# Faster acquisition of conditioned fear to fear-relevant than to non fear-relevant conditional stimuli

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**Abstract**

Seligman's (1971) theory of prepared learning posits that prepared associations are acquired rapidly and resist extinction. Although it has been shown repeatedly that prepared associations resist extinction, there is currently little evidence to support the proposal of faster acquisition. The current study provides such evidence using a within subjects conditioning procedure with a 50% reinforcement schedule. Participants were presented with pictures of four animals, two fear-relevant (snake, spider) and two non fear-relevant (fish, bird), one of each paired with an unpleasant electrotactile stimulus on 50% of the trials during acquisition. Differential electrodermal responding was observed within the first two blocks of acquisition for fear-relevant but not for non fear-relevant conditional stimuli confirming the prediction that prepared associations are acquired faster than non-prepared associations.

Keywords: Fear learning, Preparedness, electrodermal responses

According to Seligman's (1971) theory of prepared learning, certain objects and situations are more likely to enter into an association with aversive events than are others. These prepared associations are said to be acquired fast and to resist extinction. A series of fear learning experiments conducted by Öhman and colleagues (Öhman et al., 1975a; 1975b; Öhman et al., 1976) provided empirical evidence to support this account. The studies indicated fear conditioned to fear-relevant stimuli, pictures of snakes or spiders, was resistant to extinction relative to fear conditioned to non fear-relevant stimuli, flowers and mushrooms.

Although enhanced resistance to extinction is well documented for fear conditioned to fear-relevant stimuli, there seems to be less evidence for faster acquisition of prepared fear associations (Lipp & Edwards, 2002; Öhman et al., 1975a; 1975b; 1976; Schell, Dawson & Marinkovic, 1991). There are reports of overall differences in fear acquisition in that fear-relevant CSs elicited significantly larger responses than did non fear-relevant CSs (Fredrikson, Hugdahl, & Öhman, 1976; Öhman, Fredrikson, & Hugdahl, 1978; Siddle, Power, Bond & Lovibond, 1988). However, one might argue that these studies document differences in the extent of conditioning at the asymptote of learning, i.e., in the overall extent of differential responding, rather than differences in the speed of acquisition, i.e., fewer trials needed to reach significant differential responding.

The failure to document effects of fear-relevance on the speed of acquisition could be attributed to the use of between subject conditioning designs with 100% reinforcement schedules in most prior experiments. Between subject designs are less sensitive than within subject designs which have been used successfully in research on prepared learning (Olsson, Ebert, Banaji, & Phelps, 2005). Reinforcement schedules where every CS+ was accompanied by a US typically result in fear conditioning within a few pairings of CS+ and US which may mask the emergence of differences in fear learning between stimuli (Lissek, Pine, & Grillon, 2006). A partial reinforcement schedule may be better suited to assess differences in the speed of acquisition as it can eliminate ceiling effects in fear learning. The current study was designed to investigate differences in the speed of fear acquisition as a function of conditional stimulus fear relevance using a 50%

reinforcement schedule. Based on past research that had supported Seligman's (1971) preparedness theory, we predicted that differential fear learning would be evident after fewer pairings of a fear-relevant CS with an aversive US than of a non fear-relevant CS.

## Method

### Participants

Forty undergraduate students (21 females and 19 males) aged between 16 and 27 years (mean age: 19 years) volunteered in exchange for course credit and provided informed consent. The research protocol was approved by the University of Queensland ethics review board.

### Apparatus

Eight coloured images of animals, sourced from a picture set used by Lipp (2006), two snakes, two spiders, two fish, and two birds, were used as conditioned stimuli (CS), but each participant was presented only with a subset of four pictures (one each of snake, spider, fish, and bird) during conditioning. All stimuli were 520 x 390 pixels in size and presented centrally against a black background for 6 seconds. The US, a 200-ms electrotactile stimulation, pulsed at 50Hz, generated by a Grass SD9 stimulator, was applied via a concentric electrode attached to the middle of the dominant anterior forearm. The experiment was controlled using DMDX (Forster & Forster, 2003).

Electrodermal activity was recorded using two Ag/AgCl electrodes filled with an isotonic electrolyte and attached to the thenar and hypothenar eminences of the non-dominant hand. Participants' respiration rate was monitored with an adjustable Velcro device strapped around the diaphragm. All physiological responses were recorded with a Biopac MP150 system at 1000Hz.

### Procedure

After a 3-minute baseline recording, participants completed a shock workup, during which each participant adjusted the intensity of the electrotactile stimulation to a level that they found "unpleasant, but not painful". Participants then received instructions to remain relaxed and attentive during the experiment and were presented with habituation, acquisition, and extinction phases

without interruption. There were 8 trials (2 presentations of each CS) in the habituation phase. The acquisition phase was divided into 6 blocks of 8 trials, with each block consisting of 2 trials of each stimulus-type and CS-type (fear-relevant CS+ and CS-, non fear-relevant CS+ and CS-). The first fear-relevant and non fear-relevant CS+ presented during acquisition was always followed by the US, with the subsequent US presentations occurring twice within each block in a pseudorandom manner (one after the fear-relevant CS+ and the other after the non fear-relevant CS+). The US was presented 6 seconds after CS onset. The extinction phase consisted of 16 trials, four trials each of fear-relevant CS-, non fear-relevant CS-, fear-relevant CS+, non fear-relevant CS+, presented alone. Each CS was presented for 6 seconds, followed by an intertrial interval of 18, 19 or 20 seconds (CS onset to CS onset).

The trials were arranged in a pseudo-random sequence for all phases (habituation, acquisition, and extinction) with no more than two consecutive trials being the same. The stimuli were counterbalanced across participants based on three factors: The particular animal image used as CS+ and CS-; the nature of the CS (CS+ or CS-) presented first during acquisition, and the nature of animal stimuli (fear-relevant or non fear relevant) presented first during acquisition. As a result, eight different trial sequences were developed.

After extinction, participants completed a contingency questionnaire on which all eight animal images were presented in a randomized order. Participants were required to indicate animals they recalled seeing during conditioning and animals that were paired with a shock. A debriefing session was conducted upon completion.

**Response Definition and Scoring**

Skin conductance responses were scored as the largest responses that began 1-4 seconds after CS onset. Skin conductance responses were square root transformed and range corrected prior to analysis. The range correction was obtained by dividing each response by the maximum response produced by a participant, typically that to the first or the second US presentation during acquisition. Responses from acquisition and extinction were averaged into blocks of two trials

before analysis.

**Statistical Analyses**

Electrodermal responses from all three phases were subjected to separate 2 x 2 x n (Fear-relevance [fear-relevant, non fear-relevant] x CS [CS+, CS-] x trials/blocks [Habituation: HT1, HT2; Acquisition: AB1-AB6; Extinction: EB1, EB2) repeated-measure ANOVAs. Due to missing values on some trials, 38 participants provided habituation data and 39 participants provided data for acquisition. Multivariate *F* values and partial eta-squared values were reported.

## Results

**Verbal Contingency Measure**

Four participants recalled the CS-US contingencies incorrectly and a further four participants recalled the correct animal but identified the incorrect exemplar as the CS+. Analyses excluding the non-verbalisers yielded similar, if somewhat stronger results, but the current report is based on data from all participants.

**Electrodermal Data**

Figure 1 displays the electrodermal responses recorded during habituation, acquisition, and extinction. During habituation, electrodermal responses were larger to fear-relevant CSs and declined across trials, main effects for Fear-relevance, $F(1, 37) = 15.86$, $p < .001$, $\eta p^2 = .300$, and Trial, $F(1, 37) = 28.29$, $p < .001$, $\eta p^2 = .433$.

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Insert Figure 1 about here

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During acquisition, electrodermal responses were larger to CSs+ than CSs-, main effect for CS, $F(1, 38) = 18.45$, $p < .001$, $\eta p^2 = .327$, larger to fear-relevant animals than to non fear-relevant animals, main effect for Fear-relevance, $F(1, 38) = 17.36$, $p < .001$, $\eta p^2 = .314$, and varied over blocks, main effect for Blocks, $F(5, 34) = 3.79$, $p < .001$, $\eta p^2 = .355$. The Fear-relevance x Block interaction was also significant, $F(5, 34) = 4.17$, $p = .005$, $\eta p^2 = .380$, indicating that fear-relevant

stimuli elicited larger electrodermal responses than non fear-relevant stimuli on Block AB1 (Mean difference = .122, SEM = .022, p < .001), and Block AB2 (M = .071, SEM = .024, p = .006), but not on subsequent blocks, all p > .062

Although the Fear Relevance x CS, $F(1, 38) = 1.87$, $p = .179$, $\eta p^2 = .047$, and the Fear Relevance x CS x Block interactions, $F(5, 34) = 0.48$, $p = .793$, $\eta p^2 = .065$, were not significant, follow up analyses were conducted to assess the extent of differential conditioning to fear-relevant and non fear-relevant CSs on each block of acquisition. This analysis yielded significant differential responding for the non fear-relevant CSs on Block AB3, $F(1, 38) = 6.25$, $p = .017$, $\eta p^2 = .141$, Block AB4, $F(1, 38) = 6.15$, $p = .018$, $\eta p^2 = .139$, and Block AB6, $F(1, 38) = 7.47$, $p = .009$, $\eta p^2 = .164$. For fear-relevant CSs, differential responding was significant on Block AB2, $F(1, 38) = 11.02$, $p = .002$, $\eta p^2 = .225$, Block AB3, $F(1, 38) = 4.66$, $p = .037$, $\eta p^2 = .109$, Block AB4, $F(1, 38) = 8.21$, $p = .007$, $\eta p^2 = .178$, Block AB5, $F(1, 38) = 4.16$, $p = .048$, $\eta p^2 = .099$, and Block AB6, $F(1, 38) = 6.80$, $p = .013$, $\eta p^2 = .152$ (all $p$ Bonferroni corrected). To confirm that the extent of differential conditioning to fear-relevant conditional stimuli exceeded that to non fear-relevant conditional stimuli during the initial part of acquisition, a 2 x 2 x 2 (Fear-relevance [fear-relevant, non fear-relevant] x CS [CS+, CS-] x blocks [AB1, AB2]) repeated-measure ANOVA was conducted. This analysis confirmed differential responding early during acquisition for fear-relevant but not for non fear-relevant CSs, yielding main effects for Fear-relevance, $F(1, 38) = 28.28$, $p < .001$, $\eta p^2 = .427$, and CS, $F(1, 38) = 6.47$, $p = .015$, $\eta p^2 = .146$, and a Fear-relevance x CS interaction, $F(1, 38) = 4.50$, $p = .04$, $\eta p^2 = .106$. Responding to CS+ was larger than to CS- for fear-relevant CSs, $F(1, 38) = 6.83$, $p = .013$, $\eta p^2 = .152$, but not for non fear-relevant CSs, $F(1, 38) = 2.05$, $p = .160$, and the extent of differential responding was larger for fear-relevant CSs (M = .077, SD = 0.183) than for non fear-relevant CSs (M = .021, SD = .093), t(38) = 2.12, p = .040.

Analysis of the extinction data revealed larger responses to CS+ than to CS-, $F(1, 39) = 23.46$, $p < .001$, $\eta p^2 = .376$.

## Discussion

The purpose of the current study was to investigate whether differential fear conditioning would occur earlier during acquisition for fear-relevant stimuli than for non fear-relevant conditional stimuli. In order to avoid ceiling effects which may have prevented prior observations of inter-stimulus differences in fear learning a within subject design with a partial reinforcement schedule of 50% was used which was expected to slow down acquisition in particular to non fear-relevant CSs. Using this partial reinforcement schedule, the difference in the speed of fear acquisition predicted by Seligman's preparedness theory emerged in that differential electrodermal responding was evident within two CS-US pairings for fear-relevant CSs, but not for non fear-relevant CSs. It should be noted that this difference was not evident in significant interactions in the omnibus ANOVA. This is likely to reflect that the difference in differential electrodermal responding between fear-relevant CSs and non fear-relevant CSs was limited to the two initial blocks of acquisition but was not evident at the later blocks of acquisition.

In addition to providing evidence for faster acquisition of fear conditioned to fear-relevant CSs, the current study provides a number of results that are consistent with previous literature. Evidence in support of superior fear conditioning to snakes and spiders was provided in reference to control pictures that depicted non fear-relevant animals rather than the more frequently used pictures of flowers and mushrooms (see also Olsson et al., 2005). Moreover, consistent with some prior reports, there was no difference in the asymptote of conditioning between the conditional stimulus classes. This is consistent with the prediction that prepared learning differs from non-prepared learning in the speed of acquisition and extinction, but not in the extent of learning that can be supported given sufficient amounts of training.

One observation that seems to deviate from prior literature is the failure to find differences in the speed of extinction of fear conditioned to fear-relevant and to non fear-relevant stimuli (cf Öhman et al., 1976). This may reflect on the fact that only a small number of extinction trials were run in the present study as the design was optimized to assess differences during acquisition. This

number may have been too small to permit the extinction of fear acquired in a partial reinforcement schedule (Schurr & Runquist, 1973). Future studies that employ fewer acquisition trials and extend extinction training are required to clarify whether differential resistance to extinction will be observed after training in partial reinforcement schedules. These studies can also include additional measures like fear potentiated startle or ratings of CS valence and US expectations to provide a more comprehensive assessment of fear learning.

## Figure captions

*Figure 1.* Mean electrodermal first interval responses (range corrected) to fear-relevant and non fear-relevant CS as a function of trials during habituation (HT1, HT2), and a function of blocks of two trials during acquisition (AB1 to AB6) and extinction (EB1, EB2), FR = fear relevant, NF = non fear relevant, CS+ = conditioned stimulus paired with shock 50% of the time, CS- = conditioned stimulus not paired with shock.

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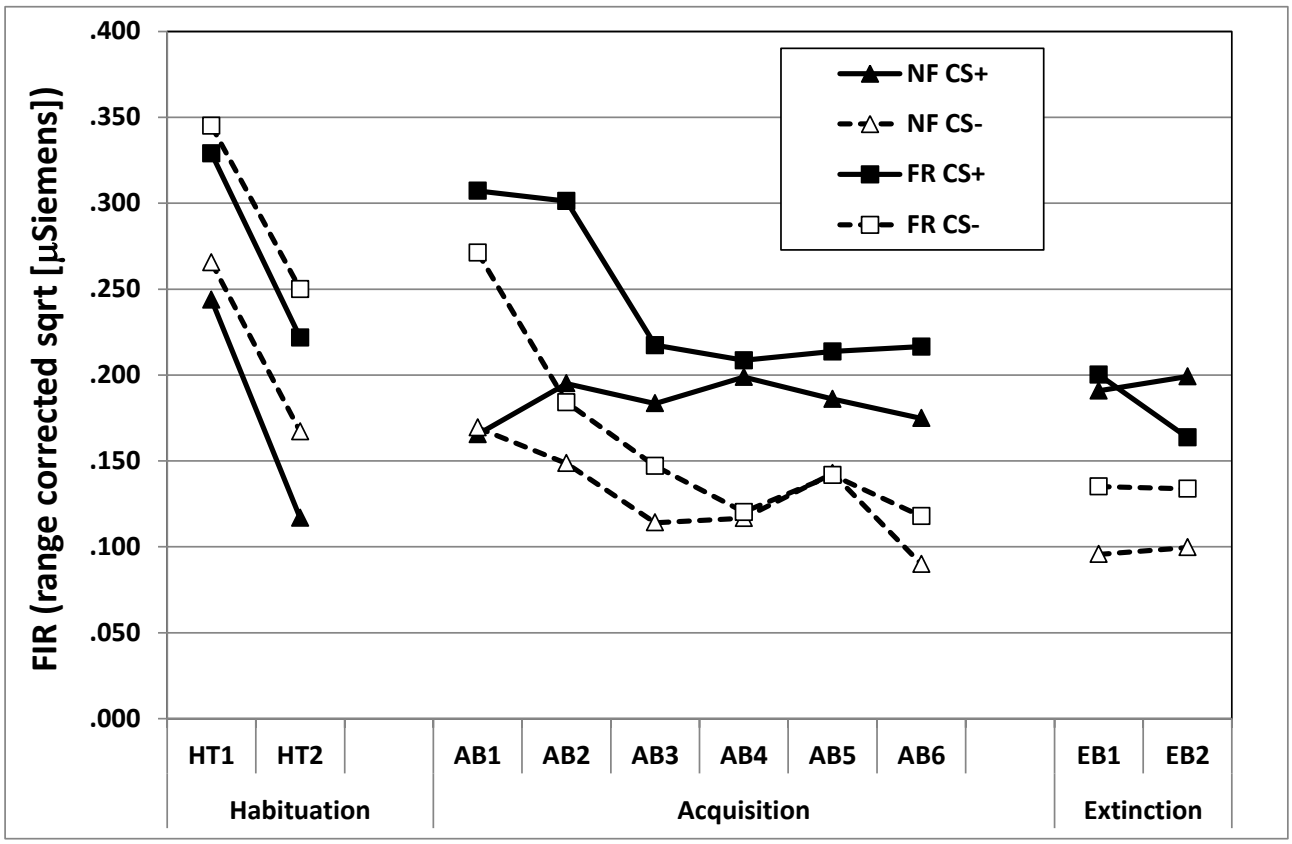
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