Disgust Versus Fear: Comparing the Generalization Pattern of Disgust and Fear

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Abstract

A major limitation of fear generalization research entails the confusing unconditional stimulus—it can often induce not only fear but also disgust. Differences between the two threat-related emotions during conditioning and generalization are currently unknown. To address this issue, 32 college students completed threat conditioning tasks including conditioned stimuli paired with fear or disgust images. A block design was used to divide fear and disgust into two randomly ordered blocks, enabling examination of differences between fear and disgust by recording subjective expectations and eye movement in the generalization process. The results revealed that participants reported larger subjective expectations of fear-related GS1 (generalized stimuli) and GS2 than disgust-related GS1 and GS2, and fear led to longer reaction times than disgust in both conditioning and generalization phases. The pupil size and fixation duration for fear stimuli were larger than for disgust stimuli, suggesting that fear generalization has a steeper gradient than disgust generalization. Participants paid more attention to fear and were more inclined to avoid disgust stimuli. These findings provide new, albeit preliminary, evidence of the differences between fear and disgust stimuli in generalization, and may offer insight into the treatment of clinical anxiety and other fear- or disgust-related disorders.

Introduction

Generalization of fear is the transfer of the conditioned response (conditioned response, CR) to other similar, but safe stimuli that resemble the original conditioned stimulus (conditioned stimulus, CS; Dunsmoor & Paz, 2015; Jasnow, Lynch, Gilman, & Riccio, 2017; Spalding, 2018). Overgeneralization of fear can be maladaptive, leading individuals to excessive avoidance of safe stimuli, and may also contribute to certain anxiety disorders, such as posttraumatic stress disorder (posttraumatic stress disorder, PTSD) and panic disorder (panic disorder, PD; Ahrens et al., 2016; Hammell, Helwig, Kaczkurkin, Sponheim, & Lissek, 2020; Tinoco-Gonzlez et al., 2015). Given the important role fear generalization plays in psychological trauma, it is necessary to further elucidate this relationship to optimize anxiety-related treatment (Michopoulos, Powers, Gillespie, Ressler, & Jovanovic, 2017; Stegmann et al., 2019).

The classical paradigms of research on anxiety disorders are mainly based on Pavlovian conditioning (Pavlov, 1927). In the classical fear generalization paradigm, a neutral CS (conditioned stimulus, e.g., a 500-Hz tone) is initially paired with an aversive unconditioned stimulus (US; e.g., an electric shock); over time, presenting the CS alone or a generalized stimuli (GS; e.g., a 600-Hz tone) can also come to elicit the CR (e.g., heart rate increasing; Dunsmoor, Kroes, Braren, & Phelps, 2017; Tuominenet et al., 2019). In most previous studies of fear generalization, mild electric shocks (Ahmed & Lovibond, 2015), pictures of snakes or spiders (Dymond, Schlund, Roche, & Whelan, 2014), and loud screams (Ahrens et al., 2016) have been used as traditional aversive US to induce a fear response. The existing question in such paradigms is that the aversive stimulus used as US can often evoke both fear and disgust. Rádlová et al. (2019) demonstrated that snakes are perceived as fearful or disgusting depending on their characteristics, including color, body size, and texture. Further, unpleasant sounds like metal scraping over the slate are alternatives to traditional US used with children and adolescents (Neumann, Waters, &

Westbury, 2008). Some people describe the sound of metal scraping as a “chill-sending screech,” because the sounds are sheer torture. It is important to note that very few studies have addressed the confusion between fear and disgust in the conditioning and generalization processes. Some researchers assert that they have used “threatening” or “fear-evoking” stimuli as US; however, the stimulus materials (e.g., International Affective Picture System—IAPS; Lang, Bradley, & Cuthbert, 2008) are, in fact, “negative,” but not necessarily threatening or fear-evoking (Schimmack & Derryberry, 2005). Many aversive IAPS images (International Affective Picture System, which include images “causing strong dislike or disinclination”) representative of salient threats (e.g., images of injuries, mutilations, or burn victims) elicit stronger disgust responses than fear responses (Libkuman, Otani, Kern, Viger, & Novak, 2007).

We approached the current study from the perspective that fear and disgust are two independent, different emotions (Comtesse, & Stemmler, 2017; Klucken et al., 2012). They differ in the display of facial expressions, behavioral responses, physiological responses, and the mechanisms of action and brain activity. Nevertheless, the similarities between fear and disgust make it difficult to disentangle one from the other in terms of emotion elicitation (Rachman, 2004). Specifically, both are unpleasant emotions associated with threat and are often involved in clinical disorders such as obsessive-compulsive disorder (OCD) and agoraphobia. This accounts for a considerable number of studies that have targeted negative emotions in general instead of specific emotions.

OCD is an anxiety disorder characterized by intrusive thoughts, i.e., obsessions (mostly about dirt or germs), and its central symptom is fear of contamination (Armstrong & Olatunji, 2017; Olatunji, Huijding, de Jong, & Smits, 2011; Wood & Tolin, 2002). There is increasing evidence that disgust is the core emotion in OCD (Stein, Liu, Shapira, & Goodman, 2001) associated with repetitive, irrational behavior, such as performing compulsively, the actions of hand washing or cleaning. For example, after putting out the trash, an individual may feel unclean even after excessive hand washing. This shows us how Pavlovian conditioning works, in which a neutral stimulus (hand) becomes an object of disgust after its pairing with the US (trash). Most Pavlovian conditioning research has focused on fear-conditioning, generalization, and extinction; while disgust associative learning studies are limited. Klucken et al. (2012) investigated the neural network underlying fear-conditioned and disgust- conditioned responses using functional magnetic resonance imaging, and revealed that both aversive CRs shared the same ROI-activations, including the cingulate cortex, nucleus accumbens, orbitofrontal cortex, and occipital cortex. In addition, insular activation was found to be sensitive to disgust conditions. Further, compared with fear-associative CS+, disgust-CS + pairing with the disgust stimuli elicits attentional avoidance (Armstrong, McClenahan, Kittle, & Olatunji, 2014). Individuals with blood-injection-injury phobia respond with elevated disgust rather than fear to threat-based US (e.g., blood, injections, and bodily mutilations), suggesting that disgust, but not fear, plays a vital role in the development of blood-injection-injury phobia (Olatunji, Lohr, Smits, Sawchuk, & Patten, 2009). Therefore, it is important to elucidate how individuals differ in response to fear-related and disgust-related associative learning.

The primary aim of the current study was to compare and contrast disgust with fear during Pavlovian associative learning and generalization processes. We expanded prior research by using a novel conditioning paradigm. Participants were exposed to the disgust (or fear) conditioning and generalization task, and the within-subjects design allowed us to disengage the different mechanisms underlying the two threat learning and generalization processes. We measured the US subjective expectation and reaction time in the experimental tasks, and recorded eye movement to capture attentional bias. We hypothesized a greater US expectation for CS + than for CS- in both fear and disgust conditioning phases, and a longer reaction time for fear-related CS than for disgust-related CS. We assumed that fear-related GS1 and GS2 would evoke larger US expectation than would disgust-related GS1 and GS2. Further, we hypothesized pupil enlargement would be greater for fear-related CS+, GS1, and GS2 than for disgust-related stimuli.

Results

Conditioning Phase

The Subjective Expectation Score

Repeated-measures ANOVA analysis demonstrated that the main effect of emotion type was significant ($F_{(1,31)}$= 3.46, p = .021, η_p^2 = .08), and the expectation of fear was greater than that of disgust (see Table 1). The main effect of stimulus type was significant ($F_{(2,62)}$ = 15.69, $p < .001$, η_p^2 = .35) and the expectation of CS+ was greater than CS-1 and CS-2. The interaction between emotion type and stimulus type was significant ($F_{(2,62)}$ = 15.69, $p < .001$, η_p^2 = .35). Bonferroni corrected post-hoc analysis revealed that the subjective expectation score of CS-1 (2.59 ± .92) and CS-2(2.74 ±1.17) under fear condition was higher than that of CS-1 (1.63 ± .38) and CS-2(1.67 ± .46) under aversion condition. However, the fear-CS+ (5.95 ± .66) and the disgust-CS+ (6.15 ± .72) scores were not significant ($p > .05$).

Reaction Time

There was a significant main effect for emotion type ($F_{(1,31)}$= 51.19, $p < .001$, η_p^2 = .13) but not for stimulus type ($F_{(2,62)}$= 1.32, $p > .05$). There was a significant interaction between emotion and stimulus type ($F_{(2,62)}$= 14.58, $p < .001$, η_p^2 = .67). Bonferroni corrected post-hoc analysis indicated that the reaction times of fear-related CS-1 (2275 ± 160 ms), CS-2 (2379 ± 87 ms), and CS+ (2303 ± 108 ms) were greater than those of disgust-related CS-1 (1669 ± 81 ms), CS-2 (1681 ± 92 ms), and CS+ (2006 ± 94 ms) (see Table 1).

Generalization Phase

The Subjective Expectation Score

We combined the four GS into two variables, where GS1 was the average value of GS1’ and GS1,” and GS2 was the average value of GS2’ and GS2” (see Figure 4). There was a significant main effect of emotion type ($F_{(1,31)}$= 71.79, $p < .001$, η_p^2 = .20), and the subjective expectation of fear-related CS was greater than that of disgust-related CS. There was a significant main effect of stimulus type ($F_{(4,124)}$= 2.24, p = .042, η_p^2 = .06) for the subjective expectation of CS+, and GS was significantly greater than CS-1 and CS-2. The interaction between emotion type and stimulus type was significant ($F_{(4,124)}$= 11.73, p < .001, η_p^2 = .49). Post-hoc analysis revealed that the subjective expectation score of GS1 (3.92 ± .13) and GS2 (3.82 ± .10) under fear condition was greater than that of GS1 (3.24 ± .11) and GS2 (2.82 ± .11) under disgust condition ($F_{(2,62)}$= 7.93, p < .001, η_p^2 = .28). The expectancy of fear-CS+ (5.36 ± .17) was significantly lower than that of disgust-CS+ (6.25 ± .14) ($F_{(2,62)}$= 6.67, p < .001, η_p^2 = .54). Further, the expectation score did not vary between fear-CS-1 (1.94 ± .16), CS-2 (1.92 ± .13), and disgust-CS-1 (1.59 ± .19), CS-2 (1.56 ± .12) (p > .05).

Reaction Time

There was a significant main effect of stimulus type ($F_{(4,124)}$= 5.94, p < .001, η_p^2 = .39) but the main effect of emotion type marginally failed to reach significance ($F_{(1,31)}$= 3.07, p = .054, η_p^2 = .06). The interaction between emotion type and stimulus type was significant ($F_{(4,124)}$= 21.72, p <.001, η_p^2 = .81). Post-hoc analysis indicated that the reaction times for fear-related GS1 (2236 ± 91 ms), CS+ (2417 ± 134 ms), GS2 (2266 ± 168 ms), and CS-1 (1613 ± 157 ms) were greater than those for disgust-related GS1 (1472 ± 55 ms), CS+ (1513 ± 140 ms), GS2 (1592 ± 137 ms), and CS-1 (1136 ± 148 ms); while the reaction time between fear-related-CS-2 (1782 ± 69 ms) and disgust-related-CS-2 (1540 ± 61 ms) did not vary significantly (p > .05).

Eye movement results

The eye movement results revealed that fear- and disgust- related stimuli elicited different pupil sizes (see Figure 5) . Pupil diameter was larger for fearful stimuli (One-Way ANOVA) than for stimuli perceived as disgusting. When exposed to the image display, the mean pupil size of the participants under the neutral, disgust, and fear conditions was 2487.4, 2304.1, and 2558.5 μm, respectively. Post-hoc comparisons indicated that the difference between any two types of emotional stimuli reached statistical significance (p < .001). There was a main effect of the fixation duration in the first-time fixation. Among the stimuli, there was a significant difference between the fear and disgust conditions (M = 396.63, p < .001), and between the fear and neutral conditions (M = 572.25, p <.001); the fixation duration in disgust conditions was significantly lower than that in neutral conditions (M = 967.03, p < .001).

Discussion

Most previous generalization studies have focused on fear; however, only a few studies have addressed the importance of disgust generalization, an equally important negative emotion (Bianchi & Carter, 2012; Olatunji et al., 2011). Further, many fear generalization experiments actually use a US that elicits both fear and disgust (e.g., mental scraping). To the best of our knowledge, the present study is the first to compare the generalization of conditioned fear and disgust.

In the selection of the experimental US, we developed a new Threat Picture System for future research on fear and disgust by using a free-association task. The fear-eliciting images were separated from the disgust eliciting pictures: there were significant differences in the disgust-, fear-, and arousal-ratings of the participants. These two types of threat emotions were identical in valance but differed in arousal—fearful pictures elicited higher arousal-ratings than did disgusting pictures. Moreover, the three categories of pictures, which included animals, scenes, and objects, were compared in terms of how well they induced the various emotions. A significant effect of category on fear was observed: people rated the animal images as more fearful than they did the scene images. There was also a significant effect of category on disgust: the scene images induced more disgust than did the animal and object images. It is also important to note that the three categories of pictures may be useful for different types of anxiety disorders. For example, the animal category is more suitable for specific phobias; whereas pictures belonging to the scene category may be a better choice for research on claustrophobia and PD.

Our results revealed that in fear-conditioning, there was no significant difference in the subjective expectations of fear- and disgust-relevant CS+, while participants reported higher expectations for fear-relevant CS-1 and CS-2 relative to disgust-relevant CS-1 and CS-2. One explanation for this observation may be that the strength of CS-US association in the two threat emotions was equally strong; however, compared to disgust, fear is associated with inferior discrimination learning. As for fear generalization, some previous studies indicate that, in general, as the difference in physical properties between GS and CS + increases, the fear response to GS decreases (Lissek et al., 2008; Lissek, et al., 2014). In other words, the more similar the stimulus, the more easily the fear will be generalized to it. The results of the current study also support this conclusion: in the generalization phase, the participants exhibited generalized fear or disgust toward GS which was close to CS+, while the subjective expectations of CS-1 and CS-2 remained at a low level consistently, and with the circle size becoming smaller and smaller, the learned fear almost completely disappeared. The subjective expectation score of fear-related GS1 and GS2 was significantly greater than that of disgust GS1 and GS2, which demonstrates that fear can be generalized more broadly, relative to disgust. Taken together, disgust-eliciting GS revealed a steep generalization gradient while fear-eliciting GS displaying a flattened gradient.

Remarkably, the CS + expectancy score of disgust was significantly higher than the disgust-CS + score for fear, which was equal in the conditioning phase. This suggests that disgust is more resistant to extinction than fear, similar to previous findings (Chapman, Johannes, Poppenk, Moscovitch, & Anderson, 2013; Olatunji, Forsyth, & Cherian, 2007; Olatunji, Wolitzky-Taylor, Willems, Lohr, & Armstrong, 2009), which have also demonstrated that the recall and recognition of disgusting stimuli are greater than those of fearful and neutral pictures. In sum, abundant research indicates that extinction treatment is less effective in reducing disgust than fear. This finding has immediate clinical relevance, as generalization and extinction are important for contamination-based OCD.

The difference in reaction time also confirmed the differences in the conditioning and generalization processes under the two emotional conditions. Participants’ response time to fear-based CS + was shorter than that for fear-based CS-; in contrast, the response time for disgust-based CS displayed an opposite trend. In general, the participants responded faster to fearful stimuli than to disgusting stimuli. Fear is more closely related to survival, and can mobilize people’s attention as well as elicit a longer reaction. It is a “stop to observe” (Hoppenbrouwers, Bulten, & Brazil, 2016) behavior pattern, and is different from disgust, which is characterized by a “just want to escape quickly” behavior pattern (Curtis, de Barra, & Aunger, 2011; Neuberg, Kenrick, & Schaller, 2011). Although both emotions are threat-related, fear is thought to elicit an instinctive response to deal with an immediate threat, and is expressed as the expansion of sensory perception, attention, and feelings in response to the surrounding environment (Susskind et al., 2008). Meanwhile, disgust elicits immediate sensory rejection to avoid contamination, expressed as the contraction of the pupils’ dilation, and the resentment and avoidance of disgusting objects (Santos, Iglesias, Olivares, & Young, 2008). It is worth noting that both pupil size and duration of fixation in response to fear stimuli were larger than those in response to disgust. This phenomenon may suggest different evolutionary responses to the two kinds of threatening emotions.

The experimental procedure of the current research was well controlled, and the paradigm integrated test performance (response to stimuli) to behavioral measures (eye movements and change in pupil size). This piece of research markedly distinguished fear from disgust, thus contributing to the clarification of their different nature on an experimental level. Nevertheless, there are some limitations of the present study. First, we did not use standardized tools to verify inclusion criteria such as right-handedness, normal eyesight, and the absence of previous traumatic experiences. Future studies should use standardized tools (e.g., the Edinburgh Handedness Inventory) instead of generic questions. Second, our sample included only healthy participants; thus, our results may not generalize well to patients with anxiety disorders. It is necessary to study patients with OCD as a special group. Finally, improving the ecological validity of fear generalization laboratory research is also a direction for future research (Claes, Crombez, & Vlaeyen, 2015). Most empirical studies use Pavlovian conditioned reflex as the experimental paradigm, and the generalized CR along with the perceptual similarity to CS + in simple sensory dimensions (e.g., sound, color, and shape). However, stimuli in real-life situations usually involve multiple sensory dimensions, and individuals' emotional experience and knowledge also affect their perception of stimuli (Dunsmoor & Murphy, 2015). In this regard, future research could examine the associations between fear, disgust, and anxiety disorders using category-based generalization.

In summary, the current study demonstrates that disgust can be more resistant to extinction relative to fear when the strength of CS-US association is the same. In the generalization phase, the subjective expectations of disgust-GS were significantly higher than that of fear. We concluded that the fear generalization gradient is steeper than the disgust generalization gradient. Further, fear-related GS lead to longer reaction times compared to disgust-related GS, and the pupil size and fixation duration for fear stimuli were larger than those for disgust stimuli, indicating that individuals exhibited an attention bias toward fear-based CS and GS. These findings have notable clinical implications, particularly in the intervention techniques of fear and disgust, as well as for learning mechanisms, anxiety disorder treatments, and interventions for emotional development in children.

Methods

Participants

Thirty-two students (18 women, mean age = 21.22 years, SD = 1.47) from Shenzhen University participated in the current study and received approximately 70 RMB for participation. An a-priori calculation of statistical power (G*Power) suggested that the recruitment target should be 28 participants to achieve a medium effect size of .20, an alpha level of .05, and a 1-beta level of .80 (Hendrikx, Krypotos, & Engelhard, 2020; Faul, Erdfelder, Lang, & Buchner, 2007). Thus, the sample recruited (N = 32) was large enough to detect an effect at the significance level of $\alpha = .05$. All participants met the following criteria: right-handed, normal or corrected-to-normal eyesight, no previous traumatic experiences, and no neurological diseases or drug abuse. The participants were informed that they could quit the experiment at any time and were asked to sign an informed consent form before the experiment began. The research was approved by the Medicine Ethics Committee of Shenzhen University was performed in accordance with the Declaration of Helsinki.

Materials

Unconditioned stimulus (US)

We asked 115 participants (51 women, mean age = 21.90 years, SD = 1.40) to provide as many fear-inducing (e.g., snake) or disgust-inducing (e.g., cockroach) nouns as possible through a free-association task (see Figure 1). We then selected the 180 most frequent stimuli (each category contained 90 different pictures) and classified these into three categories—animals, scenes, and objects—with 30 images in each category. Next, we enrolled 84 participants (39 men, mean age = 20.60 years, SD = 1.40) to assess disgust-, fear-, valence-, and arousal-ratings for each stimulus on a 9-point scale. Finally, a total of 81 fear-evoking and 84 disgust-evoking pictures were chosen. Independent t-tests revealed that the mean ratings of fear for the fear-evoking category (M = 4.80; SD = 1.06) were significantly higher than for the disgusting-evoking category (M = 3.32; SD = .86; $t(80) = 12.715$, $p < .001$, Cohen's d = .87), and the mean ratings of disgust for the disgust-evoking category (M = 5.84; SD = 1.21) were significantly higher than for the fear-evoking category (M = 4.05; SD = .97; $t(83) = 22.737$, $p < .001$, Cohen’s d = 2.40). There was no significant difference in valence between the two categories ($t(80) = 3.701$, $p = .24$, Cohen's d = .58), whereas the arousal from the images in the fear-evoking category (M = 7.62; SD = 6.16) was significantly higher than in the disgust-evoking category (M = 6.85; SD = 5.54, $t(80) = 7.329$, $p < .001$, Cohen's d = 1.17). In the current research, we selected 30 stimuli to represent the categories of Disgusting US and Fearful US (15 each). As shown in Figure 1, all US stimuli in this study were selected from the 165 emotional pictures.

Conditioned stimulus (CS) and Generalized stimulus (GS)

The stimuli were seven black rings, continuously increasing in size (7.37-11.94 cm in diameter, 15% increments; Lissek et al., 2008) (see Figure 2). The mid-sized ring (9.56 cm) served as CS+ paired with the

US (75% reinforcement), whereas the largest (11.94 cm, CS-1) and smallest (7.37 cm, CS-2) rings were used as CS- presented alone (Cha et al., 2014). The remaining four rings (8.13 cm, 8.89 cm, 10.41 cm, 11.18 cm) were used as the GS.

Experimental Procedure

The fear and disgust learning (conditioning, generalization) took place in two separate sessions, and the order was counterbalanced (see Figure 3).

Habituation

Each CS was presented without US for 3000 ms (three times each), and each CS was not repeated more than twice in a row, with a jittered inter-trial interval (ITI) ranging from 1 to 3 s.

Conditioning

The conditioning phase consisted of 12 CS+, 12 CS-1, and 12 CS-2, divided into three blocks (3000 ms duration; 36 total trials). The CS+ was partially followed by the US (1000 ms duration; 75% reinforcement rate), and the CS- (i.e., CS-1; CS-2) was presented alone. The ITI was jittered between 1 and 3 s. During each trial, participants were asked to rate the level of US expectancy on a 9-point scale (1 = *least likely*, 5 = *moderately likely*, 9 = *most likely*) and the eye movement response was recorded.

Generalization

The generalization phase included six blocks with eight trials in each block: both the CS+ and the CS- were presented twice and each of the four GS was presented once (3000 ms duration). To avoid extinction, all the CS+ in the generalization phase were paired with a US. On each trial, participants were asked to assess the US expectancy via a 9-point rating scale, and the ITI ranged between 1 and 3 s.

Acquisition and Analysis of Eye Movement Indicators

The tracking of eye movement was recorded with the Eye-Link 1000 desktop eye movement recorder (sampling rate: 1000 Hz). We focused primarily on participants' eye responses during the first exposure to threat stimuli (US) in the acquisition phase. The main eye movement variables changed in pupil diameter and initial gaze time when CS appeared.

Statistical Analysis

Analyses were performed with SPSS version 20.0 for IBM. For the conditioning phase, a 3 (Stimulus Type: CS+, CS-1, CS-2) × 2 (Emotion Type: fear, disgust) repeated-measures ANOVA was conducted on the subjective expectation scores and reaction times. The data for pupil size and fixation duration were analyzed with one-way ANOVAs with Emotion (fear/disgust/neutral) as an independent variable. For the generalization phase, a 5 (Stimulus Type: CS+, CS-1, GS-1, CS-2, GS-2) × 2 (Emotion Type: fear, disgust) repeated-measures ANOVA was performed on the US expectation scores and the reaction times (the statistical significance level was $p < .05$).

Declarations

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Author Contributions:

Conceived and designed the experiments: Sunxiaoying , Jinxia Wang, Yi Lei.

Performed the experiments: Sunxiaoying, Jiachen Lu

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Tables

Table 1 *The behavior results（M ± SD）*

		Fear condition		Disgust condition	
		Subjective expectations (1-9)	**Reaction time（ms）**	**Subjective expectations (1-9)**	**Reaction time（ms）**
Acquisition	**CS-1**	2.59 ± .92	2275 ± 160	1.63 ± .38	1669 ± 81
	CS+	5.95 ± .66	2303 ± 108	6.15 ± .72	2006 ± 94
	CS-2	2.74 ±1.17	2379 ± 87	1.67 ± .46	1681 ± 92
Generalization	**CS-1**	1.94 ± .16	1613 ± 157	1.59 ± .19	1136 ± 148
	GS1	3.92 ± .13	2236 ± 91	3.24 ± .11	1472 ± 55
	CS+	5.36 ± .17	2417 ± 134	6.25 ± .14	1513 ± 140
	GS2	3.82 ± .10	2266 ± 168	2.82 ± .11	1592 ± 137
	CS-2	1.92 ± .13	1782 ± 69	1.56 ± .12	1540 ± 61

Figures

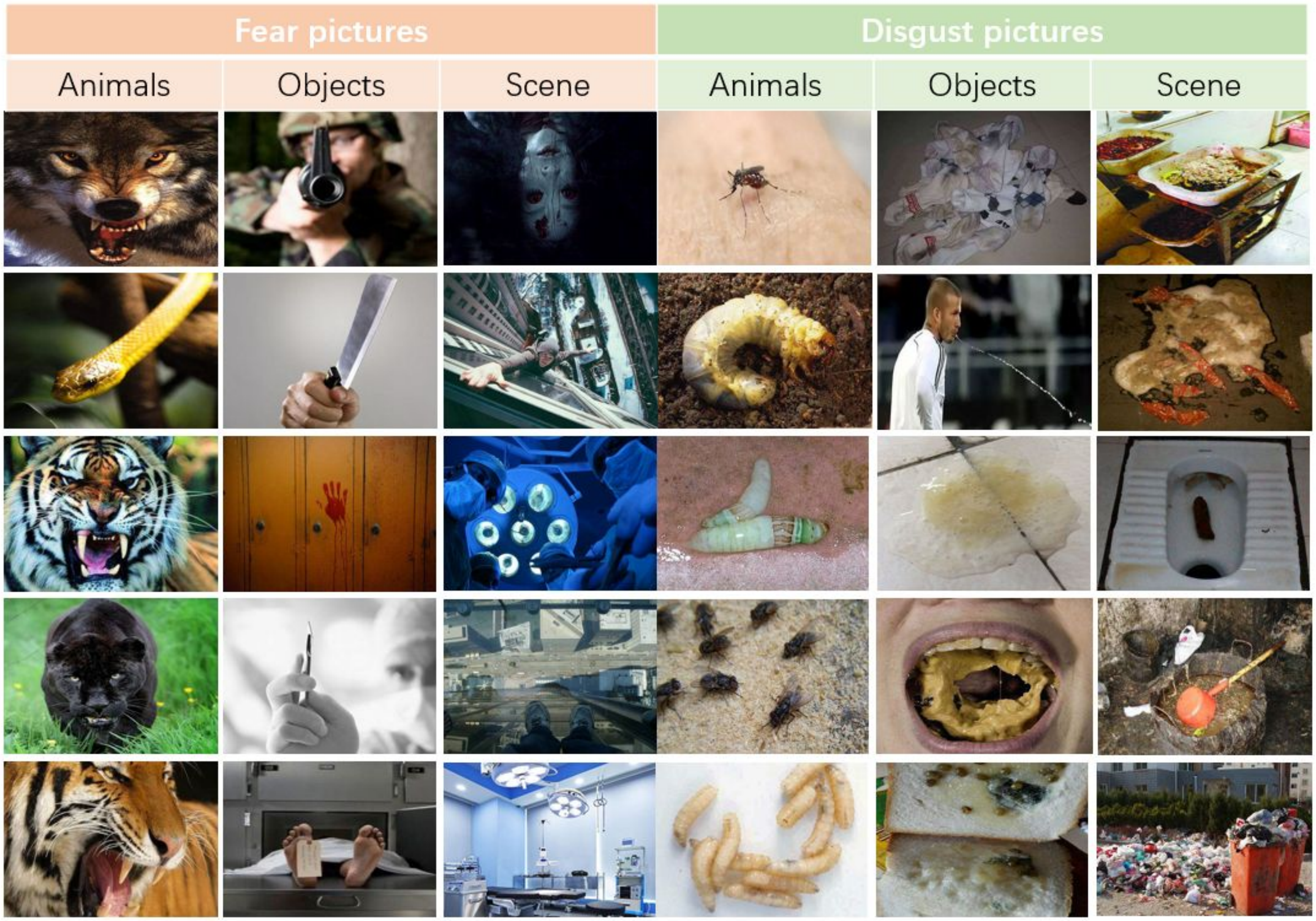

Figure 1

Experimental material: US (unconditioned stimuli)

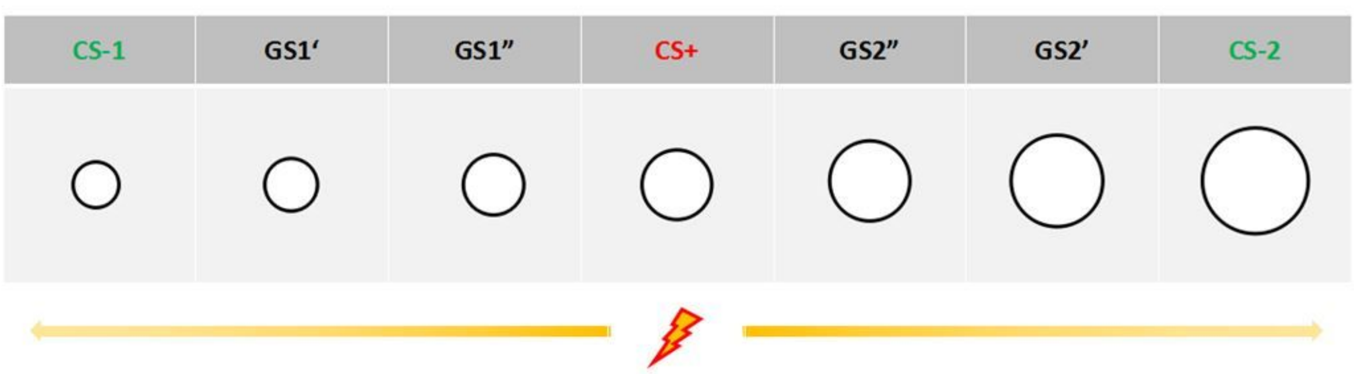

Figure 2

Experimental material: CS (conditioned stimuli)

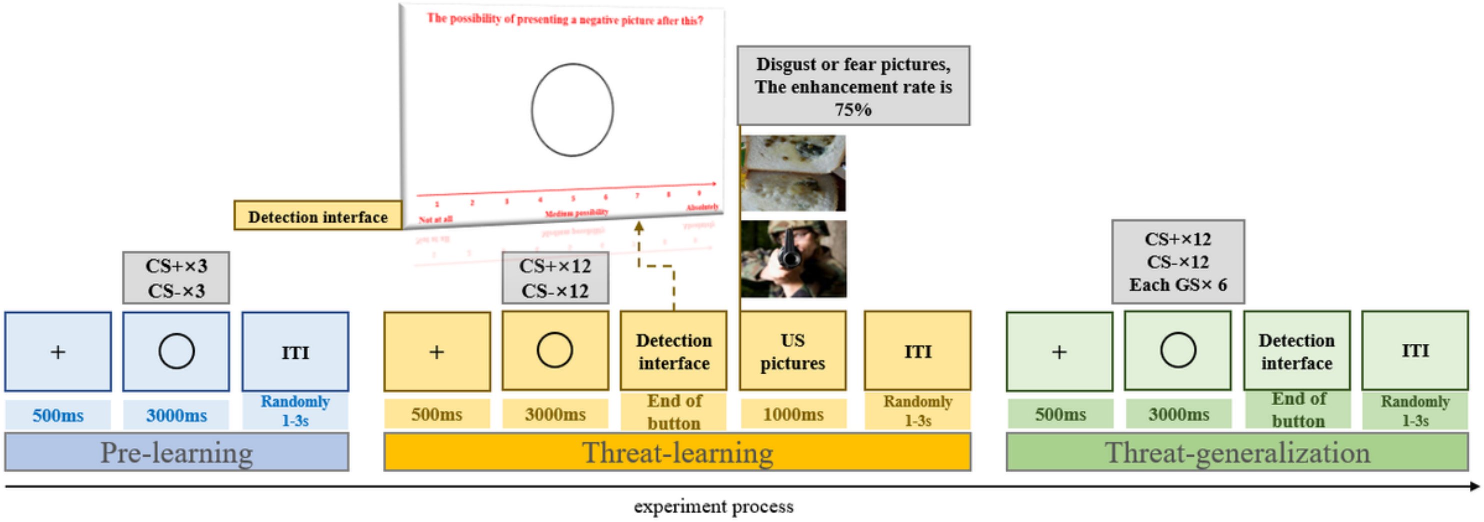

Figure 3

The experimental procedure

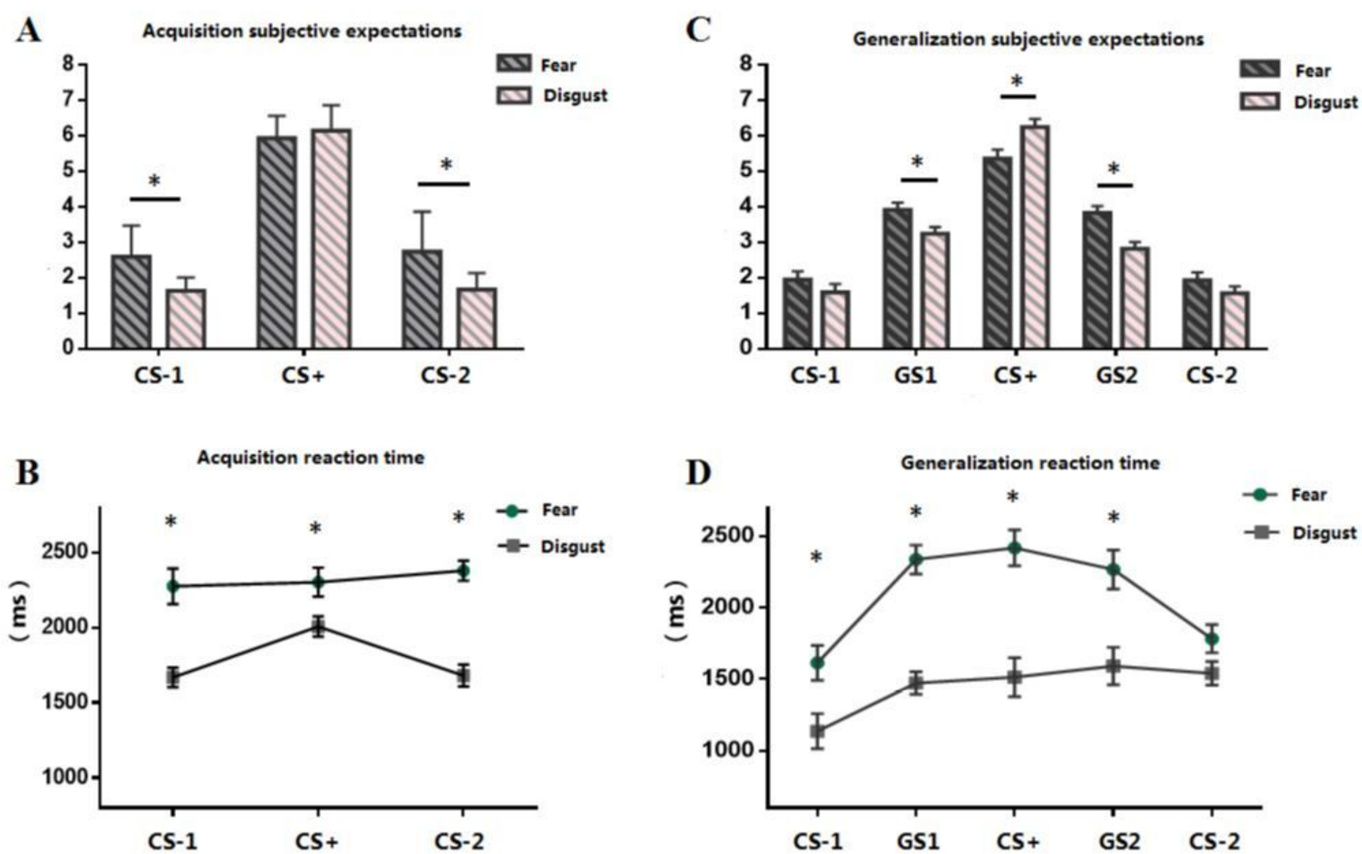

Figure 4

The behavior results

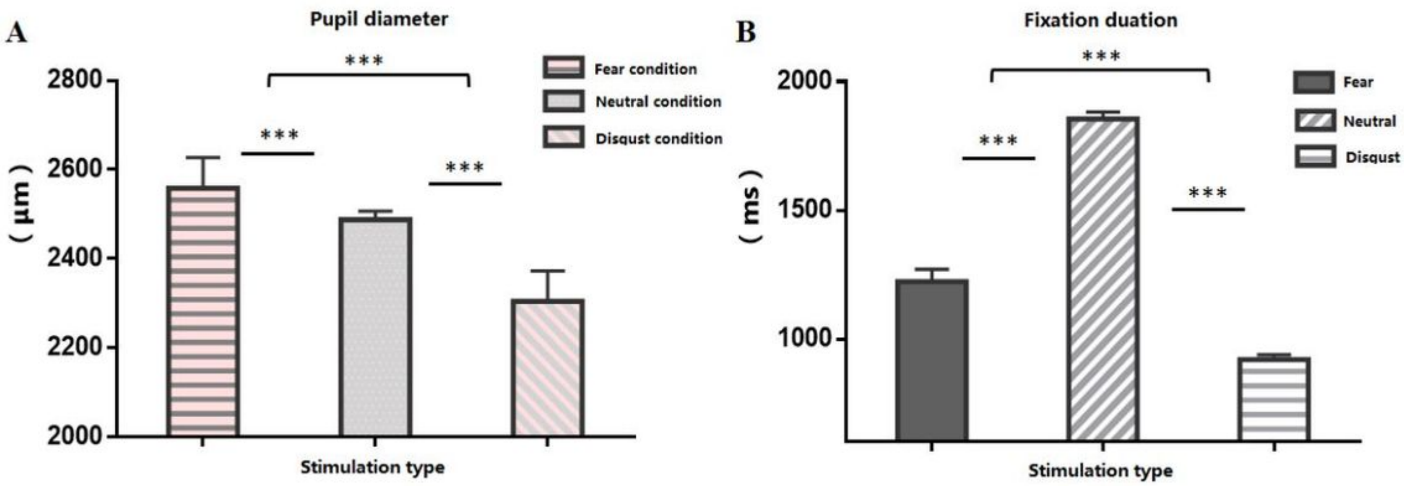

Figure 5

The differences in pupil size and fixation duration between fear and disgust