Generalization of Fear and Avoidance Along a Semantic Continuum

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Abstract

Directly conditioned fear and avoidance readily generalizes to dissimilar but conceptually related stimuli. Here, for the first time, we examined the conceptual/semantic generalization of both fear and avoidance using real words (synonyms). Participants were first exposed to a differential fear conditioning procedure in which one word (e.g., "broth"; CS+) was followed with brief electric shock (unconditioned stimulus, US) and another was not (e.g., "assist"; CS-). Next, an instrumental conditioning phase taught avoidance in the presence the CS+ but not the CS-. During generalization testing, synonyms of the CS+ (e.g., "soup"; GCS+) and CS- (e.g., "help"; GCS-) were presented in the absence of shock. Conditioned fear and avoidance, measured via skin conductance responses, behavioral avoidance and US expectancy ratings, generalized to the semantically related, but not to the semantically unrelated, synonyms. Findings have implications for how natural language categories and concepts mediate the expansion of fear and avoidance repertoires in clinical contexts.

Keywords: fear conditioning, avoidance, generalization, semantic generalization.

Over a century ago, Pavlov showed that adjusting the frequency of a tone used as a conditioned stimulus (CS), the conditioned response (CR) of fear was modulated, with the greatest response elicited by the CS closest in frequency to the original (Pavlov, 1927). Fear generalization refers to the emergence of fear responses to stimuli that are related to a conditioned fear stimulus along some formal continuum (e.g., shape, colour). Typically, the degree of generalization is related to the degree of relatedness between the CS and the novel, generalized stimulus. Numerous early generalization studies (e.g., Guttman & Kalish, 1956) showed that as the physical properties of a CS are degraded (e.g., changes in colour), the probability of a CR being observed is reduced (i.e., a generalization gradient). The process of fear generalization is evident outside the laboratory when, for example, after a road traffic collision with a bus an individual comes to fear not only buses but also other transportation vehicles that physically resemble buses (e.g., large or similarly-colored trucks).

Despite a plethora of basic research on generalization in nonhumans (Pearce, 1987), fear generalization has until recently only begun to be studied in humans, with the potential relevance of this process to the understanding and treatment of fear and anxiety disorders widely acknowledged (Dymond, Dunsmoor, Vervliet, Roche, & Hermans, 2014; Hermans, Baeyens, & Vervliet, 2013; Lissek et al., 2008). For instance, Dunsmoor and LaBar (2013) found evidence for a fear generalization gradient with humans using a blue-green color spectrum. By pairing a hybrid color created using both blue and green with electric shock (CS+) and pairing either blue or green with the absence of shock (CS-), they demonstrated an increase in skin conductance responses (SCRs) to the color most unlike the CS- and closer in similarity to the CS+ (see also Dunsmoor, Mitroff & LaBar, 2009; Vervliet, Kindt, Vansteenwegen, & Hermans, 2010; Vervliet & Geens, 2014). These findings have clinical relevance to the extent that anxiety disorders and obsessive-compulsive disorder may involve an overgeneralization of fear and avoidance responses via physical dimensions (Lissek, 2012; Lissek et al., 2008; van Meurs, Wiggert, Wicker, & Lissek, 2014).

The generalization of fear and avoidance has been shown to occur along other formal continua such as facial dimensions of increasing fear intensity (Dunsmoor et al., 2009) and via conceptual/symbolic dimensions. For example, Declercq and De Houwer (2009) demonstrated “inferred avoidance” by examining the generalized transfer between seemingly unrelated shapes and symbols of an avoidance response that cancelled upcoming monetary loss. A sensory preconditioning procedure was used to pair certain shapes with certain abstract symbols before the shapes were presented as CSs that signalled monetary loss unless an avoidance response was made. Generalization testing showed avoidance transferred to the related symbols, in the absence of further training. Dunsmoor, Martin and LaBar (2012), in a study reminiscent of Keller (1943), paired exemplar images of one category of objects (i.e., tools) with shock and exemplars of another (i.e., animals) with a safety (no shock) outcome. Upon the appearance of each image, participants had the opportunity to rate their expectancy level of receiving a shock using a computer mouse and an onscreen rating metric. During the fear-conditioning phase, one category was designated as CS+ and paired with shock, while members of the other category were not followed by shock. Dunsmoor et al. (2012) recorded generalization of fear, using SCR measures, from trained exemplars to novel category-consistent exemplars (tools vs. animals) and observed significant fear generalization within categories and high levels of US expectancy ratings. These researchers suggested that such findings illustrate that the range of continua along which fear can generalize would appear to include conceptual as well as formal ones (see also Dunsmoor and Murphy, 2014).

Interestingly, fear generalization along non-formal continua has a long tradition within experimental psychopathology vis-à-vis the seminal analysis of what was termed ‘semantic generalization’ (e.g., Branca, 1957; Eisen, 1954). In several early studies conditioned vasoconstriction (Luria & Vinogradova, 1959), electromyography (Cramer, 1970) and skin conductance (see Feather, 1965, for a review) responses were show to generalize from words to their semantic referents. For instance, Branca (1957) examined generalization of fear between nouns and their synonyms or other closely related words. By pairing one word, "brook" (CS+) with shock, other related words, such as "stream", "river", and "creek" could be used to test for generalization. Branca reported high levels of fear generalization between conditioned and probe stimuli, but only when participants were aware of the semantic relationship between the CS and US. Clearly, semantic fear generalization relies on the formation and elaboration of complex language structures in order for related words to elicit fear. Early semantic generalization researchers emphasised a key role for "complex thought processes", rather than simple stimulus-response (S-R) processes, in explaining the resulting effects (e.g., Malzman, Langdon & Feeney, 1970). This perspective was consistent with an emerging consensus that semantic language processes were central to the generalization of fear (Branca, 1957; Eisen, 1954; Mednick & Wild, 1962; Mink, 1963).

While the generalization of fear along non-formal continua has now come under the radar of fear conditioning researchers (e.g., Dunsmoor & Murphy, 2014), few have attempted to examine avoidance behavior in the same way (Beckers, Krypotos, Boddez, Effting & Kindt, 2013). This is surprising given the importance of avoidance as an instrumental process in the development and maintenance of anxiety disorders and as an instantiation of fear itself (Beckers et al., 2013; Dymond et al., 2014; Luciano et al., 2013).

The current study, therefore, sought to demonstrate for the first time, the semantic generalization of fear and avoidance and US expectancy ratings across semantically related pairs of stimuli. During Phase 1, participants were exposed to fear conditioning trials in which one word was designated as CS+ (e.g., *broth*) and followed by shock, while the other was designated CS- (e.g., *assist*) and never followed by shock. In Phase 2, an instrumental conditioning phase trained an avoidance response in the presence of the CS+ that cancelled shock. The generalization test phase included stimuli semantically related to the CS+ and CS-, respectively. Throughout all phases, SCR, avoidance, and US expectancy ratings were measured. It was predicted that participants would show spontaneous fear and avoidance of words semantically related to the CS+, but not to those words semantically related to the CS-. It was also predicted that participants' expectancies would correlate with both SCR and rates of avoidance of both the conditioned and generalized words.

Method

Participants

Twenty-eight healthy volunteers (15 women), with a mean age of 32.3 (*SD*=11.60), were recruited from notice board advertisements, and a research participant volunteer pool organised within the Department of Psychology at Maynooth University. Participants were not screened for prior or current anxiety conditions and were assumed to be normally functioning. They were carefully briefed as to the aversive nature of the experiment and invited to leave if they had concerns regarding their suitability (none did so). The Maynooth University research ethics committee approved the study.

Apparatus

An Apple MacBook running *PsyScope* (Version B57; Cohen, MacWhinney, Flatt & Provost, 1993) presented the stimuli, recorded responses, and was interfaced to a skin conductance recorder (Biopac MP45) and to an external stimulator (Lafayette model 82415). Two Velcro finger straps containing Ag-AgCl electrodes were positioned on the distal phalanges of the index and middle finger of the participant's non-dominant hand and connected to the skin conductance recorder. Mounted in polyurethane holders, each electrode measured 6mm in diameter; the analysis software corrected for this non-uniform size and recorded all SCRs in Siemens per cm^2. The electrodes were non polarisable and shielded to reduce noise interference. A PH balanced and isotonic electrode gel was employed to secure the electrode contact points. The participant's forearm was also connected to the two signal wires using a pair of disposable electrodes for stimulation situated approximately 50 mm apart.

Six pairs of synonyms (Table 1) were selected from *The University of South Florida Word Association, Rhyme and Word Fragmentation Norms* database of free association (Nelson, McEvoy, & Schreiber, 1998). The chosen pairs were all rated highly (i.e., above 80%) for frequency of free association when single word priming was provided. All stimuli were presented on a standard 15" computer monitor in uppercase size 72 bold font, in red and made up both the aversive and appetitive cues assigned to participants. Two pairs of stimuli were required for both conditioning and probe phases and the two pairs employed were counterbalanced across participants (see Table 1).

Insert Table 1 about here

Procedure

Participants were tested individually in research laboratory cubicles (1.5 m x 2 m). First, a shock calibration procedure was employed to identify the highest acceptable shock level to which participants would accept given the descriptor, "uncomfortable but not painful". The wave amplitude level selected was then fixed and maintained throughout the experiment for each participant. The shock generator employed here allowed only for the adjustment of voltage (M = 60.2v, SD = 13.6v), and thus the level of current administered varied across participants as a function of their skin resistance, and was not quantified on any read-outs in terms of amperage.

Phase 1: Fear conditioning. In this phase, participants were presented with the CS+ and CS-. All presentations of the CS+ were followed by a short (50 ms) shock and the CS- was never followed by shock. Each stimulus was presented 6 times in a quasi-random order, with the constraint that no more than two consecutive trials of the same type could occur, for a total of 12 trials (see Table 2). The following instructions were presented at the outset:

In a moment some words will begin to appear on this screen. You will also receive mild electric shocks. During the first stage you will not be able to avoid these shocks, but we will provide you with further instructions when this is possible. Please concentrate on the screen at all times. It is important that you continue to pay attention. If you have any questions please ask the experimenter now. Press any key to continue.

Following the instructions, a blank screen appeared for 20 s. Then, the CS+ or CS- was then presented for 4 s. The CS+ word provided the cue for the immediate subsequent delivery of a brief cutaneous shock, delivered at the previously established level, for a period of 500 ms immediately at CS+ offset. Shock never followed the presentation of the CS-. A random inter-trial interval (ITI) of between 10 and 20 s (during which time the screen remained blank) separated trials.

Insert Table 2 about here

Phase 2: Avoidance conditioning and semantic generalization testing. Immediately following Phase 1, participants were provided with the following onscreen instructions:

At this point you will be given the opportunity to avoid any further electric shocks. You can avoid the shocks by pressing the spacebar on the computer keyboard at the appropriate time. Please pay careful attention to everything that is happening on screen. If you have any questions please ask the experimenter now. Press any key to continue.

During Phase 2, the CS+ and CS- were once again presented according to the same schedule with the same stimulus parameters, but for 20 trials (i.e., 10 each; see Table 2).

Participants could cancel a shock (i.e., a deletion procedure) by pressing the spacebar while the CS+ cue appeared on-screen (i.e., signalled avoidance) but before the onset of shock (which, in the absence of avoidance, was scheduled for CS+ offset). No feedback was given regarding any cancellation of shock and pressing the spacebar did not remove the CS+ from the screen. There was a 100% contingency between the space bar press and the cancellation of the impending shock on CS+ trials. A spacebar press during the CS- presentation had no effect and was not acknowledged by any form of feedback.

After the 20 avoidance conditioning trials had been completed, the generalization test phase was initiated without warning. During this test phase, the CS+ and CS- stimuli were again presented across trials as normal (i.e., not in extinction) but interspersed with trials presenting synonyms of the conditioned stimuli (i.e., the generalized cues GCS+ and GCS-, respectively), in the absence of shock. The same trial schedule and stimulus parameters as before were employed across a further 16 trials (i.e., four exposures to each of the four sitmiuli), save for the absence of any shock following the GCS+ in the event that the spacebar was not pressed.

Immediately upon completion of this phase, participants completed a brief, written questionnaire in which they were asked to rate (post-hoc) their prior expectancy of shock in the event that they; (a) did not produce an avoidance response in its presence and; (b) if they did produce an avoidance response in its presence. All questions took the form of; "What is your expectancy of shock if **X** appears and you **DO NOT** press the space-bar"? Participants rated their expectancy of shock on a five-point scale, where *5 = definitely expect a shock* and *1= definitely no shock*).

Skin conductance response (SCR) quantification and data analysis

Skin conductance responses (SCRs) were defined as the maximum deviation in skin conductance during the four seconds following stimulus onset, calculated against a floating baseline of skin conductance level taken at the moment of stimulus onset (Dawson, Schell & Filion, 1990). Negative responses were not calculated but were included as zero responses (i.e., a hybrid response amplitude and magnitude measure was employed). Responses were recorded in microsiemens *(u*S) but were square root transformed to reduce skew and kurtosis in the data set and in order to normalise the distribution.

Individual one-way repeated measures ANOVA (Geisser-Greenhouse corrected) were conducted on each of the dependent measures during probe phases. Further analyses of responding to the learned and generalized cues were examined with post-hoc paired sample *t*-tests (with Bonferroni-correction) as were a small number of planned comparisons. Finally, correlations (Spearman's *Rs*) were performed to ascertain co-variances between dependent measures.

Results

One participant (P8) was excluded from the final data analysis due to a hardware malfunction during Phase 2, while another (P18), was omitted due to his failure to produce any avoidance responses to either the CS+ or CS-.

Insert Figure 1 about here

Conditioning

During the fear conditioning phase, significantly greater SCRs were recorded immediately following CS+ compared to CS- presentations, $t(25) = 4.71$, $p < .0001$. The effect size was large at 0.99 (Cohen's *d*), confirming that Pavlovian fear conditioning had occurred.

Participants made significantly more avoidance responses to the CS+ (96.9% of trials) than to the CS- (2.3% of trials), $t(25) = 48.77$, $p < .0001$. The effect size was large at 0.47 (Cohen's *d*). More specifically, the CS+ elicited avoidance on 70% of trials for one participant, 80% of CS+ trials for another, and 90% of CS+ trials for three further participants. The remaining participants made an avoidance response on 100% of CS+ trials during avoidance conditioning. In contrast, two participants produced avoidance responses to the CS- during 20% of conditioning trials, while a further two produced avoidance responses during 10% of trials. All remaining participants made no avoidance response in the presence of the CS- on any trial.

Generalization of avoidance

Figure 1A shows the mean proportion of trials in which participants made avoidance responses to the CS+, CS-, GCS+ and GCS- during semantic generalization testing. Rates of avoidance were higher for conditioned and semantically related threat stimuli than for conditioned and semantically related safety stimuli. There was a statistically significant main effect of stimulus type, F (3, 25) = 118.9, $p < .0001$, $\eta p^2 = 0.8262$, indicating that the proportion of avoidance responding evoked by the four cues differed significantly.

Post-hoc analysis showed there was a significant difference between the proportion of avoidance responding to the CS+ and the CS-, $t(25) = 60.99$, $p < .0001$. This indicates that the directly learned avoidance and non-avoidance responses established in avoidance acquisition trials in Phase 2 were maintained across the generalization test trials. Figure 1A shows that during the probe trials, there was a very high rate of avoidance to the conditioned and semantically related threat cues and considerably less to the conditioned and semantically related safety cues. The difference in avoidance rates between the GCS+ and the GCS- stimuli was also statistically significant, $t(25) = 7.543$, $p < .0001$. While CS+ / CS- and CGS+ / GCS- response rate differences emerged as expected, it should also be pointed out that the generalized stimulus (GCS+) produced significantly less avoidance than the conditioned (CS+) stimulus, $t(25) = 3.73$, $p < .001$.

Generalization of fear expression

Figure 1B shows the mean phasic SCRs produced upon the presentation of conditioned and semantically related threat cues (CS+ and GCS+) and conditioned and semantically related safety cues (CS- and GCS-) during probes for avoidance (Phase 2). SCRs were significantly higher for conditioned and semantically related threat cues than for conditioned and semantically related safety cues, respectively.

A one-way repeated measures ANOVA was conducted comparing differences in SCRs for all four stimuli during the probe trials. There was a statistically significant main effect for stimulus type, F (3,25) = 4.550, p = .0095, ηp^2 = .1540. Post-hoc analyses showed that there was a significant difference in SCRs to the CS+ and CS-, t(25) = 3.191, p < .05 and GCS+ and GCS-, t(25) = 2.110, p <.05. There was no significant difference in the magnitude of skin conductance responses recorded for the conditioned (CS+) and generalized (GCS+) stimulus.

Insert Figure 2 about here

US expectancy ratings

As predicted, participants' ratings of shock expectancy were higher for the CS+ than the CS-, and for the CGS+ compared to the GCS-, in the hypothetical case that no avoidance response was made (see Figure 2A). A one-way repeated measures ANOVA showed that differences in shock expectancies across stimuli was significant, F (3,25) = 62.17 p < .0001, ηp^2 =0.7132. Post-hoc analyses revealed a significant difference during the probe trials in expectancy of shock following the CS+ and CS-, t(25)= 16.16, p < .0001, and the GCS+ and GCS-, t(25) = 5.027, p < .001, again in the hypothetical the case that no avoidance response had been made. Similarly, retrospective shock expectancies following the four cues, when an avoidance response *had* been made, also differed, F (3,25) = 8.112, p < .001, ηp^2 =0.2450 (Figure 2B). Post-hoc analysis showed that the CS+ and CS- differed in this regard, t(25) = 3.728, p =.001, as did the GCS+ and GCS-, t(25) = 2.547, p =.017.

Expectancies of shock were higher following non-avoidance than avoidance for the CS+, $t(25) = 18.482, p<.0001$ and GCS+, $t(25) = 3.689, p = .001$, and paradoxically higher following avoidance than non-avoidance for the CS-, $t(25) = -2.799, p = .010$, and the GCS-, $t(25) = -3.275, p = .003$ (Figure 2; see also Discussion).

Correlations between measures

The relationship between percentage of avoidance responses during GCS+ trials and expectancies of shock following no avoidance response to the GCS+, was significant and positive, $r_s = .862, n = 25, p <.005$. The relationship between percentage of avoidance responses to the GCS- and ratings of expectancy of shock in the case that no avoidance was made, was also and paradoxically (see Discussion) positive and significant, $r_s = .446, n = 25, p < .05$. Mean avoidance levels and SCRs during Phase 2 for the CS+, CS-, GCS+ and GCS- stimuli correlated weakly to moderately, r_s -.292, -.170, .240 and -.311, respectively, but none of these relationships reached significance.

No significant correlation was found between fear expression to the CS+, as measured by SCRs, and reaction times (RTs) to the CS+, during conditioning, r_s .09, $n = 25, p >.05$ or during the probe phase, r_s .18, $n = 25, p >.05$. Fear expression to the CS+ during avoidance conditioning was also not associated with faster reaction times when avoiding the GCS+ during probes, $r_s = .39, n = 25, p >.05$.

Fear expression for the CS+ during the probe phase was not associated with RTs to the CS+ during the same phase, $r_s = .21, n = 25, p >.05$, nor were SCRS to the GCS+ and RTs to the GCS+ correlated significantly, $r_s = .19, n = 25, p >.05$, respectively. Reaction times to the CS+ during the probe phase also failed to correlate with rates of avoidance of the CS+, $r_s = .09, n = 25, p >.05$. However, a large and significant positive correlation was found between RTs during GCS+ trials and avoidance rates produced by the GCS+, $r_s = .73, n = 25$, p <0.0001 (i.e., indicating that longer RTs predicted more avoidance responding).

In summary, significant differences in levels of avoidance, SCR and US expectancy were found across the directly conditioned CS+ and CS- stimuli, as well as across the semantically related (GCS+ & GCS-) stimuli. Higher levels of avoidance responding were not associated with higher SCRs but were associated with higher shock expectancies for GCS+ and GCS- only. Reaction times failed to correlate with fear expression for CS+ stimuli, but longer RTs to the GCS+ were associated with higher levels of avoidance.

Discussion

The current study demonstrated generalization of fear, avoidance and US expectancies from word stimuli to their semantically related synonyms. Larger SCRs were also observed for conditioned threat and semantically related stimuli than for conditioned safety and semantically related stimuli, respectively, although SCR magnitudes were not significantly correlated with avoidance rates.

The results obtained here correspond broadly to the early findings in the field of semantic generalization, but using avoidance and US expectancy measures in addition to fear response measures. In summary, participants demonstrated almost 100% avoidance responding to the CS+ cue and 66% avoidance rates to the GCS+ cue. In contrast, avoidance responding to the safety cues (i.e., CS- and GCS-) was at a rate of less than 2%. These rates of avoidance for conditioned and semantically related probe stimuli are comparable to the rates of conditioned and derived avoidance observed in studies on the transfer of avoidance via stimulus equivalence classes (i.e., ‘symbolic generalization’; see Dymond et al., 2011). Those studies intended to model a process that likely occurs in the world outside the laboratory, facilitated by natural language categories, but using entirely abstract laboratory-created stimuli. The current study, however, is the first to show that such symbolic generalization processes can occur solely by virtue of the semantic relatedness of words that has arisen naturalistically in the vernacular.

While CS+ / CS- and CGS+ / GCS- avoidance rate differences emerged as expected, the generalized stimulus (GCS+) produced significantly less avoidance than the CS+. This is a common observation in literature in on symbolic generalization (e.g., Gannon, Roche, Kanter, Forsyth, & Linehan, 2011; Dymond, Roche, Forsyth, Whelan, & Rhoden, 2007; Dymond, Roche, Forsyth, Whelan, & Rhoden, 2008; Dymond, Schlund, Roche, De Houwer, & Freegard, 2012). This effect is understood here to simply reflect the fact that generalization of fear and avoidance along a merely symbolic continuum might not be expected to be as robust as the original conditioned response. It should be pointed out, however, that in this study, SCRs elicited by the GCS were *not* significantly lower than those produced by the CS+ during the probe phase, and so it would appear that the generalization of fear was more extensive than the generalization of overt avoidance.

While typically more avoidance was observed for the CGS+ than the GCS-, several participants failed to show any avoidance at all of the GCS+, and a small number of others showed avoidance on some GCS+ probe trials only. However, where avoidance did not occur, it does not seem to be explicable by extinction. Specifically, for the seven participants for whom avoidance was absent on all GCS+ probe trials, it was absent from the first GCS+ trial, even where it was observed for the CS+ stimulus (i.e., no extinction). For five further participants, avoidance was not always produced by the GCS+, but neither did it disappear after a single exposure to the non-aversive consequences of not avoiding during probe trials. That is, Ps 1 and 25 avoided during the first three presentations of the GCS+, but not on the final exposure. P3 produced an avoidance response only on the final presentation of the GCS+ while Ps 8 and12 both made an avoidance response on the first, second and fourth GCS+ trial, but not the third. In effect, the semantic generalization effect was relatively robust even where exposure to the non-aversive consequences of non-avoidance were encountered.

One interesting corollary of the foregoing is why participants did not more often avoid during GCS- probes given that the response cost of doing so was so low and the risk of failing to make an appropriate response was relatively high (i.e., shock). From our perspective this outcome is related to the quality of the discriminative control over responding established during the avoidance conditioning phase. Following effective Pavlovian conditioning, avoidance conditioning was established very quickly and effectively, with participants showing a clear and discriminated pattern of responding to the CS+ and CS-. The fact that this discrimination continued into the probe phase using generalized stimuli, simply reflects this clear discriminative control and its extension through an effective generalization procedure. This pattern has been widely observed in the literature on symbolic generalization (e.g., Bennet, Hermans, Dymond, Vervoort, & Baeyens, 2014; Gannon et al., 2011; Dymond et al., 2007, 2008, 2011).

The analysis of SCRs, RTs, and rates of avoidance revealed only low or medium levels of correlation between these variables, none of which were significant with the exception of a significant correlation between rates of avoidance and RTs to the GCS+. However, it is important to note that this significant correlation was positive, which indicates that larger RTs were associated with *more* avoidance, and so the outcome was not necessarily to be expected. Perhaps the most interesting outcome of the correlational analyses, however, is the apparent decoupling of fear expression and avoidance rates. Indeed calls for the conceptual separation of fear and threat appreciation have been prompted due to conflicting results from physiological measures of fear and fear responding in a number of studies (see LeDoux, 2014: Luciano et al., 2013; Mineka, 1979). In addition, recent evidence suggests that reduced levels of activation in the neural areas associated with fear, as measured by fMRI, do not influence the level of overt avoidance responding emitted by aversive stimuli (Schlund, Hudgins, Magee, & Dymond, 2013).

At first glance, the lack of correlation between avoidance rates and SCRs may appear unusual. However, while SCRs are a highly accurate indication of imminent threat appreciation, it has long been proposed that the rate of increase in skin conductance levels rather than phasic SCR magnitude (a variant of which was employed here) may be a superior index of stimulus aversiveness (Szpiler & Epstein, 1976). In addition, there may have been a paradoxical effect at work in the current study whereby the possibility of emitting an avoidance response likely *reduced* anticipatory arousal in participants (Thomson, 1981), thereby decoupling the fear levels from the avoidance probabilities (see also Lovibond, Saunders, Weidemann & Mitchell, 2008). Indeed, Szpiler and Epstein (1976) provided evidence supporting the idea that SCR levels are reduced for threat stimuli when an overt avoidance response option is available. This reduction in SCR over those expected for an unavoidable US, merely indicates the very fact that avoidance has been successfully conditioned rather than it indicating that the US has lost its aversive Pavlovian functions.

In line with the results from Dymond et al. (2011) and Declercq and De Houwer (2009), post-hoc expectancy ratings were broadly higher for the receipt of shock subsequent to the appearance of the threat cues (CS+ & GCS+) than for the safety cues (CS- & GCS-) in the event that an avoidance response was not made. However, post-hoc shock expectancies were not significantly positively correlated with overt avoidance of the CS+, although they were for the GCS+. Comparatively low shock expectancy was also evident for all cues in the hypothethical case that an avoidance response was made. This outcome appears to broadly support Lovibond's expectancy model (2006) which argued that avoidance is based on a number of propositional assumptions that can be measured as expectancies.

One apparently paradoxical aspect of the expectancy data was that participants provided a medium level expectancy rating for the receipt of a shock in the event that avoidance responses were made following the CS- and GCS-. However, upon closer inspection of the instrumental contingencies in operation, this may not be so surprising. More specifically, participants were engaging in a learning task that involved making correct responses in order to avoid shocks. There was a clear history of punishment by shock for failing to produce the appropriate response in the presence of the CS+. It would be reasonable, therefore, for participants to expect that a shock may also be delivered for failure to make an appropriate response to the CS- , for which a learned responses of non-avoidance had been successfully acquired. Thus, while no explicit reinforcement or punishment was ever delivered for avoidance of safety cues, it was a reasonable assumption for participants to make that such punishment may be delivered in the case of an "incorrect" response. As a result, expectancy of shock following an avoidance response to a safety cue or its semantically related counterpart (i.e., an incorrect response) might have been expected.

It is interesting that the relationship between expectancies and avoidance rates were not stronger given their noted utility as a measure of stimulus potency (Boddez et al., 2013). However, the relationship has not been universally viewed as entirely reliable. For example, Schwerdtfeger (2004) asked participants to assess their own level of anxiety as well as measuring heart rate and SCR taken both previous and subsequent to the delivery of a public speech. There was no correlation between self-reported levels of anxiety with SCRs or heart rate. Schwerdtfeger claimed that self-reports of emotion and motivation have consistently provided inaccurate measures of autonomic response and he called for subjective measures to be omitted from future psychophysiological research. Of course, CS-US expectancy and emotional awareness may well overlap insofar as threat expectancy is related somewhat to fear of the US, but the nature and direction of the relationship between these two variables is not well understood. Indeed, this issue bears not only on our understanding of the relationship between verbal reports (expectancies) and physiologically recorded fear levels. It may well also apply to the less than reliable relationship between physiological levels of arousal and behavioral probability (Lang, Davis, & Ohman, 2000). In effect, factors related to the various methodologies employed to measure quite distinct aspects of the same overall phenomenon may help to partly explain these divergences. Clearly, further research is needed to test whether or not expectancies or physiological arousal, or both, explicitly mediate overt avoidance (Lovibond, 2006).

While the relationship between US expectancies and overt avoidance behaviour may not be well understood, it is at least equally likely that correlations between expectancies and avoidance rates were not observed in this study due to limited statistical power, which was in turn due to narrow ranges in the data obtained. Specifically, the ratings scales employed here required participants to rate the likelihood of the delivery of a shock on a five-point scale. Not only is this range small given the sample size, but participants tended to provide high or low ratings to the threat and safety cues, respectively (in the case of no avoidance response being made). In effect, participants appear to have been relatively certain of what to expect given each stimulus, and the binomial data yielded by this certainty was unsuitable for correlational analyses. Indeed, standard deviations in shock expectancy ratings for the CS+, CS-, GCS+ and GCS- (in the case that no avoidance response was made) were very low, at .64, 1.76, .87, and .63, respectively.

In should also be acknowledged that the current expectancy rating method was post-hoc and hypothetical and so may not produce as reliable a set of US expectancy ratings as an online expectancy rating system, in which US expectancy is measured in the CS-US interval (e.g., Sevenster, Beckers, & Kindt, 2014). In addition, expectancy scales are often recorded along more refined continua (e.g., 11-point) and scores are often taken across multiple trials and then standardized to a 100-point scale (e.g., Schultz & Helmstetter, 2010). Given that these more robust measurement methods were not employed here to index US expectancies, we should not be conclusive regarding the lack of correlation between expectancies, SCRs and avoidance rates.

A key limitation of the current study may be that only one type of GCS+ and GCS- was presented for each participant. It is not uncommon for similar studies to employ multiple exemplars of the generalization probe stimuli. Of course, multiple exemplars were employed as conditioned and generalization probe stimuli *across* participants. Nevertheless, the lack of variation in probe stimulus topography and function within participants limit the degree of generalization demonstrated in the current study and prevent the possibility of a generalization curve being demonstrated across stimuli of varying degrees of semantic relatedness to the US. It is important to understand, however, that this limitation does not take from the interesting nature of the core process at work here (i.e., semantic generalization of fear, avoidance and US expectancies). Future studies could consider employing antonyms as well as synonyms and unrelated stimuli during generalization probes.

The current study served to fill a knowledge gap between the semantic generalization literature and current procedures for studying symbolic or inferred fear and avoidance. This research extends upon the semantic generalization research and contributes to our understanding of the conditions and boundary conditions of generalization. The most important contribution in this regard is the introduction of an avoidance response into the generalization paradigm (see also van Meurs et al., 2014). This is important because the core problem in anxiety conditions is not necessarily fear itself but excessive avoidance, which has been implicated as a core process in many pathological forms of anxiety (Dymond & Roche, 2009; Lissek, 2012; van Meurs et al., 2014). Indeed, anxiety and avoidance are a fundamental aspect of human adaptive behavior (Hayes, Strosahl, & Wilson, 1999) but we have some way to go in understanding the conditions under which they become extensive and excessive. The current study implicates the semantic relatedness of words in natural language as one possible supporting contingency for the spread of fear and avoidance in the world outside the laboratory.

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Table 1.

Sets of word stimuli assigned as CS+, CS-, GCS+ and GCS- for randomly selected cohorts of participants.

	CS+	CS-	GCS+	GCS-
Set 1	broth	assist	soup	help
Set 2	fib	ill	lie	sick
Set 3	weep	brawl	cry	fight

Table 2.

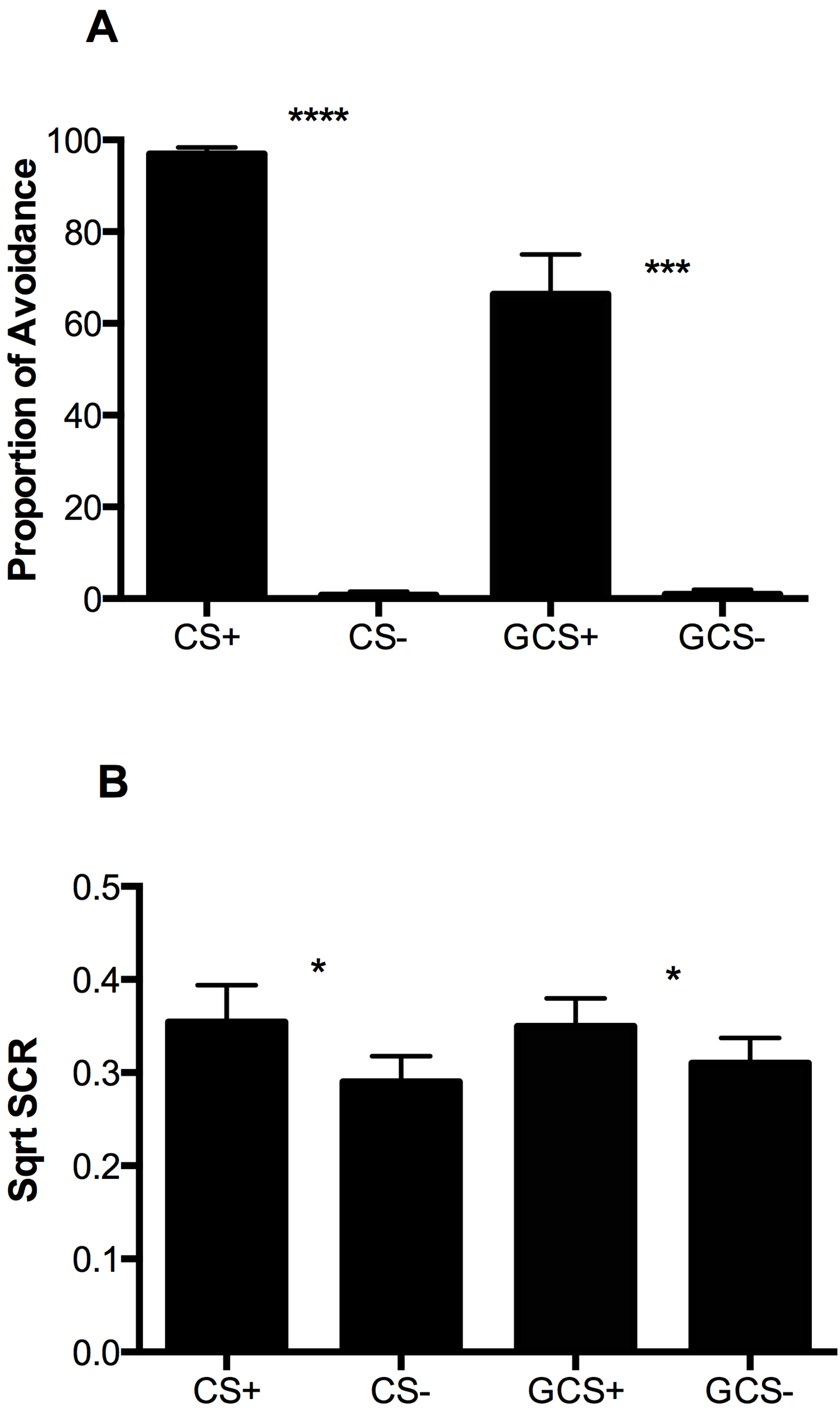
Numbers of trials presented during fear conditioning, avoidance acquisition and generalization test phases.

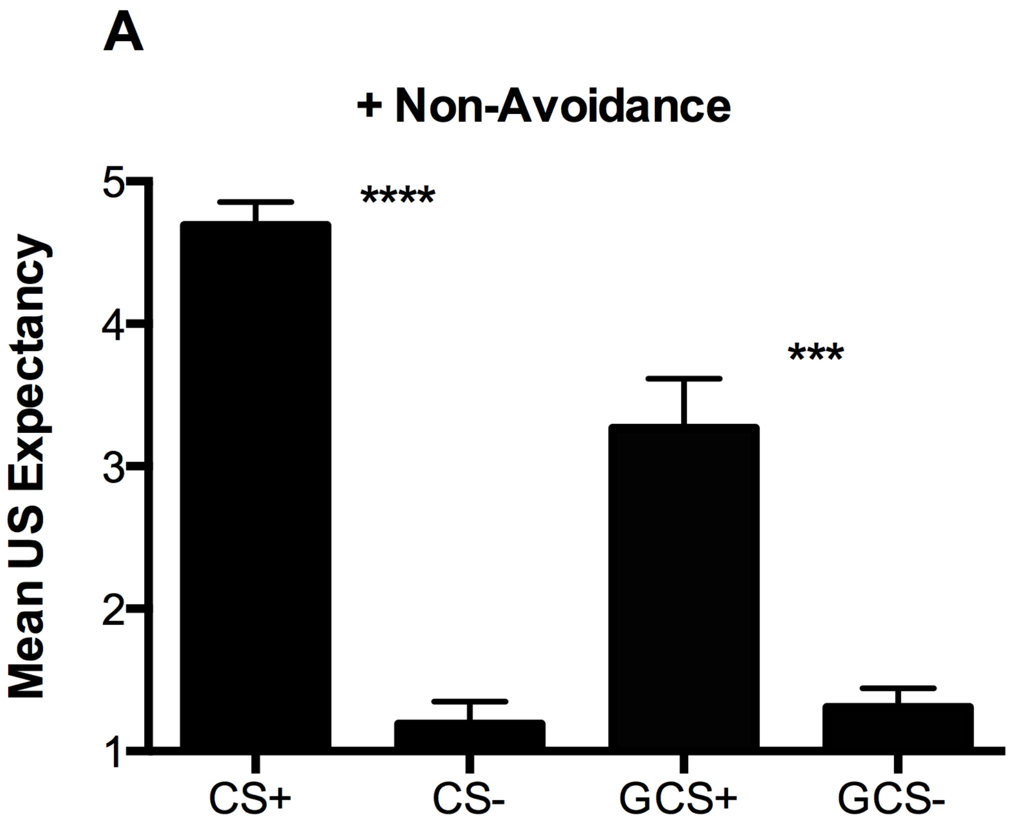
Fear Conditioning	Avoidance Acquisition	Generalization Test
CS+ (6)	CS+ (10)	CS+ (4)
CS- (6)	CS- (10)	CS- (4)
		GCS+ (4)
		GCS- (4)

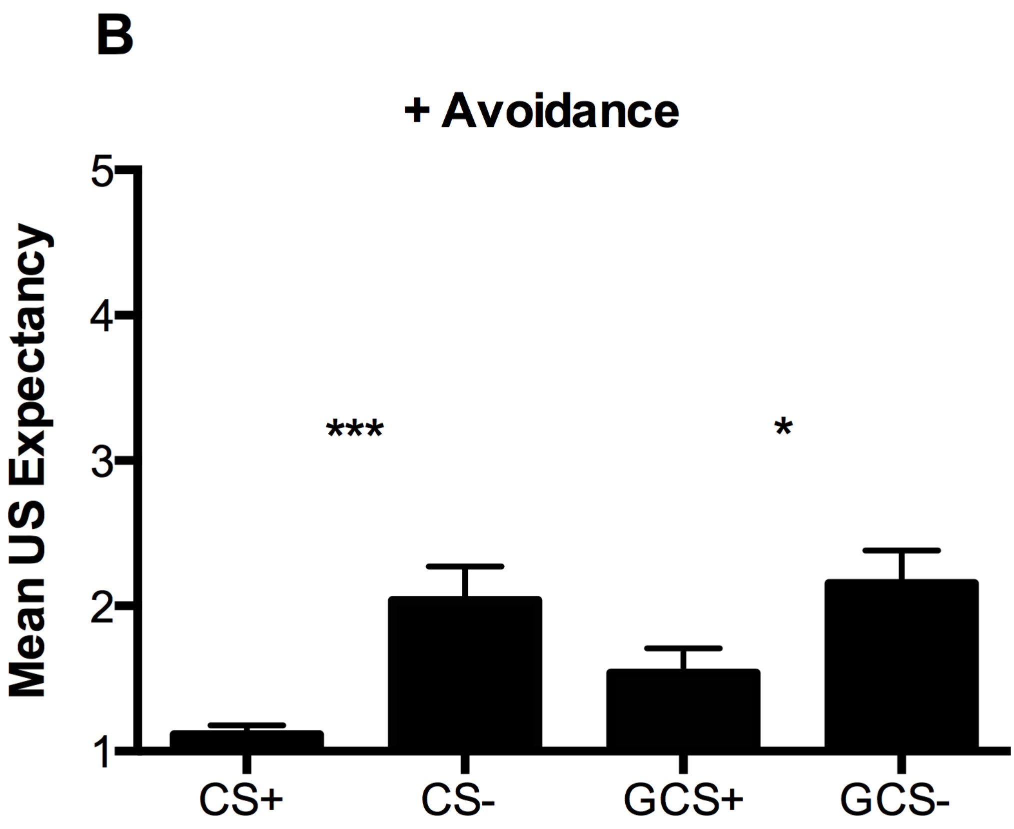
Figure Captions

Figure 1. A: Mean proportion of avoidance responses to CS+, CS-, GCS+ and GCS- during Phase 2. B: Mean SCR (measured as square root of *u*S per cm^2) for conditioned (CS+ & CS-) and semantically related (GCS+ & GCS-) cues during Phase 2. Error bars illustrate standard error. **** = $p < .0001$, *** = $p < .001$, * = $p < .05$.

Figure 2. A: Mean US expectancy ratings for all cues when the avoidance response was assumed to be absent (+Non-Avoidance). B: Mean US expectancy ratings for all cues when the avoidance response was assumed to be present (+Avoidance). Error bars illustrate standard error. *** = $p < .001$, * = $p < .05$.


A
****
***
100
80
60
40
20
0
Proportion of Avoidance
CS+
CS-
GCS+
GCS-
B
*
*
0.5
0.4
0.3
0.2
0.1
0.0
Sqrt SCR
CS+
CS-
GCS+
GCS-


A
+ Non-Avoidance
Mean US Expectancy
5
4
3
2
1
****
***
CS+
CS-
GCS+
GCS-


B
+ Avoidance
Mean US Expectancy
5
4
3
2
1
***
*
CS+
CS-
GCS+
GCS-