect subsequent fear learning – and neither should prior acquisition of a like to the CS+ and a dislike to the CS-. If, however, evaluative and fear learning are in some way related, then prior acquisition of a dislike to the CS+ and a like to the CS- should facilitate subsequent fear learning, and prior acquisition of a like to the CS+ and a dislike to the CS- should hinder fear learning. This positive or negative transfer should be evident in self-reported stimulus valence, a measure that has been employed in

evaluative and fear conditioning research, but also in electrodermal responses, the most frequently used physiological measure in human fear learning which is sensitive to emotional arousal (Bradley, 2000).

The current study presented participants with an evaluative conditioning picture-picture task followed by differential fear conditioning using an electrotactile US. To retain the fidelity of both paradigms, stimulus parameters were selected that match those typically used in studies of evaluative and fear conditioning, i.e., stimulus durations, interstimulus intervals, and intertrial intervals differed across paradigms. Moreover, the practice of having both CSs followed by multiple USs in evaluative conditioning, but using only one US and presenting one CS alone in differential fear conditioning was retained. The current design comprised three groups that were presented with the same stimulus sequences during Pavlovian fear conditioning using two geometric shape CSs – one followed by the US (CS+) and the other presented alone (CS-). The groups, however, differed in the evaluative conditioning procedures carried out before fear conditioning. Group Congruent was presented with unpleasant pictures after the to-be-CS+ shape and with pleasant pictures after the to-be-CS- shape, whereas, group Incongruent was presented with unpleasant pictures after the to-be-CS- shape and with pleasant pictures after the to-be-CS+ shape. Group Different was presented with different shape CSs during evaluative and during fear conditioning to control for non-associative effects such as the mere exposure to emotionally salient pictures before the onset of fear conditioning. If prior evaluative conditioning does not affect subsequent fear conditioning, then no difference in the acquisition of fear conditioning across groups would be expected. If, however, prior evaluative conditioning affects fear conditioning then, relative to group Different, acquisition of self-reported stimulus valence and differential electrodermal responses would be expected to be accelerated in group Congruent and retarded in group Incongruent.

2. Method

2.1. Participants.

One-hundred (34 male) participants aged 18 to 65 years (M = 24.15, SD = 9.30) volunteered in exchange for course credit or a compensation of AUS $15 and provided informed consent. Participants were assigned to the three groups upon arrival at the laboratory with the proviso of maintaining an equal gender ratio and until each group had 32 participants who provided complete skin conductance data. Final group numbers were: Congruent: 34; Incongruent: 33; Different: 32. Sample size was based on previous studies on fear conditioning that had yielded robust effects (Luck & Lipp, 2015, 2016).

2.2. Apparatus and materials.

Participants were tested individually in a psychophysiological laboratory equipped with a Biopac MP150 data acquisition unit and a separate computer to control the experiment. Stimuli were presented on a 24'' LED (1920 ×1080 pixels) screen with 60Hz refresh rate. CSs were black on white outlines of four geometric shapes (circle, square, diamond, and triangle; 900 x 675 pixels) presented for 3s during evaluative conditioning and for 6s during fear conditioning. USs during evaluative conditioning were four pleasant (1460: Kitten; 1710: Puppies; 2340: Grandfather with grandchildren; 5833: Beach) and four unpleasant (2800: Sad child; 9220: Cemetery; 9295: Garbage; 9560: Duck in oil slick) pictures from the International Affective Picture System (Lang et al., 2008). The US during fear conditioning was a 200ms electrotactile stimulus generated by a Grass SD9 stimulator unit, set to an intensity that was evaluated as 'unpleasant, but not painful' by each participant individually, and applied to the preferred forearm with a concentric stimulus electrode.

Fear and valence ratings of the CSs were collected by displaying each of the four shapes and asking participants to indicate on a Likert scale of 1-9 how fearful they felt when seeing the shape ('not at all' to 'absolutely terrified') and how pleasant they felt the shape was ('very unpleasant' to 'very pleasant'). Participants completed these ratings using a QWERTY keyboard placed in front of them. After completion of the experiment, participants completed a post experimental questionnaire that required an indication of which of the 4 shapes had been viewed in the experiment and which shape

had been paired with the electrotactile stimulus as well as the provision of demographic information and of pleasantness ratings of the 8 US pictures and the electrotactile stimulus on a 7 point Likert scale ranging from -3 (very unpleasant) to +3 (very pleasant).

Electrodermal activity was recorded with two pre-gelled disposable electrodes (Biopac EL507) attached to the thenar and hypothenar eminences of participants' non-preferred hand and connected to a Biopac EDA100C DC amplifier with a gain of 5 µS/V. Respiration was recorded with a respiration transducer attached to a chest strap and connected to a RSP100C amplifier to control for respiration and movement related artefacts in electrodermal activity. Online valence ratings for CSs and for the picture USs used during evaluative conditioning were collected continuously using a Biopac TSD115 variable assessment transducer (anchors: 0 = 'unpleasant' to 9 = 'pleasant'). All measures were recorded with a sampling rate of 1000Hz.

2.3. Design and procedures.

Upon arrival at the laboratory, participants were given information about the experiment, provided informed consent, and washed their hands. After the attachment of the measurement devices, participants provided fear and valence ratings for the four CSs and were instructed in the use of the variable assessment transducer. Participants were asked to indicate their evaluation of the visual stimuli displayed on the computer screen by moving the slider to the position on the continuum of 'very pleasant' to 'very unpleasant' that best represented their evaluation of the stimulus and then to move the slider back to neutral. The experimenter confirmed that participants understood the instructions by asking them to indicate what they would do if a pleasant or an unpleasant stimulus was presented. After this, a three minute baseline of electrodermal activity was recorded and the experimental protocol commenced. The conditioning protocol was run without interruption and comprised the evaluative conditioning sequence followed by the fear conditioning procedure including acquisition, extinction, the reinstatement manipulation (3 presentations of the US alone) and a reinstatement test. After the

conditioning protocol, participants completed a second fear and valence rating of the four CSs and the post experimental questionnaire. After this, participants were debriefed and thanked and any questions they had about the experiment were answered. The entire procedure took about 40 min.

The evaluative conditioning procedure comprised 20 pairings of one shape with negative pictures and 20 pairings of a second shape with positive pictures. Trials were presented in blocks of 8 such that all other US pictures were shown before a particular US was repeated and no more than two consecutive trials displayed the same geometric shape. CS and US pictures were presented consecutively for 3s each with an intertrial interval (US offset to CS onset) of 2.5, 3.5 or 4.5 s such that CS offset coincided with US onset (3 s delay conditioning). Acquisition of fear conditioning comprised eight presentations of one shape (CS+) followed by the electrotactile US, such that US onset coincided with CS+ offset and eight presentations of a second shape alone (CS-). Shapes were presented for 6s with an intertrial interval (CS offset to CS onset) of 15, 17, or 19 s in a pseudo random sequence with the restriction that no more than two consecutive trials were the same. Acquisition was followed by 24 extinction trials (12 CS+, 12 CS-) structured in the same manner as acquisition. Sixteen seconds after the last extinction trial, participants were presented with three unpaired electrotactile USs separated by an 8 s interstimulus interval to induce reinstatement followed by 4 unreinforced test trials (2 CS+, 2 CS-). The stimulus sequences within each phase were counterbalanced such that for half the participants each phase started with a shape followed by a positive/negative picture or paired with the electrotactile US/presented alone. Allocation of shape to CS+/CS- was counterbalanced across participants. The inclusion of the extinction and reinstatement phases was exploratory and as the results are not pertinent to the present research question, they are reported in the supplement.

The fear conditioning component of the experiment was the same for all three groups, but the groups differed in the design of the evaluative conditioning component. In group Congruent, the shape to be used as CS+ was presented with negative pictures whereas the shape to be used as CS- was

presented with positive pictures. In group Incongruent, the shape to be used as CS+ was presented with positive pictures whereas the shape to be used as CS- was presented with negative pictures. In group Different, different shapes were presented during evaluative and fear conditioning.

2.4. Scoring, response definition and statistical analysis.

Electrodermal responses during the 3-min baseline were counted as an index of overall responsiveness. Electrodermal responses were quantified during fear conditioning using three latency windows (Prokasy & Kumpfer, 1973; Luck & Lipp, 2016), first interval responses commenced 1-4 s after CS onset, second interval responses commenced 4-7 s after CS onset and third interval responses commenced 7-10 s after CS offset (1-4 s after US onset). The largest response starting within the latency window was scored and responses were quantified as the difference between response onset and response peak. Prior to analyses, electrodermal responses were square root transformed and range corrected to control for the skew of the distribution and individual differences in response size respectively (Dawson, Schell, & Filion, 2007). Online evaluations were scored as the largest deviation in Volts from a zero baseline during the presentation of a CS or picture US respectively (Range -2.5V – 2.5V). Positive and negative values correspond to assessments of pleasant and unpleasant, respectively. Prior to statistical analyses, online ratings and electrodermal responses were averaged into blocks of two trials. Evaluations of shapes and US pictures collected during evaluative conditioning were subjected to 3 × 2 × 10 (Group [Congruent, Incongruent, Different] × US valence [negative vs. positive] × Block) factorial ANOVAs with repeated measures on the last two factors. CS evaluations and electrodermal first interval responses collected during fear conditioning were subjected to 3 × 2 × 4 (Group [Congruent, Incongruent, Different] × CS [CS+ vs. CS-] × Block) factorial ANOVAs with repeated measures on the last two factors. Analyses of electrodermal second interval responses yielded results similar to those of first interval responses and are not reported separately. The multivariate

solution of the ANOVA (Pillai's Trace) was used to assess significance and alpha was set to .05[1].

3. Results

3.1. Preliminary analyses.

For descriptive statistics see Table 1. The three groups did not differ in the number of spontaneous electrodermal responses during baseline or age, both $F < 0.50$, $p > .600$, $\eta_p^2 < .011$, or in the ratio of male to female and or the ratio of contingency verbalizers to non-verbalizers in fear conditioning, both $\chi^2(2) < 5.41$, $p > .065$. Participants rated the unpleasant US pictures as less pleasant than the pleasant ones in the post experimental questionnaire, $F(1,97) = 990.169$, $p < .001$, $\eta_p^2 = .911$, with no difference between the groups, all $F < 1.30$, $p > .290$, $\eta_p^2 < .026$. Participants rated the CS+ as more unpleasant and fear evoking after the experiment than before as indicated by main effects for CS, both $F(1,97) > 16.24$, $p < .001$, $\eta_p^2 > .140$, and time, both $F(1,97) > 67.70$, $p < .001$, $\eta_p^2 > .410$, and CS × Time interactions, both $F(1,97) > 29.57$, $p < .001$, $\eta_p^2 > .230$. CS+ was evaluated as less pleasant than CS- after the experiment, both $F(1,97) > 27.0$, $p < .001$, $\eta_p^2 > .210$, but not before the experiment, both $F < 0.30$, $p > .640$, $\eta_p^2 < .003$.

The analysis of the evaluations of the picture USs presented during evaluative conditioning yielded main effects for US, $F(1,96) = 790.44$, $p < .001$, $\eta_p^2 = .892$, as well as Group × Block, $F(18,178) = 1.95$, $p = .015$, $\eta_p^2 = .325$, and US × Block interactions, $F(18,178) = 4.70$, $p < .001$, $\eta_p^2 = .325$, all other $F < 1.65$, $p > .195$, $\eta_p^2 < .034$. The Group × Block interaction reflects that the average ratings for the USs differed across blocks in groups Congruent and Incongruent, both $F(9,88) > 2.12$, $p < .036$, $\eta_p^2 > .178$, but not in group Different, $F(9,88) = 0.86$, $p = .567$, $\eta_p^2 = .081$. The US × Block interaction indicates that positive USs were evaluated as more pleasant than negative USs on each block, all $F(1,96) > 512.80$, $p < .001$, $\eta_p^2 > .842$, but the evaluation of the positive pictures differed across blocks, $F(9,88) = 2.38$, $p = .018$, $\eta_p^2 = .196$, whereas evaluations of the negative pictures were

[1] The current report is limited to significant findings – see the Supplement for tables of all ANOVA results.

stable, $F(9,88) = 1.67$, $p = .107$, $\eta_p^2 = .146$.

Insert Table 1 about here

Electrodermal responses to the electrotactile US declined across blocks of acquisition, $F(3,91) = 26.95$, $p < .001$, $\eta_p^2 = .471$, with responses on blocks 1 and 2 being larger than on subsequent blocks, and did not differ between groups, all other $F < 1.41$, $p > .250$, $\eta_p^2 < .030$.

3.2. CS evaluations

One participant in group Different did not follow the instructions to evaluate each CS consistently and was excluded from the evaluation data, leaving ninety nine participants with CS evaluation data suitable for analyses. As shown in Figure 1A, the groups seemed to differ in the extent to which they displayed differential evaluative conditioning with differential evaluations of shapes paired with pleasant and unpleasant pictures more evident in group Different, than in the other groups. The latter impression was only partially confirmed by the analysis which yielded a main effect for block, $F(9,88) = 2.40$, $p = .018$, $\eta_p^2 = .197$, and a US valence × Block interaction, $F(9,88) = 2.12$, $p = .036$, $\eta_p^2 = .178$. The Group × US valence interaction, $F(2,96) = 2.88$, $p = .061$, $\eta_p^2 = .057$, was not significant on the preset level, all other $F < 1.92$, $p > .150$, $\eta_p^2 < .040$. The US valence × Block interaction reflects that shapes paired with unpleasant pictures were evaluated as more negative across blocks, $F(9,88) = 3.75$, $p < .001$, $\eta_p^2 = .277$, whereas evaluations of the shapes paired with pleasant pictures did not change, $F(9,88) = 0.71$, $p = .699$, $\eta_p^2 = .068$. All other $F < 193$, $p > .151$, $\eta_p^2 < .04$. The differential evaluation of the CS shapes approached significance on the last block of training, $F(1,96) = 3.941$, $p = .050$, $\eta_p^2 = .039$, all other $F < 3.43$, $p > .068$, $\eta_p^2 < .035$.

During acquisition of fear conditioning, differential evaluations of CS+ and CS- developed across blocks in all groups as illustrated in Figure 1B and indicated by main effects for CS, $F(1,96) =$

30.36, $p < .001$, $\eta_p^2 = .240$, and block, $F(3,94) = 12.98$, $p < .001$, $\eta_p^2 = .293$, and a CS × Block interaction, $F(3,94) = 18.07$, $p < .001$, $\eta_p^2 = .366$, all other $F < 1.58$, $p > .209$, $\eta_p^2 < .031$. The interaction reflects that CS evaluations did not differ during block 1, $F(1,96) = 1.03$, $p = .313$, $\eta_p^2 = .011$, but were more negative for CS+ on all subsequent blocks, all $F(1,96) > 17.20$, $p < .001$, $\eta_p^2 > .150$.

Insert Figure 1 about here

3.3. First interval electrodermal responses

Ninety-six participants, 32 from each group, provided valid electrodermal first interval response data. The remaining participants were classed as electrodermal non-responders. Figure 1C suggests some difference between groups in electrodermal responses to CS+ and CS- early during acquisition which is superseded by uniform differential conditioning with larger responses to CS+ than to CS- late during acquisition. The overall analysis provided evidence for differential conditioning yielding main effects for CS, $F(1,93) = 27.08$, $p < .001$, $\eta_p^2 = .225$, and block, $F(3,91) = 12.03$, $p < .001$, $\eta_p^2 = .284$, and a CS × Block interaction, $F(3,91) = 4.95$, $p = .003$, $\eta_p^2 = .140$, all other $F < 1.26$, $p > .285$, $\eta_p^2 < .027$. The interaction reflects that responses to CS+ and CS- did not differ on block 1, $F(1,96) = 0.15$, $p = .695$, $\eta_p^2 = .002$, but were larger to CS+ on all subsequent blocks, all $F(1,96) > 10.70$, $p < .002$, $\eta_p^2 > .102$.

The omnibus analysis did not substantiate what appears to be a between group difference early during acquisition. To assess whether this apparent difference is reliable a further analysis of electrodermal responses on the first two trials of acquisition was conducted (1 participant in group Congruent was excluded due to missing data). This analysis yielded a main effect for trial, $F(1,92) = 49.01$, $p < .001$, $\eta_p^2 = .348$, and CS × Trial, $F(1,92) = 6.89$, $p = .010$, $\eta_p^2 = .070$, and Group × CS interactions, $F(2,92) = 5.11$, $p = .008$, $\eta_p^2 = .10$, all other $F < 1.0$, $p > .535$, $\eta_p^2 < .014$. As shown in

Figure 1D, electrodermal responses to CS+ and CS- did not differ on trial 1, $F(1,92) = 2.97$, $p = .088$, $\eta_p^2 = .031$ (responses to CS- tended to be larger than responses to CS+), but were larger to CS+ than to CS- on trial 2 of acquisition, $F(1,92) = 5.17$, $p = .025$, $\eta_p^2 = .053$. The Group × CS interaction reflects that responses to CS+ were larger than responses to CS- in group Congruent, $F(1,92) = 4.36$, $p = .040$, $\eta_p^2 = .045$, whereas responses to CS+ were smaller than responses to CS- in group Incongruent, $F(1,92) = 4.97$, $p = .028$, $\eta_p^2 = .051$. There was no difference between CS+ and CS- in group Different, $F(1,92) = 1.17$, $p = .282$, $\eta_p^2 = .013$.

4. Supplementary Analyses

The current results suggest that prior evaluative conditioning training affects the acquisition of fear conditioning as indexed by electrodermal responses, but not by stimulus evaluations. The failure to find an influence of evaluative conditioning training on stimulus evaluations may occur because evaluative conditioning was weak in some groups and may not have occurred in some participants. To address this issue, a set of supplementary analyses was conducted excluding participants who displayed evaluative conditioning in the opposite direction, i.e., evaluated the shape paired with positive pictures as more negative than the shape paired with negative pictures by more than one tenth of the total scale (.5V) during the last two blocks of evaluative conditioning training. This resulted in the exclusion of 6 participants from group Congruent, 5 from group Incongruent, and 4 from group Different leaving 85 participants with valid evaluation data (Congruent: 28; Incongruent; 28; Different 29) and 81 participants with valid electrodermal data (Congruent: 26; Incongruent; 27; Different 28).

4.1. CS evaluations

As shown in Figure 2A, differential evaluative conditioning was acquired. This impression was confirmed by the analysis which yielded main effects for US valence, $F(1,82) = 19.31$, $p < .001$, $\eta_p^2 = .191$, and block, $F(9,74) = 3.22$, $p = .002$, $\eta_p^2 = .281$, as well as a US valence × Block interaction, $F(9,75) = 2.78$, $p = .007$, $\eta_p^2 = .253$, all other $F < 1.77$, $p > .176$, $\eta_p^2 < .042$. CSs paired with unpleasant

pictures were evaluated as more negative than CSs paired with pleasant pictures on blocks 3-10, all $F(1,82) > 9.37$, $p < .004$, $\eta_p^2 > .102$, and CSs paired with unpleasant pictures were evaluated as more negative across blocks, $F(9,74) = 3.57$, $p = .001$, $\eta_p^2 = .303$, whereas evaluations of CSs paired with pleasant pictures did not change, $F(9,74) = 1.31$, $p = .245$, $\eta_p^2 = .138$.

Insert Figure 2 about here

Figure 2B suggests transfer of the stimulus evaluations acquired during evaluative condition to fear conditioning in groups Congruent and Incongruent. This impression was confirmed by the analysis which yielded main effects for CS, $F(1,82) = 34.50$, $p < .001$, $\eta_p^2 = .296$, and block, $F(3,80) = 10.16$, $p < .001$, $\eta_p^2 = .276$, as well as CS × Block, $F(3,80) = 18.92$, $p < .001$, $\eta_p^2 = .415$, and Group × CS interactions, $F(2,82) = 4.02$, $p = .022$, $\eta_p^2 = .089$, all other $F < 1.15$, $p > .384$, $\eta_p^2 < .042$. CS evaluations did not differ on block 1, $F(1,82) = 0.48$, $p = .490$, $\eta_p^2 = .006$, but CS+ was evaluated as less pleasant than CS- on blocks 2-4, all $F(1,82) > 18.63$, $p < .001$, $\eta_p^2 > .184$. The Group × CS interaction reflects more negative evaluations of CS+ than CS- in groups Congruent and Different, both $F(1,82) > 18.59$, $p < .001$, $\eta_p^2 > .184$, with no difference in group Incongruent, $F(1,82) = 1.71$, $p = .282$, $\eta_p^2 = .014$.

To further illustrate the acquisition of CS evaluations in group Incongruent, the data from this group were subjected to a separate 2 × 4 (CS × Block) factorial ANOVA which yielded a CS × Block interaction, $F(3,25) = 4.36$, $p = .013$, $\eta_p^2 = .344$. CS+ was evaluated as more pleasant than CS- on block 1, $F(1,27) = 8.96$, $p = .006$, $\eta_p^2 = .249$, but as less pleasant than CS- on blocks 3 and 4, both $F(1,27) > 5.64$, $p < .026$, $\eta_p^2 > .172$.

4.2. First interval electrodermal responses

To confirm the results of the omnibus analysis we reanalyzed the electrodermal data in the reduced sample. This analysis, see Figure 2C, revealed main effects for CS, $F(1,78) = 17.91$, $p < .001$,

η_p^2= .187, and block, $F(3,76) = 8.34$, $p < .001$, η_p^2= .248, and a CS × Block interaction, $F(3,76) = 3.21$, $p = .028$, η_p^2= .113, all other $F < 1.68$, $p > .130$, $\eta_p^2 < .062$. CS+ elicited larger responses than did CS- on blocks 2-4, all $F(1,78) > 7.70$, $p < .008$, $\eta_p^2 > .080$, but not on block 1, $F(1,78) = 0.08$, $p = .777$, η_p^2= .001.

As for the entire sample, inspection of the initial phase of acquisition suggests differences between the groups in conditioning. The reliability of this impression was assessed in an additional analysis that only includes the first two trials of acquisition. As for the entire sample, this analysis yielded a main effect for trial, $F(1,77) = 27.96$, $p < .001$, η_p^2= .266, and CS × Trial, $F(1,77) = 4.84$, $p = .031$, η_p^2= .059, and Group × CS interactions, $F(2,77) = 5.39$, $p = .006$, η_p^2= .123, all other $F < 1.0$, $p > .637$, $\eta_p^2 < .010$. As shown in Figure 2D, the CS × Trial interaction reflects that responses to CS+ increased from trial 1 to trial 2, $F(1,77) = 26.94$, $p < .001$, η_p^2= .259, whereas responses to CS- did not, $F(1,77) = 2.33$, $p = .131$, η_p^2= .029. Responses to CS+ and CS- did not differ on trial 1 or 2, both $F(1,77) < 3.63$, $p > .060$, $\eta_p^2 < .045$. The Group × CS interaction reflects that responses to CS+ were larger than responses to CS- in group Congruent, $F(1,77) = 4.07$, $p = .047$, η_p^2= .05, whereas responses to CS+ were smaller than responses to CS- in group Incongruent, $F(1,77) = 5.64$, $p = .020$, η_p^2= .068, and did not differ in group Different, $F(1,77) = 1.26$, $p = .265$, η_p^2= .016.

5. Discussion

The purpose of the current study was to assess whether prior evaluative conditioning would affect subsequent fear conditioning as indicated by continuous CS evaluations and electrodermal responses. Three groups of participants underwent differential fear conditioning preceded by an evaluative conditioning picture-picture paradigm in which one CS shape was paired with positive pictures and a second was paired with negative pictures. In group Congruent, the CS shape paired with negative pictures during evaluative conditioning served as the danger cue predicting the aversive electrotactile US during fear conditioning, whereas, in group Incongruent, the CS shape paired with

negative pictures during evaluative conditioning served as the safety cue predicting the absence of the electrotactile US (CS-) during fear conditioning. In group Different, different shape CSs were employed during evaluative and fear conditioning.

The analysis of the electrodermal data during the acquisition of fear conditioning indicated a transfer from evaluative conditioning to fear conditioning. Group Congruent displayed differential electrodermal responding within the first two trials of acquisition and acquired differential responding faster than group Different. Group Incongruent showed the inverse pattern displaying larger responses to the CS- – the stimulus to be trained as a safety signal. This between group difference was, however, eliminated within a few further training trials as physiological responses changed to reflect the new stimulus contingencies. The results for CS evaluations were less clear, however, due to a small group of participants who failed to display evaluative conditioning in the picture-picture paradigm and provided evaluations strongly in the opposite direction, i.e., evaluated shape CSs paired with negative pictures as more positive than shape CSs paired with positive pictures. After removal of these participants, evaluative conditioning was observed in all three groups in the picture-picture paradigm. In this reduced sample, a clear transfer effect in stimulus evaluations emerged. Differential stimulus evaluations during the acquisition phase of fear conditioning were acquired readily in groups Congruent and Different, but only slowly in group Incongruent. Of note, removal of participants did not alter the pattern of electrodermal responses seen during early acquisition – faster acquisition of differential responding in group Congruent and delayed acquisition of differential responding in group Incongruent.

Taken together, the current results provide the first evidence that training in a picture-picture paradigm can affect subsequent fear conditioning. This transfer was evident in electrodermal responses for the entire sample and became apparent in CS evaluations after participants who evaluated CSs paired with positive pictures as more negative than CSs paired with negative pictures were removed

from the analysis. What led to these reversed evaluations in about 10% of the sample remains unclear. The evaluative conditioning procedure used here was modelled on a paradigm that has been used in our laboratory in the last three years yielding reliable differential evaluative conditioning (see Luck & Lipp, in press). It should be noted, however, that some changes were made that may have affected the relative evaluations of CS+ and CS-. All participants underwent a shock workup procedure prior to evaluative conditioning, exposing them to a stimulus that arguably is more aversive than any of the pictures used during evaluative conditioning. This and the knowledge that this stimulus would be encountered at some stage during the experiment may have provided an anchor that biased subsequent stimulus evaluations. In our typical evaluative conditioning procedure, conditional stimulus evaluations are assess in test phases presented interleaved with blocks of evaluative conditioning training. In the current experiment, we utilized a continuous assessment as used in fear conditioning (see Luck & Lipp, 2015) which required evaluation of CS and US pictures. Inclusion of the US pictures may have deemphasized the valence of the CSs and reduced the contrast between the CSs during evaluative conditioning which are usually assessed together and in isolation from the USs. Post hoc analyses also confirmed that the four US pictures chosen per valence category were not uniformly assessed as positive or negatively, Some participants perceived one of the negative US pictures as slightly positive and one of the positive pictures as slightly negative (IAPS No 9560 and 1460, respectively). This may reflect on misinterpretations of the content depicted (not realizing that the seabird is caught in an oil slick or believing that the kitten is in danger). Future studies may benefit from the selection of US pictures that are more uniformly regarded as positive or negative and utilize a continuous assessment procedure that requires the assessment of only the valence of the CSs.

It should be noted, however, that an effect of evaluative conditioning on subsequent fear conditioning as indexed by electrodermal responses was evident in the entire sample – including those participants who indicated CS evaluations during evaluative conditioning that were in the opposite

direction to that expected given the stimulus contingencies. This seems to suggest that the failure to find clearer evidence for evaluative conditioning in some participants was due to a problem with measurement rather than with the evaluative conditioning manipulation. Transfer of emotional learning as evidenced by online ratings was observed after the removal of those participants. This may indicate that some participants were not clear as to the use of the measurement device and that in spite of the explicit instructions used to clarify the use of the slider a more formal training may be required.

The current study clearly shows that evaluative conditioning does affect subsequent fear conditioning, by accelerating or slowing its acquisition at least during the initial trials of training. This transfer was evident not only in the measure that is common across the two emotional learning paradigms – self-reported stimulus evaluation – but also in the physiological index of emotional arousal that is most commonly used in fear conditioning – electrodermal responses. This finding of transfer is not consistent with the view that evaluative and fear conditioning are independent (Baeyens, & De Houwer, 1995; Gawronski & Bodenhausen, 2018). However, it is currently not clear whether this interdependence is indicative of a shared emotional learning mechanism, the convergence of distinct learning mechanisms onto shared response pathways or a change in CS salience or valence that would affect the speed of fear conditioning. While further studies are required that explore the relationship between evaluative and fear conditioning, the current demonstration is an important first step. These further studies may benefit from a refinement of the manner in which evaluative learning is assessed continuously and from the employment of a 'weaker' fear conditioning procedure (i.e. using partial reinforcement) to allow transfer effects to be observed in more detail without being overridden by the fear conditioning contingencies within a few trials (see Lissek, Pine & Grillon, 2006). More research will be required to understand how evaluative conditioning affects subsequent fear learning, but the current results provide an important first step towards understanding this phenomenon and encourage the exploration of evaluative conditioning as a potential intervention to accelerate the extinction of fear

conditioning – an approach that may have implications not only for the understanding of emotional learning, but also for clinical practice (Kerkhof et al., 2012).

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Tables

Table 1.

Summary descriptive statistics for the preliminary analyses.

	Congruent	Incongruent	Different
SCRNS: M (SD)	16.46 (13.32)	16.91 (14.10)	15.94 (11.39)
Age: M (SD)	24.56 (11.29)	25.03 (8.98)	22.85 (7.28)
Sex: F/M	22/12	24/8	20/13
Contingency: Y/N	29/5	23/10	30/3
Valence Ratings USu: M (SD)	2.03 (0.90)	1.67 (1.18)	1.83 (0.87)
USp: M (SD)	7.28 (0.91)	7.52 (1.12)	7.67 (1.01)
CS+ Pre: M (SD)	6.38 (1.65)	6.42 (1.92)	6.58 (1.89)
CS- Pre: M (SD)	6.26 (1.85)	6.70 (1.88)	6.45 (1.91)
CS+ Post: M (SD)	4.29 (2.10)	5.0 (2.51)	3.64 (2.49)
CS- Post: M (SD)	5.59 (1.89)	6.33 (1.98)	5.76 (1.99)
Fear Ratings CS+ Pre: M (SD)	2.41 (1.91)	1.79 (1.54)	2.03 (1.85)
CS- Pre: M (SD)	2.21 (2.20)	2.0 (1.84)	2.18 (2.11)
CS+ Post: M (SD)	4.71 (2.61)	4.45 (3.06)	5.21 (2.82)
CS- Post: M (SD)	2.62 (1.84)	2.79 (2.33)	2.88 (2.30)

Figure Captions

Figure 1: Stimulus evaluations (N=99) and electrodermal responses (N=96) for the entire sample in groups Congruent (C_), Incongruent (I_), and Different (D_). A) Evaluations of shapes paired with pleasant (_CSP and _DSP) or unpleasant pictures (_CSU or _DSU) during evaluative conditioning; B) Evaluations of CS+ and CS- during acquisition; C) Electrodermal responses to CS+ and CS- during acquisition; D) Electrodermal responses to CS+ and CS- during the first two trials of acquisition. Responses are displayed as a function of blocks of two trials in panels A-C and as a function of single trials in panel D. Please note: The same shapes were used as stimuli C_CSU and C_CS+, C_CSP and C_CS-, I_CSU and I_CS-, and I_CSP and I_CS+; different shapes were used as stimuli D_DSU and D_CS+ and D_CSP and D_CS-.

Figure 2: Stimulus evaluations (N=85) and electrodermal responses (N=81) excluding participants who during the last two blocks of evaluative condition evaluated the shapes in the opposite direction by more than one tenth of the total scale (.5V) in groups Congruent (C_), Incongruent (I_), and Different (D_). A) Evaluations of shapes paired with pleasant (_CSP and _DSP) or unpleasant pictures (_CSU or _DSU) during evaluative conditioning; B) Evaluations of CS+ and CS- during acquisition; C) Electrodermal responses to CS+ and CS- during acquisition; D) Electrodermal responses to CS+ and CS- during the first two trials of acquisition. Responses are displayed as a function of blocks of two trials in panels A-C and as a function of single trials in panel D. Please note: The same shapes were used as stimuli C_CSU and C_CS+, C_CSP and C_CS-, I_CSU and I_CS-, and I_CSP and I_CS+; different shapes were used as stimuli D_DSU and D_CS+ and D_CSP and D_CS-.

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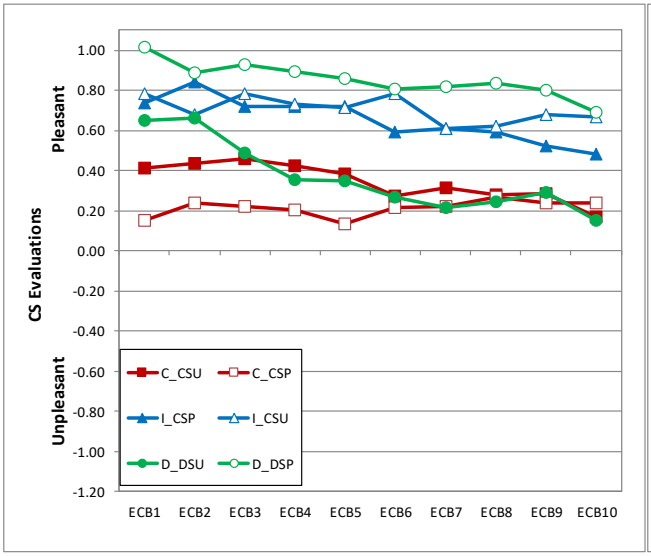
CS Evaluations
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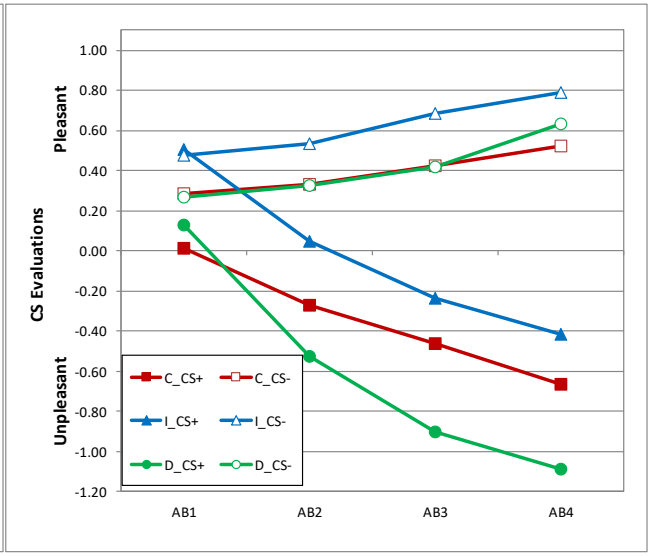
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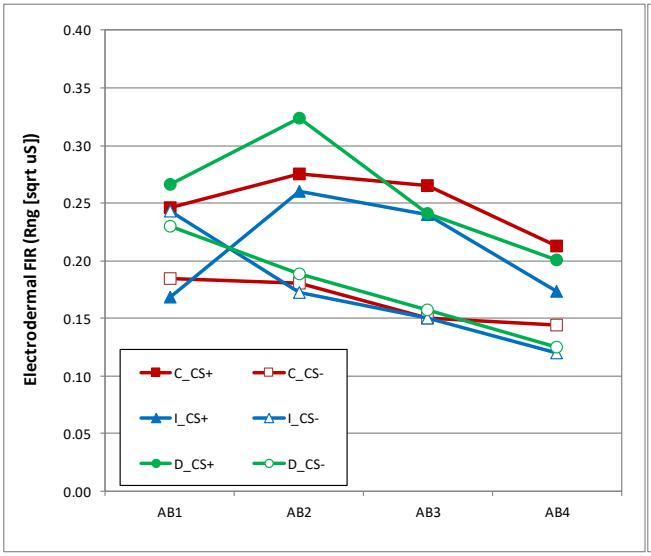
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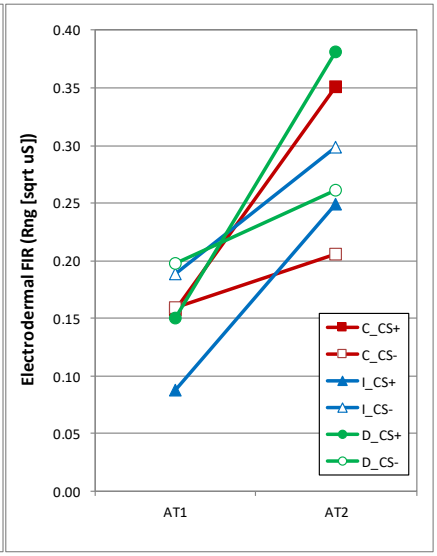
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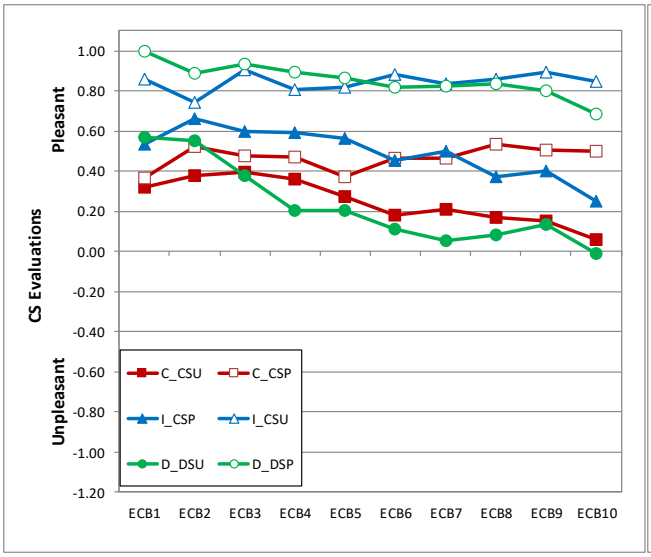
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CS Evaluations
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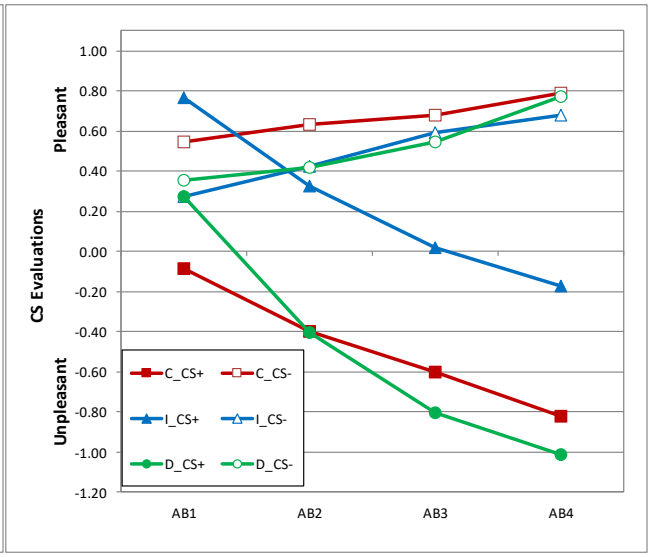
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CS Evaluations
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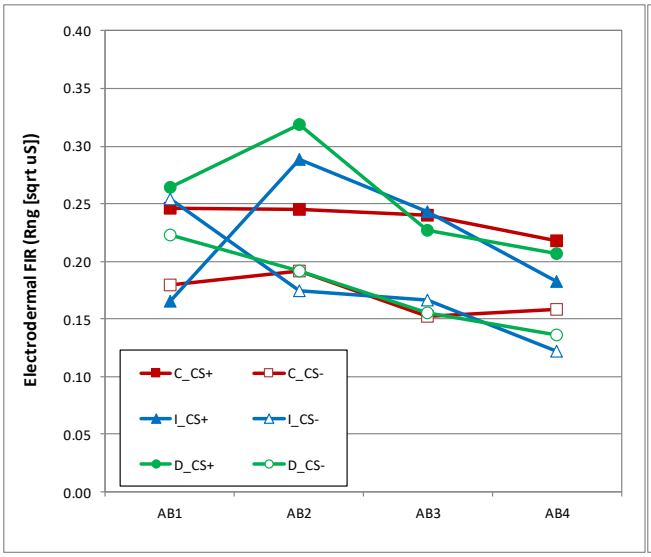
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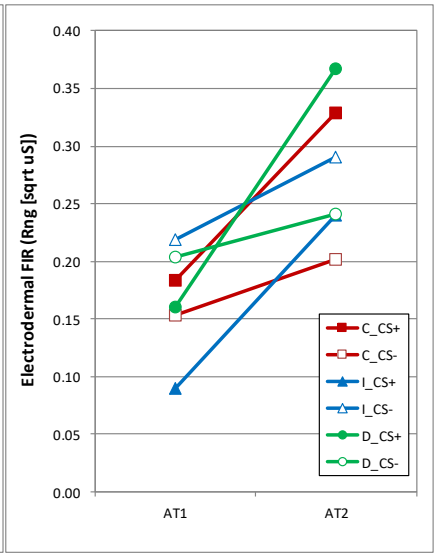
D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I_CS+
I_CS-
D_CS+
D_CS-
AT1
AT2

Evaluative conditioning affects the subsequent acquisition of differential fear conditioning as indexed by electrodermal responding and stimulus evaluations

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Supplement

Extinction and reinstatement

CS evaluations and electrodermal first interval responses collected during extinction were subjected to 3 × 2 × 6 (Group [Congruent, Incongruent, Different] × CS [CS+ vs. CS-] × Block) factorial ANOVAs with repeated measures on the last two factors. The effect of the reinstatement manipulation was assessed in 3 × 2 × 2 (Group [Congruent, Incongruent, Different] × CS [CS+ vs. CS-] × Block) factorial ANOVAs including the last block of extinction and the reinstatement test block. Analyses of electrodermal second interval responses yielded results similar to those of first interval responses and are not reported separately. The multivariate solution of the ANOVA (Pillai's Trace) was used to assess significance and alpha was set to .05.

Results

CS evaluations

As shown in Figure S1, differential evaluations of CS+ and CS- extinguished across blocks in all groups as indicated by main effects for CS, $F(1,96) = 22.38$, $p < .001$, $\eta_p^2 = .189$, and block, $F(5,92) = 4.45$, $p = .001$, $\eta_p^2 = .195$, and a CS × Block interaction, $F(5,92) = 7.66$, $p < .001$, $\eta_p^2 = .294$, all other $F < 1.03$, $p > .361$, $\eta_p^2 < .041$. The interaction reflects that evaluations of CS+ became more positive as

a function of blocks, $F(5,92) = 9.49$, $p < .001$, $\eta_p^2 > .340$, whereas evaluations of CS- remained unchanged, $F(5,92) = 1.94$, $p = .096$, $\eta_p^2 = .095$. CS+ was evaluated as more negative than CS- on all blocks, all $F > 9.94$, $p < .003$, $\eta_p^2 > .093$.

There was some evidence for reinstatement of conditional stimulus valence as indicated by main effects for CS, $F(1,96) = 14.21$, $p < .001$, $\eta_p^2 = .129$, and block, $F(1,96) = 17.79$, $p < .001$, $\eta_p^2 = .156$, and a marginal CS × Block interaction, $F(1,96) = 3.23$, $p = .076$, $\eta_p^2 = .032$, all other $F < 1.72$, $p > .183$, $\eta_p^2 < .036$. After the presentation of the three USs, both CS+ and CS- were evaluated as more negative, but this change was significant only for CS+, $F(1,96) = 12.66$, $p = .001$, $\eta_p^2 = .117$, not for CS-, $F(1,96) = 2.93$, $p = .090$, $\eta_p^2 = .030$. CS+ was evaluated as more negative than CS- on the last block of extinction and after reinstatement, both $F > 9.94$, $p < .003$, $\eta_p^2 > .093$.

First interval electrodermal responses

As shown in Figure S2, electrodermal responses declined across the blocks of extinction although it appeared that some extent of differential responding remained. This impression was confirmed by main effects for CS, $F(1,93) = 11.74$, $p = .001$, $\eta_p^2 = .112$, and block, $F(5,89) = 9.17$, $p < .001$, $\eta_p^2 = .340$, all other $F < 2.13$, $p > .124$, $\eta_p^2 < .045$. Electrodermal responding increased from the last block of extinction to the reinstatement test, $F(1,93) = 8.38$, $p = .005$, $\eta_p^2 = .083$, but this increase did not differ between CSs, $F(1,93) = 1.99$, $p = .162$, $\eta_p^2 = .021$, all other $F < 2.41$, $p > .123$, $\eta_p^2 < .026$.

Analyses for Restricted Sample

CS evaluations

As shown in Figure S3, differential evaluations extinguished as indicated by main effects for CS, $F(1,82) = 27.89$, $p < .001$, $\eta_p^2 = .254$, and block, $F(5,78) = 4.31$, $p = .002$, $\eta_p^2 = .216$, and a CS × Block interaction, $F(5,92) = 8.12$, $p < .001$, $\eta_p^2 = .342$, all other $F < 1.96$, $p > .147$, $\eta_p^2 < .047$. Evaluations of CS+ were less pleasant than of CS- at each block of extinction training, all $F(1,82) >$

10.60, $p < .003$, $\eta_p^2 > .114$, but evaluations of CS+ became more positive across blocks, $F(5,78) = 9.22$, $p < .001$, $\eta_p^2 = .371$, whereas evaluations of CS- did not change, $F(5,78) = 1.88$, $p = .107$, $\eta_p^2 = .108$. The omnibus analysis for reinstatement yielded main effects for CS, $F(1,82) = 18.74$, $p < .001$, $\eta_p^2 = .186$, and block, $F(1,82) = 20.48$, $p < .001$, $\eta_p^2 = .20$, and a CS × Block interaction, $F(1,82) = 7.08$, $p = .009$, $\eta_p^2 = .079$, all other $F < 2.67$, $p > .075$, $\eta_p^2 < .062$ (with Group x Block the largest). Evaluations of CS+ were more negative than evaluations of CS- on the last block of extinction and during the reinstatement test, both $F(1,82) > 10.60$, $p < .003$, $\eta_p^2 > .114$, and became more negative from the last block of extinction to the reinstatement test for CS+, $F(1,82) = 17.60$, $p < .001$, $\eta_p^2 = .177$, whereas the evaluations of CS- did not change, $F(1,82) = 1.17$, $p = .284$, $\eta_p^2 = .014$.

First interval electrodermal responses

Analysis of the electrodermal responses during extinction (see Figure S4) yielded main effects for CS, $F(1,78) = 6.29$, $p = .014$, $\eta_p^2 = .075$, and block, $F(5,74) = 6.85$, $p < .001$, $\eta_p^2 = .3.16$, and a marginal Group × CS interaction, $F(2,78) = 2.86$, $p = .063$, $\eta_p^2 = .068$, all other $F < 1.14$, $p > .347$, $\eta_p^2 < .072$. CS+ elicited larger responses than CS- in groups Congruent and Different, both $F(1,78) > 4.20$, $p < .043$, $\eta_p^2 > .051$, but not in group Incongruent, $F(1,78) = 0.22$, $p = .643$, $\eta_p^2 = .003$. Responses increased from the end of extinction to reinstatement test, $F(1,78) = 4.57$, $p = .036$, $\eta_p^2 = .055$, all other $F < 2.14$, $p > .124$, $\eta_p^2 < .053$.

ANOVA Results

All participants (Evaluations N = 99; electrodermal responses N = 96).

US Evaluations – Evaluative conditioning

	F(df1, df2)	df	p	η_p^2
Group	1.653	2,96	.197	.033
US valence	790.439	1,96	.000	.892
Block	1.385	9,88	.207	.124
G * U	1.361	2,96	.261	.028
G * B	1.953	18,178	.015	.165

U * B	4.697	9,89	.000	.325
G * U * B	0.672	18,178	.835	.064

CS Evaluations – Evaluative conditioning

	F(df1, df2)	df	p	η_p^2
Group	1.925	2,96	.152	.039
US valence	1.608	1,96	.208	.016
Block	2.40	9,88	.018	.197
G * U	2.883	2,96	.061	.057
G * B	0.732	18,178	.775	.069
U * B	2.123	9,89	.036	.178
G * U * B	1.124	18,178	.332	.102

CS Evaluations – Acquisition

	F(df1, df2)	df	p	η_p^2
Group	1.585	2,96	.210	.032
CS	30.355	1,96	.000	.240
Block	12.980	3,94	.000	.293
G * C	0.551	2,96	.578	.011
G * B	1.044	6,190	.398	.032
C * B	18.074	3,94	.000	.366
G * C * B	0.542	6,190	.776	.017

CS Evaluations – Extinction

	F(df1, df2)	df	p	η_p^2
Group	2.003	2,96	.140	.040
CS	22.382	1,96	.000	.189
Block	4.447	5,92	.001	.195
G * C	1.026	2,96	.362	.021
G * B	0.688	10,186	.735	.036
C * B	7.660	5,92	.000	.294
G * C * B	0.769	10,184	.659	.040

CS Evaluations – Reinstatement

	F(df1, df2)	df	p	η_p^2
Group	2.280	2,96	.108	.045
CS	14.206	1,96	.000	.129
Block	17.790	1,96	.000	.156
G * C	1.030	2,96	.361	.021
G * B	1.723	2,96	.184	.035
C * B	3.225	1,96	.076	.032
G * C * B	0.144	2,96	.866	.003

Electrodermal responses – Acquisition

	F(df1, df2)	df	p	η_p^2
Group	0.279	2,93	.757	.006
CS	27.077	1,93	.000	.225
Block	12.031	3,91	.000	.284
G * C	1.264	2,93	.287	.026
G * B	0.714	6,184	.639	.023
C * B	4.947	3,91	.003	.140
G * C * B	1.084	6,184	.374	.034

Electrodermal responses – Trials 1 and 2 of Acquisition

	F(df1, df2)	df	p	η_p^2
Group	0.624	2,92	.538	.013
CS	0.313	1,92	.577	.003
Trial	49.008	1,92	.000	.348
G * C	5.107	2,92	.008	.100
G * T	0.167	2,92	.846	.004
C * T	6.885	1,92	.010	.070
G * C * T	0.604	2,92	.549	.013

Electrodermal responses – Extinction

	F(df1, df2)	df	p	η_p^2
Group	0.150	2,93	.861	.003
CS	11.744	1,93	.001	.112
Block	9.166	5,89	.000	.340
G * C	2.133	2,93	.124	.044
G * B	0.886	10,180	.547	.047
C * B	1.679	5,89	.148	.086
G * C * B	0.663	10,180	.757	.036

Electrodermal responses – Reinstatement

	F(df1, df2)	df	p	η_p^2
Group	0.185	2,93	.831	.004
CS	2.405	1,93	.124	.025
Block	8.384	1,93	.005	.083
G * C	1.996	2,93	.142	.041
G * B	0.955	2,93	.398	.020
C * B	1.985	1,93	.162	.021
G * C * B	1.036	2,93	.359	.022

Reduced sample (Evaluations N = 85; electrodermal responses N = 81)

US Evaluations – Evaluative conditioning

	F(df1, df2)	df	p	η_p^2
Group	1.087	2,82	.342	.026
US valence	1024.824	1,82	.000	.926
Block	1.902	9,74	.065	.188
G * U	0.544	2,82	.583	.013
G * B	1.954	18,150	.016	.190
U * B	5.151	9,74	.000	.385
G * U * B	0.653	18,150	.852	.073

CS Evaluations – Evaluative conditioning

	F(df1, df2)	df	p	η_p^2
Group	0.803	2,82	.452	.019
US valence	19.309	1,82	.000	.191
Block	3.221	9,74	.002	.281
G * U	1.768	2,82	.177	.041
G * B	0.912	18,150	.566	.099
U * B	2.779	9,74	.007	.253
G * U * B	1.200	18,150	.268	.126

CS Evaluations – Acquisition

	F(df1, df2)	df	p	η_p^2
Group	1.109	2,82	.335	.029
CS	34.504	1,82	.000	.296
Block	10.163	3,80	.000	.276
G * C	4.023	2,82	.022	.089
G * B	1.146	6,162	.383	.041
C * B	18.916	3,80	.000	.415
G * C * B	0.697	6,162	.653	.025

CS Evaluations – Extinction

	F(df1, df2)	df	p	η_p^2
Group	1.233	2,82	.297	.029
CS	27.889	1,82	.000	.254
Block	4.308	5,78	.002	.216
G * C	1.957	2,82	.148	.046
G * B	0.758	10,158	.669	.046
C * B	8.116	5,78	.000	.342
G * C * B	0.781	10,158	.647	.047

CS Evaluations – Reinstatement

	F(df1, df2)	df	p	η_p^2
Group	1.649	2,82	.199	.039
CS	18.738	1,82	.000	.186
Block	20.478	1,82	.000	.200
G * C	1.201	2,82	.306	.028
G * B	2.665	2,82	.076	.061
C * B	7.076	1,82	.009	.079
G * C * B	0.002	2,82	.998	.000

Electrodermal responses – Acquisition

	F(df1, df2)	df	p	η_p^2
Group	0.087	2,78	.917	.002
CS	17.913	1,78	.000	.187
Block	8.342	3,76	.000	.248
G * C	0.580	2,78	.562	.015
G * B	0.981	6,154	.440	.037
C * B	3.213	3,76	.028	.113
G * C * B	1.674	6,154	.131	.061

Electrodermal responses – Trials 1 and 2 of Acquisition

	F(df1, df2)	df	p	η_p^2
Group	0.343	2,77	.710	.009
CS	0.223	1,77	.638	.003
Trial	27.956	1,77	.000	.266
G * C	5.394	2,77	.006	.123
G * T	0.121	2,77	.886	.003
C * T	4.839	1,77	.031	.059
G * C * T	0.285	2,77	.753	.007

Electrodermal responses – Extinction

	F(df1, df2)	df	p	η_p^2
Group	0.236	2,78	.791	.006
CS	6.293	1,78	.014	.075
Block	6.850	5,74	.000	.316
G * C	2.864	2,78	.063	.068
G * B	0.906	10,150	.529	.057
C * B	1.138	5,74	.348	.071
G * C * B	0.700	10,150	.723	.045

Electrodermal responses – Reinstatement

	F(df1, df2)	df	p	η_p^2
Group	0.273	2,78	.761	.007
CS	0.332	1,78	.566	.004
Block	4.571	1,78	.036	.055
G * C	2.133	2,78	.125	.052
G * B	0.614	2,78	.544	.015
C * B	1.427	1,78	.236	.018
G * C * B	0.883	2,78	.418	.022

Figure Captions

Figure S1: Evaluations of CSP and CSU during evaluative conditioning (ECB1-ECB10), and of CS+ and CS- during the acquisition (AB1-AB4), extinction (EB1-EB6) and reinstatement test (RB1) of fear conditioning as a function of blocks of two trials in groups Congruent (C_), Incongruent (I_), and Different (D_) for the entire sample (N=99).

Figure S2: Electrodermal first interval responses to CS+ and CS- during the acquisition (AB1-AB4), extinction (EB1-EB6) and reinstatement test (RB1) of fear conditioning as a function of blocks of two trials in groups Congruent (C_), Incongruent (I_), and Different (D_) for the entire sample (N=96).

Figure S3: Evaluations of CSP and CSU during evaluative conditioning (ECB1-ECB10), and of CS+ and CS- during the acquisition (AB1-AB4), extinction (EB1-EB6) and reinstatement test (RB1) of fear conditioning as a function of blocks of two trials in groups Congruent (C_), Incongruent (I_), and Different (D_) excluding participants who during the last two blocks of evaluative condition training evaluated the CSs in the opposite direction by more than one tenth of the total scale (.5V; N=85).

Figure S4: Electrodermal first interval responses to CS+ and CS- during the acquisition ((AB1-AB4), extinction (EB1-EB6) and reinstatement test (RB1) of fear conditioning as a function of blocks of two trials in groups Congruent (C_), Incongruent (I_), and Different (D_) excluding participants who during the last two blocks of evaluative condition training evaluated the CSs in the opposite direction by more than one tenth of the total scale (.5V; N=81).

Figure S1

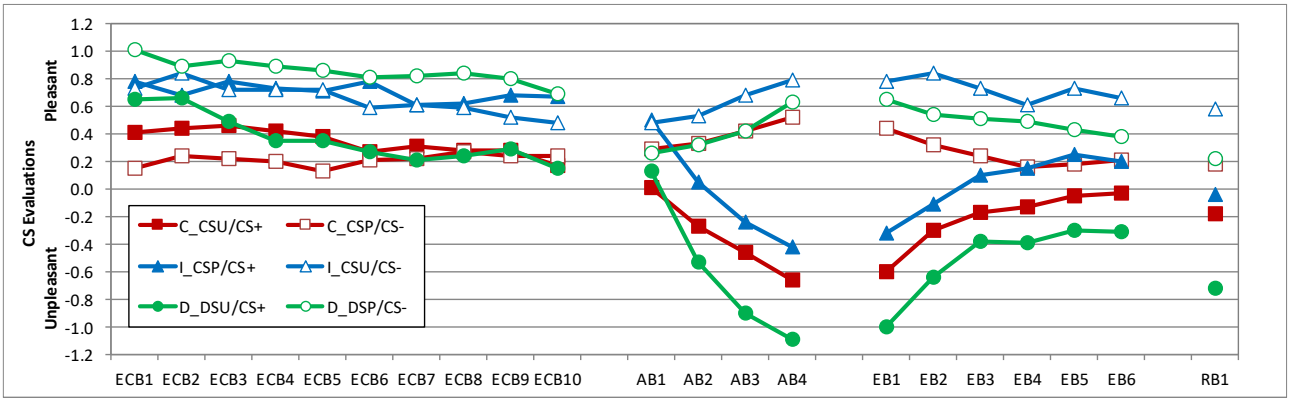

Figure S2

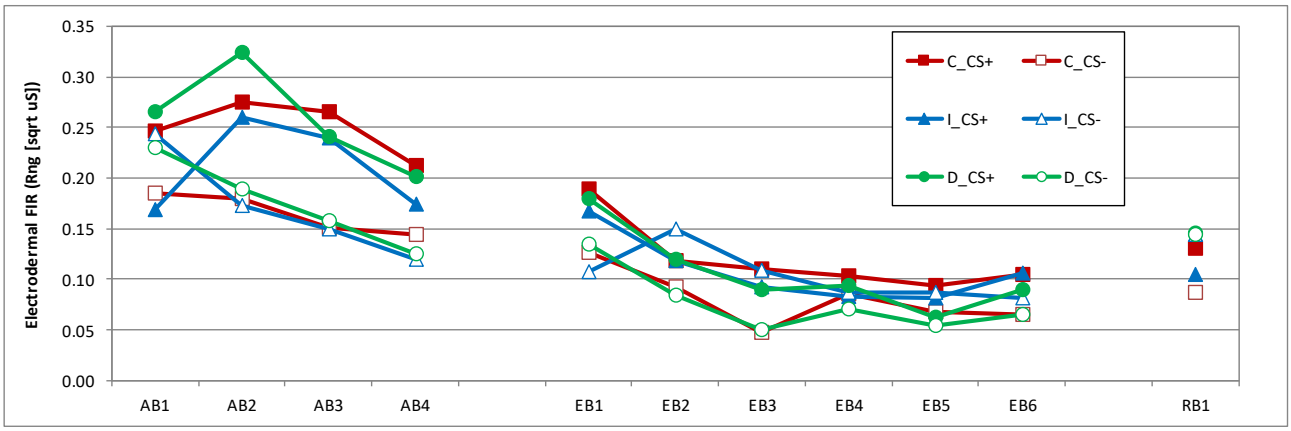

Figure S3

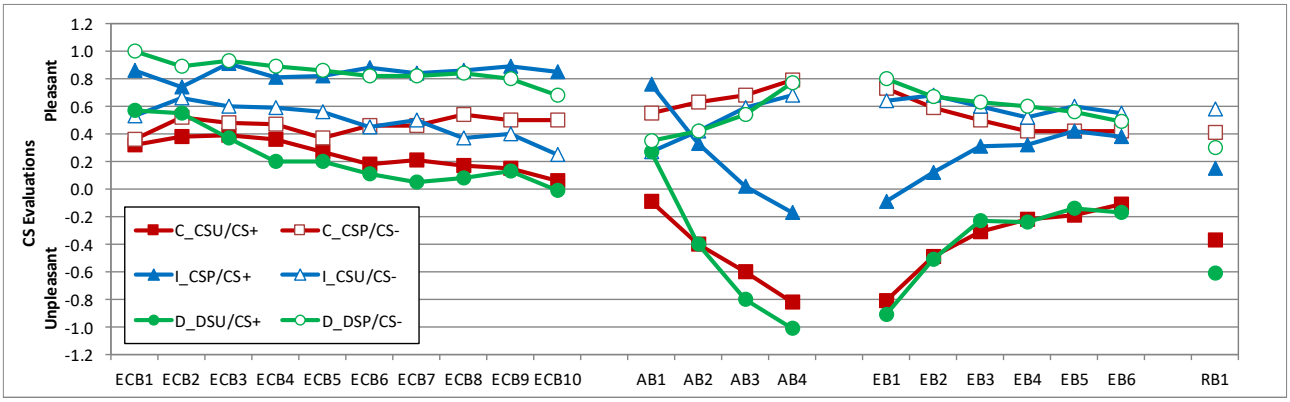

Figure S4