

Fast-Forwarding Disgust Conditioning: US Pre-Exposure Facilitates the Acquisition of  
Oculomotor Avoidance

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*Author note:*

This research was supported in part by the Sally Ann Abshire Research Scholar Award from Whitman College.

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### Abstract

During human development, disgust is acquired to a broad range of stimuli, from rotting food to moral transgressions. Disgust's expansion surely involves associative learning, yet little is known about Pavlovian disgust conditioning. The present study examined conditioned disgust responding as revealed by oculomotor avoidance, the tendency to look away from offensive stimuli. In two experiments, oculomotor avoidance was acquired to a neutral image associated with a disgusting image. However, to our surprise, participants initially dwelled on disgusting images, avoiding them only after multiple exposures. In Experiment 1, this "rubbernecking" response delayed oculomotor avoidance of the associated neutral image. In Experiment 2, we exhausted rubbernecking prior to conditioning by repeatedly exposing participants to the disgusting images. This procedure elicited earlier oculomotor avoidance of the associated neutral stimulus, essentially *fast-forwarding* conditioning. These findings reveal competing motivational tendencies elicited by disgust stimuli that complicate associative disgust learning.

*Keywords:* disgust, conditioning, eye movements,

## Fast-Forwarding Disgust Conditioning: US Pre-Exposure Facilitates the Acquisition of Oculomotor Avoidance

Disgust is a basic emotion that motivates avoidance of debasing stimuli, such as rotting food, bodily wastes, wounds, and people perceived as diseased or otherwise impure or contaminating (Angyl, 1941; Rozin & Fallon, 1987). There is a broad consensus that disgust evolved under selective pressure from pathogens (Davey, 2011; Oaten, Stevenson, & Case, 2009; Tybur, Lieberman, Kurzban, & DeScioli, 2013). Disgust appears to function as a “behavioral immune system” that prevents contact with an array of disease vectors (Schaller & Park, 2011). However, this evolved psychobiological mechanism requires a considerable degree of social input (Rozin & Fallon, 1987). Although rotting food, bodily waste, and infected wounds seem inherently revolting, children must learn from adults to be disgusted by these stimuli. For example, cultural anthropologists have observed that ‘feral’ children do not exhibit disgust (Malson, 1964), and children undergoing typical development exhibit disgust only after years of socialization (Stevenson et al., 2010). By requiring cultural input, the disgust mechanism likely gains a level of flexibility and sophistication lacking in innate reflexes (e.g., the distaste food rejection reflex), which have fixed sensory inputs and cannot adjust to changing environments or new knowledge (Lazarus, 1982).

Although all disgust responding requires learning, there may be a distinction between *primary* and *secondary* disgust learning. According to Rozin and Fallon (1987), children first acquire a limited set of primary disgusts (e.g., to bodily waste, rotting food, certain insects) through a socialization process involving instrumental conditioning and modeling. After this initial socialization process, disgust continues to expand to new

objects, but only through their association with primary objects of disgust. As Rozin and Fallon (1987) explain, secondary disgust objects become disgusting by resembling primary disgust objects, through stimulus generalization, or by having a spatial or temporal association with a primary disgust object, a process known as contagion (Rozin et al., 1986). Although Rozin and colleagues (1986) explain contagion through the “laws of sympathetic magic” posited by cultural anthropologists, they acknowledge that Pavlovian conditioning could explain the phenomenon. Indeed, a secondary disgust stimulus appears to acquire the capacity to elicit a disgust response in the same manner that a conditioned stimulus (CS) acquires the capacity to elicit a conditioned response (CR): by acquiring an excitatory connection, through spatiotemporal contiguity, to the representation of an unconditioned stimulus (US) that elicits an unconditioned response (UR) (Bouton, 2007).

Despite the clear potential of applying associative learning frameworks to disgust, there is surprisingly little research on Pavlovian disgust conditioning in humans, particularly given the wealth of research on Pavlovian fear conditioning (Duits et al., 2015). This is unfortunate, as research on disgust conditioning could clarify the acquisition of adaptive disease-avoidance behavior as well as maladaptive behaviors, such as the excessive avoidance of secondary disgust stimuli in contamination-based OCD (Armstrong & Olatunji, 2017), the avoidance of food in anorexia nervosa (Hildebrandt et al., 2015), or the avoidance of disgust-eliciting trauma reminders in post-traumatic stress disorder (Badour, Feldner, Blumenthal, & Knapp, 2013). A disgust conditioning framework could also provide insight into the acquisition of disgust to marginalized social groups (e.g., gay men, people with disabilities, immigrants), which may underlie widespread forms of prejudice and discrimination (Inbar, Pizarro, Knobe & Bloom, 2009; Nussbaum, 2001;

Schaller & Park, 2011). In summary, understanding the acquisition of secondary disgust through associative learning could inform efforts to address a variety of human problems.

One barrier to investigating disgust conditioning may be the lack of a reliable, objective measure of conditioned responding. In contrast to research on fear conditioning (Duits et al., 2015), research on disgust conditioning in humans often relies on self-report measures of disgust responding (e.g., David & Olatunji, 2011; Olatunji, Lohr, Smits, Sawchuk, & Patten, 2009; Olatunji, Tomarken, & David, 2013). Although self-report measures are ideal for gauging certain subjective aspects of conditioned responding (e.g., US expectancy; Boddez et al., 2013), they hinge on a participant's ability to recognize and parse subtle mental processes that may be difficult to discern and quantify, or may not be fully available to consciousness (see Nosek, 2007).

To obtain an objective measure of conditioned disgust responding, some researchers have examined indicators of autonomic arousal, such as skin conductance or heart rate (Schienle, Stark, & Vaitl, 2001; Olatunji, Forsyth, & Cherion, 2007); however, these measures do not specifically capture disgust responding and have yielded mixed results. Electromyographical recording of the levator labii muscle, which underlies the disgust facial expression, may offer a more specific psychophysiological measure of disgust (Vrana, 1993). However, this measure of disgust has been found to lack reliability (Hess et al., 2016) and may not be sensitive enough to register milder disgust (Vartanian, Trewartha, Beames, Azevedo, & Vanman, 2017), such as conditioned disgust responding. Although one study (Bosman, Borg, & de Jong, 2016) was able to observe levator activity as a conditioned disgust response, another study (Borg, Bosman, Engelhard, Olatunji, & de Jong, 2014) did not observe levator activity as a conditioned disgust response, and instead

found that only the corrugator muscle—a more general measure of negative affect—indexed conditioned disgust responding. Another study did not observe levator activity as a conditioned disgust response, but also failed to observe conditioned disgust responding on self-report measures (Schienle et al., 2001). Advanced techniques, such as triangulating multiple indices (Hess et al., 2016), may improve the psychophysiological assessment of conditioned disgust; however, it may also be important to look beyond psychophysiology to alternative measures of disgust responding (e.g., Engelhard, Leer, Lange, & Olatunji, 2014).

One novel way to measure disgust is through eye tracking technology. As noted by Darwin (1872/1965), disgusting stimuli are repellant to the senses. For the domain of vision, this can be observed in the tendency to avert one's gaze from a disgusting sight, which can be directly measured by recording eye movements (Armstrong & Olatunji, 2012). Indeed, such 'oculomotor avoidance' may be relatively specific to disgusting stimuli. Prior research suggests that videos (Armstrong et al., 2014) and images (Armstrong, Olatunji, & Sarawgi, 2012) with disgust-relevant content (vomit, feces) elicit oculomotor avoidance, whereas videos or images with fear-relevant content (car accidents, interpersonal violence) do not elicit oculomotor avoidance. Similarly, Bradley, Costa, and Lang (2015) found that images of contamination elicited oculomotor avoidance, as did images of undesired nude bodies, particularly in women who rated the nudes as disgusting. In Bradley et al.'s study, fear-relevant content, such as violence and mutilation, did not elicit oculomotor avoidance.

There is preliminary evidence that oculomotor avoidance occurs not only as an unconditioned disgust response, but also as a conditioned disgust response. Mason and

Richardson (2010) found that a neutral face previously paired with disgusting images (CS+) elicited oculomotor avoidance when presented alongside a neutral face previously paired with neutral images (CS-). However, a subsequent study by Mason and Richardson (unpublished, described in Mason & Richardson, 2012) found weaker evidence of this effect, perhaps due to the use of fewer acquisition trials prior to assessing oculomotor avoidance. In addition, a subsequent study (Armstrong et al., 2014), which used disgusting videos instead of images as USs, found no oculomotor avoidance of the CS+ relative to the CS- after an acquisition procedure, but unexpectedly observed the phenomenon after an extinction procedure. An additional study by Armstrong (2014), which adhered more closely to Mason and Richardson's (2010) study, but used several different unconditioned disgust stimuli to prevent possible habituation, did not observe oculomotor avoidance of the CS+ following acquisition or extinction.

Although these mixed findings may cast doubt on the reliability of oculomotor avoidance as a conditioned disgust response, it should be noted that all of these studies assessed oculomotor avoidance *after* the relevant stage of associative learning. Because oculomotor selection requires competing stimuli, oculomotor avoidance could not be measured during conditioning in these studies because the CS and US were presented serially, without accompanying stimuli. In contrast, psychophysiological measures of conditioned responding are acquired during the conditioning procedure itself, when the CS is serving as a cue for the possible presentation of the US. Measuring oculomotor avoidance separately from conditioning may be problematic, because it requires the conditioned response to generalize to a different context and to resist extinction during the multiple unreinforced trials of assessment. Furthermore, measuring oculomotor avoidance

separately from conditioning precludes any insight into the dynamics of conditioning, which can only be revealed by assessing both the CR and UR repeatedly during conditioning.

With these limitations in mind, the present study sought to establish a new eye tracking paradigm for studying disgust conditioning. To allow assessment of conditioned oculomotor responding *within* the stages of an associative learning task (e.g., habituation, acquisition, extinction) rather than afterward, we presented neutral faces simultaneously. Then one face (CS+) was replaced by a disgusting image (US+), whereas the other face (CS-) was replaced by a neutral image (US-). Simultaneous presentation of the CSs (as well as the USs) elicits competition between the stimuli for oculomotor selection, creating a meaningful oculomotor response that is lacking in serial CS and US presentation.

### **Experiment 1**

In experiment 1, we tested the proposed paradigm in an associative learning task with the following stages: habituation (8 trials of CSs unreinforced), acquisition (16 trials of CSs followed by USs), and extinction (16 trials of CSs unreinforced). The acquisition and extinction stages were presented in two blocks of 8 trials. For the habituation stage, we predicted equivalent oculomotor responding to the CSs. For the acquisition stage, we predicted that the US+ would elicit an unconditioned response (UR) of oculomotor avoidance, leading to greater viewing of the US-. We predicted that this UR would be consistent across the two blocks. Critically, we predicted that the CS+ would elicit a conditioned response (CR) of oculomotor avoidance. We predicted that this CR would be consistent across the two blocks. In light of prior eye tracking research suggesting that condition disgust responding is insensitive to extinction (Armstrong et al., 2014; Mason &



Richardson, 2010), we predicted that the CS+ would continue to elicit a CR of oculomotor avoidance throughout both blocks of extinction.

## Method

**Participants.** Eighty-four students at a private liberal arts college completed the study in exchange for course credit or \$10. Eight participants were excluded due to difficulty tracking their eyes, resulting in a final sample size of 76 (age:  $M = 18.89$ ,  $SD = 1.03$ ; 28 male, 48 female; 79% White, 6.6% Latina/o, 5.3% Asian, 1.3% Black, 6.6% Other). The target sample size for both experiments in this study was  $n = 75$ , as this  $n$  could be achieved in one semester of data collection and would provide adequate power (80%) to detect a smaller effect ( $d_z = .33$ ) than the large effect that Mason and Richardson's (2012) observed in terms of oculomotor avoidance of the CS+ versus the CS-. All participants provided informed consent, and all procedures were approved by the Whitman College Institutional Review Board. All data and study materials are available on the Open Science Framework (OSF) at <https://osf.io/m964v>.

## Measures.<sup>1</sup>

***The Empirical Valence Scale.*** (EVS; Lishner, Cooter, & Zald, 2008) is a labeled magnitude scale designed for rating subjective experiences. In contrast to the equidistant verbal labels of visual analogue or Likert-like scales, the verbal labels on the EVS are spaced according to prior research assessing how participants rate the verbal labels themselves on a 0-100 scale. Participants rated their disgust response to the CSs and USs, as well as their

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<sup>1</sup> Participants also completed individual difference measures related to disgust and anxiety for the purpose of exploratory analyses. These measures are not reported; however, we include them in the data file shared on the OSF.

expectancy of the US during the CS, using the unipolar version of the EVS scale.<sup>2</sup> The unipolar version of the scale contains the following labels and corresponding values: not at all (0), barely (7), slightly (12), mildly (24), moderately (38), strongly (70), extremely (85), and most imaginable (100). These labels are placed on a line (without the corresponding numeric values). Ratings are made by clicking anywhere on the line with a mouse.

**Materials and apparatus.** The CS stimuli were two male faces selected from the Karolinska Directed Emotional Faces set (KDEF; Lundqvist, Flykt, & Öhman, 1998). A male with blonde hair and a male with brown hair were selected to maximize discrimination, and we selected faces that our lab group ( $N = 8$ ) rated as the most strange or odd looking in order to facilitate the acquisition of disgust (see Öhman & Dimburg, 1978). The faces were 16.4 cm x 12.4 cm, subtending  $9.6^\circ \times 7.2^\circ$  of visual angle at the viewing distance of 98 cm. Their centers were separated by  $14.5^\circ$  degrees of horizontal visual angle. The US stimuli were two disgusting images (pus-filled wound, feces in a toilet bowl) selected from publicly available online images and two neutral images (book, mug) from the International Affective Picture System (IAPS; Lang, Bradley, & Cuthbert, 2008). These images were matched in size to the CSs. To maximize CS-US association during the acquisition procedure, each CS was transformed into the associated US using Photo Morpher software (Morpheus Software; Howell, MI). All stimuli were presented in color against a grey background on a monitor with 1920 x 1080 resolution using E-Prime 2.0 software

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<sup>2</sup> At the end of each stage, participants also rated the CSs in terms of how afraid, how pleasant/unpleasant, and how aroused the stimuli made them feel. These ratings were included to allow us to compare these results with a fear conditioning version of this experiment, if we were to run one in the future (we instead decided to pursue the rubbernecking finding in Experiment 2). Also, as an experimental measure of conditioning, participants rated how attractive the faces were at the end of each stage. We have omitted these measures for the sake of brevity, but we include them in the data file shared on the OSF.

(Psychology Software Tools, Pittsburgh, PA) on a desktop PC. Eye movements were recorded monocularly at 1000 Hz with an EyeLink 1000 Plus eye tracker (SR Industries; Ontario, Canada) using head support.

**Procedure.** Participants were randomly assigned to receive either the blonde-haired male as the CS+ and the brown-haired male as the CS–, or vice versa. Participants were informed that one face would be paired with unpleasant images, and one face would be paired with neutral images, and that they would later be asked about this contingency. To minimize self-monitoring of gaze behavior, participants were told that the eye tracker was a pupillometer and that the study concerned pupil dilation. In all stages of the procedure, the CSs were presented side-by-side for 6 s and were preceded by a central fixation cross (1 s) and followed by an inter-trial interval (ITI) consisting of a blank grey screen for (4 s, 5 s, or 6 s varied randomly). During the habituation stage, the CSs were presented 8 times without subsequent presentation of the USs. During the acquisition stage, the CSs were presented 16 times, in two blocks of 8. After being presented for 6 s, the CS morphed into the US for 2 s, and then the US was presented for 6 s, followed by the ITI. During the extinction stage, the CSs were presented 16 times, in two blocks of 8, without subsequent presentation of the USs. Eye movements were recorded throughout each stage. At the end of each stage, participants rated each CS in terms of how disgusted it made them feel. At the end of each stage and the end of each block of acquisition and extinction, participants rated how much they expected an unpleasant image to follow each CS. After the conditioning procedure, participants rated each US in terms of how disgusted, afraid, pleasant/unpleasant, and aroused it made them feel. For brevity, we report only the disgust

ratings, but the other ratings are available in the data file shared in the Open Science Framework.

**Eye movement data reduction.** Fixations were defined as periods of gaze between saccades (or blinks) using a 30 °/s velocity threshold for saccade detection. We computed the total fixation duration (dwell time) on each stimulus (CS+,CS-,US+ or US-) for each trial of each block. We then excluded trials (10.02%) in which participants spent less than half of the trial viewing the stimuli. We then computed the mean fixation duration of the remaining trials for each stimulus for each block. Mean fixation durations for a block were only computed if half or more trials were included for the block. The resulting missing data was addressed with listwise deletion, leading to some variability in the number of cases in each analysis. We analyzed the dynamics of conditioning over blocks of trials, rather than individual trials, because it reduced listwise deletion due to missing trials, and because the aggregate block dwell time indices were more stable than the individual trial dwell time indices. We used Cronbach's  $\alpha$  to measure the internal consistency of our aggregate block variables (Waechter, Nelson, Wright, Hyatt, & Oakman, 2014), in light of concerns regarding the internal consistency of attentional bias measures (see Rodebaugh et al., 2016).

**Analysis plan.** In line with prior studies on fear and disgust conditioning (e.g., Lissek et al., 2008; Mason & Richardson, 2010), we conducted separate analyses for each stage of the associative learning task (habituation, acquisition, extinction). To further test extinction, we then examined the change in discriminant responding from acquisition to extinction (Armstrong et al., 2014; Kelly & Forsyth, 2007; Waters, Theresiana, Neumann, & Craske, 2017).

***Self-report CRs.*** For disgust ratings, we compared self-reported CRs to the CS+ and CS- after each stage using paired-samples *t*-tests. Because US expectancy was assessed after each of the two blocks during acquisition and extinction, we first submitted these data to a 2 (CS: CS+, CS-) X 2 (block: first, second) repeated-measures ANOVA and then used paired-sample *t*-tests as necessary to clarify any interactions. For the direct test of extinction, we conducted a 2 (stage: acquisition, extinction) X 2 (CS: CS+, CS-) repeated-measures ANOVA and examined the stage by CS interaction term. Because US expectancy was rated twice in each stage, we entered the mean US expectancy for each CS for each stage.

***Oculomotor CRs.*** As a manipulation check to confirm that the US+ elicited oculomotor avoidance, we conducted separate 2 (US: US+, US-) by 2 (block:1, 2) repeated-measures ANOVA on dwell time for each block of the acquisition procedure. To examine responding to the CSs, we conducted separate 2 (CS: CS+, CS-) by 2 (block:1, 2) repeated-measures ANOVA on fixation duration for habituation, acquisition, and extinction. For the direct test of extinction, we conducted a 2 (stage: acquisition, extinction) X 2 (CS: CS+, CS-) repeated-measures ANOVA and examined the stage by CS interaction term.

## Results

**US validation.** Participants rated the two US+ images ( $M = 58.64$ ,  $SD = 21.96$ ) as more disgusting than the two US- images ( $M = 1.18$ ,  $SD = 3.55$ ),  $t(75) = 22.70$ ,  $p < .001$ ,  $d_z = 2.60$ .

### Habituation.

***Self-report CRs.*** As predicted, there were not significant differences between CSs in self-reported US expectancy at the end of the habituation stage,  $t(75) = .19$ ,  $p = .851$ ,  $d_z = .02$ .

or disgust,  $t(75) = .18$   $p = .859$ ,  $d_z = .02$ . Table 1 reports *Ms* and *SDs* for self-report CRs at each stage of the task, and Figure 1 depicts these results.

**Oculomotor CRs.** As predicted, there was not a significant difference in dwell time on the CSs in the single block of trials in the habituation stage,  $t(75) = 1.08$   $p = .282$ ,  $d_z = .13$ . Table 1 reports *Ms*, *SDs*, and Cronbach's  $\alpha$  for oculomotor CRs at each stage of the task, and Figure 2 depicts these results.

### Acquisition.

**Self-report CRs.** As predicted, participants reported expecting the US more when viewing the CS+ compared to the CS-, as revealed by a main effect of CS,  $F(1, 75) = 190.56$ ,  $p < .001$ ,  $\eta^2_p = .71$ . This main effect was qualified by a CS by block interaction,  $F(1, 75) = 21.42$ ,  $p < .001$ ,  $\eta^2_p = .22$ . Although participants showed greater US expectancy to the CS+ versus the CS- by large margins following both block 1,  $t(75) = 10.47$ ,  $p < .001$ ,  $d_z = 1.20$ , and block 2,  $t(75) = 14.28$ ,  $p < .001$ ,  $d_z = 1.64$ , their US expectancy for the CS+ increased from block 1 to block 2,  $t(75) = 3.98$ ,  $p < .001$ ,  $d_z = .46$ , whereas US expectancy decreased for the CS-,  $t(75) = -3.34$ ,  $p < .001$ ,  $d_z = -.38$ . As predicted, participants also reported experiencing more disgust in response to the CS+ compared to the CS- at the end of the acquisition stage,  $t(75) = 8.37$ ,  $p < .001$ ,  $d_z = .96$ .

**Oculomotor URs.** There was no main effect of US on dwell time,  $F(1, 71) = .003$ ,  $p = .995$ ,  $\eta^2_p = .00$ . Thus, the hypothesized oculomotor avoidance of the US+ was not observed. However, there was a significant US by block interaction,  $F(1, 73) = 17.79$ ,  $p < .001$ ,  $\eta^2_p = .20$ . This interaction was driven by a significant decrease in dwell time on the US+ from block 1 ( $M = 2538$ ,  $SD = 925$ ;  $\alpha = .86$ ) to block 2 ( $M = 2127$ ,  $SD = 1219$ ;  $\alpha = .88$ ),  $t(73) = 4.79$ ,  $p < .001$ ,  $d_z = .56$ , and a significant increase in dwell time on the US- from block 1 ( $M = 2160$ ,

$SD = 1084$ ;  $\alpha = .90$ ) to block 2 ( $M = 2478$ ,  $SD = 1353$ ;  $\alpha = .90$ ),  $t(73) = -3.38$ ,  $p = .001$ ,  $d_z = -.39$ . Although there were not significant differences in dwell time on the USs at block 1,  $t(73) = 1.65$ ,  $p = .104$ ,  $d_z = .19$ , or block 2,  $t(75) = -1.24$ ,  $p = .220$ ,  $d_z = -.14$ , an exploratory analysis at the trial level (uncorrected for multiple comparisons) revealed that in the first two trials, participants dwelled on the disgusting US+ more than the neutral US- [trial 1:  $t(70) = 5.64$ ,  $p < .001$ ,  $d_z = .67$ ; trial 2:  $t(73) = 3.57$ ,  $p < .001$ ,  $d_z = .42$ ]. In trials 3-15 there were not significant differences in dwell time ( $ps > .207$ ), and then on the last trial of acquisition, the predicted avoidance of the disgusting US+ compared to the US- emerged [trial 16:  $t(67) = -2.23$ ,  $p = .023$ ,  $d_z = -.28$ ]. In summary, there was no sign of avoidance of the US+ until the final trial of acquisition, and to our surprise, the first two trials revealed an opposite effect in which participants looked *more* at the US+.

**Oculomotor CRs.** There was a significant main effect of CS on dwell time,  $F(1, 72) = 4.76$ ,  $p = .032$ ,  $\eta^2_p = .06$ , such that overall, participants spent less time looking at the CS+ compared to the CS-. This main effect was qualified by a CS by block interaction,  $F(1, 72) = 10.78$ ,  $p = .002$ ,  $\eta^2_p = .13$ . Dwell time on the CS+ decreased from block 1 to block 2,  $t(72) = 3.64$ ,  $p = .001$ ,  $d_z = .43$ , and dwell time on the CS- increased from block 1 to block 2,  $t(72) = -2.78$ ,  $p < .008$ ,  $d_z = -.32$ . In block 1, there was not a significant difference in dwell time on the CSs,  $t(72) = -.45$ ,  $p = .655$ ,  $d_z = -.05$ , but in block 2, participants avoided looking at the CS+ compared to the CS-,  $t(75) = -2.94$ ,  $p = .005$ ,  $d_z = -.34$ . Thus, the predicted CR was only observed in the second block of acquisition.

### **Extinction.**

**Self-report CRs.** Participants reported expecting the US more when viewing the CS+ compared to the CS- during extinction, as revealed by a main effect of CS,  $F(1, 75) = 95.11$ ,

$p < .001$ ,  $\eta^2_p = .56$ . The main effect of CS was qualified by a CS by block interaction,  $F(1, 75) = 12.30$ ,  $p = .001$ ,  $\eta^2_p = .14$ . Although participants showed greater US expectancy to the CS+ versus the CS- following both block 1,  $t(75) = 10.12$ ,  $p < .001$ ,  $d_z = 1.16$ , and block 2,  $t(75) = 7.31$ ,  $p < .001$ ,  $d_z = .84$ , their US expectancy for the CS+ decreased from block 1 to block 2,  $t(75) = -4.77$ ,  $p < .001$ ,  $d_z = -.55$ , whereas US expectancy did not change significantly for the CS-,  $t(75) = 1.00$ ,  $p = .324$ ,  $d_z = .11$ . As predicted, participants also reported experiencing more disgust in response to the CS+ compared to the CS- at the end of the extinction stage,  $t(75) = 5.25$ ,  $p < .001$ ,  $d_z = .60$ .

**Extinction test.** From acquisition to extinction, there was a significant decrease in discriminant responding in terms of both self-reported US expectancy,  $F(1, 75) = 39.50$ ,  $p < .001$ ,  $\eta^2_p = .35$ , and disgust,  $F(1, 75) = 21.35$ ,  $p < .001$ ,  $\eta^2_p = .22$ . Thus, while extinction was not complete for either CR, as reflected by discriminant responding after extinction, both aspects of disgust conditioning were *sensitive* to extinction, as reflected in the substantial reduction in CRs from acquisition to extinction.

**Oculomotor CRs.** There was not a significant main effect of CS on dwell time,  $F(1, 70) = .55$ ,  $p = .462$ ,  $\eta^2_p = .008$ , nor was there a block by CS interaction,  $F(1, 70) = .19$ ,  $p = .669$ ,  $\eta^2_p = .00$ .

**Extinction test.** Overall, from acquisition to extinction, there was not a significant decrease in oculomotor avoidance of the CS+,  $F(1, 75) = 1.09$ ,  $p = .301$ ,  $\eta^2_p = .01$ . However, the CR of oculomotor avoidance did not emerge until the second block of acquisition. An exploratory test of the change in discriminant responding from the second block of acquisition to extinction indicated that oculomotor avoidance of the CR was reduced,  $F(1, 75) = 5.59$ ,  $p = .021$ ,  $\eta^2_p = .07$ .



## Discussion

The current experiment assessed a new paradigm for studying conditioned disgust responding as revealed by oculomotor avoidance. To our surprise, the oculomotor UR to the disgusting USs changed dramatically during the two blocks of acquisition. Viewing of the disgusting US decreased markedly, while viewing of the neutral US increased. Indeed, for the first two trials of acquisition, participants looked *more* at the disgusting US than the neutral US. The predicted oculomotor avoidance CR occurred, but it did not emerge until the second block of acquisition, after the period of increased viewing of the disgusting US had subsided. Contrary to prior findings (Armstrong et al., 2014; Mason & Richardson, 2010), the oculomotor disgust CR was sensitive to extinction, as were self-reported disgust CRs.

Increased initial viewing of the disgusting US may reflect what is colloquially referred to as “rubbernecking”; that is, the tendency to stare at certain negatively-valenced stimuli out of fascination (i.e., “morbid curiosity”; Oosterwijk, Lindquist, Adebayo, & Barrett, 2015; Turner & Silvia, 2006; Zuckerman & Litle, 2006). Turner and Silvia argue that such rubbernecking is motivated by the emotion of interest, which is elicited by novel stimuli that hold the potential for expanding our understanding of the world. In line with this account, Kron and colleagues (2014) observed that on *initial* viewing, novel affective images of both positive and negative valence elicited more viewing compared to neutral scenes; the “hedonic principle” of viewing, in which positive images draw gaze and negative images repel gaze, emerged only on repeat viewing, when the images were less novel.

Thus, the present findings for the acquisition stage may be understood in terms of competing motivations. Disgusting stimuli are uniquely repellant to the senses (Darwin,

1872/1965; Royzman & Sabini, 2001), and thereby motivate reduced perceptual contact. However, this motivation initially competes with an impulse to examine the stimuli out of interest. As the novelty attenuates on successive viewings, interest declines, and disgust predominates. As a result, rubbernecking gives way to oculomotor avoidance of the disgusting US. Interestingly, rubbernecking as a UR in the current paradigm was not preceded by a rubbernecking CR. However, the rubbernecking UR does seem to inhibit the oculomotor avoidance CR, which did not emerge until the second block of acquisition, after the rubbernecking was completed. The oculomotor avoidance CR also seems to precede the oculomotor avoidance UR, as the CR was observed in the second block of trials, but the UR was not (and could only be seen in the last trial of acquisition in an exploratory analysis). Perhaps the motivation to avoid perceptual contact with the disgusting US predominates during the anticipatory CS period, and then must compete with the motivation to learn more about the US during the actual US presentation.

If this motivational conflict account is correct, it may be possible to “fast-forward” the acquisition of oculomotor avoidance by exhausting interest in the disgusting US prior to conditioning. Repeatedly presenting the US prior to conditioning typically leads to reduced CRs; indeed, US pre-exposure is a well-established form of US *deflation* (Bouton, 2007; Mason & Richardson, 2012). However, due to the dynamic UR in the case of oculomotor disgust conditioning, we would predict that US pre-exposure would have a paradoxical effect, leading to an enhanced rather than an attenuated CR.

## **Experiment 2**

The first experiment sought to establish a new paradigm for objectively studying disgust conditioning through the CR of oculomotor avoidance. The paradigm succeeded in

generating this CR; however, it was delayed until the second block of acquisition, seemingly by the rubbernecking phenomenon that occurred as a UR in the first block of acquisition. To improve the association learning task and to test our theory regarding the motivational conflict during the first block of acquisition trials, we replicated Experiment 1 with a block of US pre-exposure trials added prior to association learning. We expected that this procedure would exhaust the rubbernecking phenomenon prior to acquisition, thereby fast-forwarding the acquisition of oculomotor avoidance as a CR. Critically, we predicted that with US pre-exposure, the oculomotor avoidance CR would be observed in both the first and second blocks of acquisitions, rather than only the second block as in Experiment 1.

## Method

**Participants.** Eighty-one students at a private liberal arts college completed the study in exchange for course credit or \$10. Four participants were excluded due to difficulty tracking their eyes, resulting in a final sample size of 77 (age:  $M = 19.87$ ,  $SD = 1.32$ ; 24 male, 52 female; 67.5% White, 15.6 % Asian, 3.9% Latina/o, 1.3% Black, 10.4% Other).

**Measures, apparatus, procedure.** The remaining methodological details directly replicated Experiment 1 with one exception. Following the CS habituation stage (and prior to the acquisition stage), participants underwent a US pre-exposure stage, which involved one block of 8 trials. The US pre-exposure stage was identical to the CS habituation stage, only it involved the US stimuli rather than the CS stimuli, and there were no self-report ratings afterwards.

## Results

**US validation.** Participants rated the two US+ images ( $M = 59.11$ ,  $SD = 20.91$ ) as more disgusting than the two US- images ( $M = 1.99$ ,  $SD = 6.02$ ),  $t(76) = 23.80$ ,  $p < .001$ ,  $d_z = 2.71$ .

### Habituation.

**Self-report CRs.** As predicted, there were not significant differences between CSs in self-reported US expectancy at the end of the habituation stage,  $t(76) = .12$ ,  $p = .91$ ,  $d_z = -.01$  or disgust,  $t(76) = 1.67$ ,  $p = .096$ ,  $d_z = -.19$ . Table 2 reports  $M$ s and  $SD$ s for oculomotor CRs at each stage of the task, and Figure 1 depicts these results.

**Oculomotor CRs.** As predicted, there was not a significant difference in dwell time on the CSs in the single block of trials in the habituation stage,  $t(71) = 1.58$ ,  $p = .120$ ,  $d_z = .19$ . Table 2 reports  $M$ s,  $SD$ s, and Cronbach's  $\alpha$  for oculomotor CRs at each stage of the task, and Figure 2 depicts these results.

### US Pre-exposure.

**Oculomotor URs.** There was not a significant difference in overall dwell time on the US+ ( $M = 2331$ ,  $SD = 1038$ ;  $\alpha = .90$ ) versus the US- ( $M = 2334$ ,  $SD = 1127$ ;  $\alpha = .90$ ) in the single block of trials in the US pre-exposure stage,  $t(73) = -.01$ ,  $p = .991$ ,  $d_z = .00$ . An exploratory analysis (uncorrected for multiple comparisons) at the trial level revealed increased dwell time on the US+ versus the US- on the first trial, as in Experiment 1,  $t(73) = 2.29$ ,  $p = .025$ ,  $d_z = .27$ . In contrast to Experiment 1, this effect was not present on the second trial,  $t(74) = 1.23$ ,  $p = .225$ ,  $d_z = .14$ , and the difference in dwell time on the USs remained non-significant ( $ps > 2.51$ ) until the last trial of pre-exposure, in which oculomotor avoidance of the US+ was observed,  $t(74) = -2.68$ ,  $p = .009$ ,  $d_z = -.33$ .

### Acquisition.

**Self-report CRs.** As predicted, participants reported expecting the US more when viewing the CS+ compared to the CS-, as revealed by a main effect of CS,  $F(1, 76) = 222.0, p < .001, \eta^2_p = .75$ . As in Experiment 1, this main effect was qualified by a CS by block interaction,  $F(1, 75) = 13.84, p < .001, \eta^2_p = .15$ , such that while participants showed greater US expectancy to the CS+ versus the CS- by large margins following both block 1,  $t(76) = 11.41, p < .001, d_z = 1.30$ , and block 2,  $t(76) = 15.57, p < .001, d_z = 1.77$ , their US expectancy for the CS+ increased from block 1 to block 2,  $t(76) = 2.97, p = .004, d_z = .33$ , whereas US expectancy decreased for the CS-,  $t(75) = -2.90, p = .005, d_z = -.34$ . As predicted, participants also reported experiencing more disgust in response to the CS+ compared to the CS- at the end of the acquisition stage,  $t(76) = 8.26, p < .001, d_z = .94$ .

**Oculomotor URs.** There was a main effect of US on dwell time,  $F(1, 75) = 4.95, p = .029, \eta^2_p = .06$ . There was also a significant US by trial interaction,  $F(1, 75) = 9.64, p = .003, \eta^2_p = .11$ . There was a significant decrease in dwell time on the US+ from block 1 ( $M = 2150, SD = 1265; \alpha = .90$ ) to block 2 ( $M = 1843, SD = 1354; \alpha = .93$ ),  $t(75) = -3.54, p < .001, d_z = -.41$ , and a significant increase in dwell time on the US- from block 1 ( $M = 2565, SD = 1455; \alpha = .92$ ) to block 2 ( $M = 2792, SD = 1567; \alpha = .93$ ),  $t(75) = 2.51, p = .014, d_z = -.37$ . In block 1, there was not a significant difference in dwell time on the USs,  $t(76) = -1.32, p = .190, d_z = -.15$ ; however, in block 2, there was oculomotor avoidance of the US+ compared to US-,  $t(75) = -2.87, p = .005, d_z = -.33$ . This contrasts with Experiment 1, in which oculomotor avoidance was not observed as the dominant UR for either block 1 or block 2.

**Oculomotor CRs.** There was a significant main effect of CS on dwell time,  $F(1, 67) = 13.40, p < .001, \eta^2_p = .17$ , such that overall, participants spent less time looking at the CS+ compared to the CS-. In contrast to Experiment 1, the main effect of CS was not qualified by a CS by block interaction,  $F(1, 67) = .003, p = .955, \eta^2_p = .00$ , and instead was consistent across blocks.

### **Extinction.**

**Self-report CRs.** Participants reported expecting the US more when viewing the CS+ compared to the CS- during extinction, as revealed by a main effect of CS,  $F(1, 76) = 123.77, p < .001, \eta^2_p = .62$ . The main effect of CS was qualified by a CS by block interaction,  $F(1, 76) = 8.80, p = .004, \eta^2_p = .10$ . Although participants showed greater US expectancy to the CS+ versus the CS- by following both block 1,  $t(76) = 10.81, p < .001, d_z = 1.23$ , and block 2,  $t(76) = 9.63, p < .001, d_z = 1.10$ , their US expectancy for the CS+ decreased from block 1 to block 2,  $t(75) = -4.50, p < .001, d_z = -.51$ . In contrast to Experiment 1, there was also a small but significant reduction in US expectancy for the CS-,  $t(76) = -2.23, p = .029, d_z = .25$ . As predicted, participants also reported experiencing more disgust in response to the CS+ compared to the CS- at the end of the acquisition stage,  $t(76) = 5.31, p < .001, d_z = .61$ .

**Extinction test.** From acquisition to extinction, there was a significant decrease in discriminant responding in terms of both self-reported US expectancy,  $F(1, 76) = 41.84, p < .001, \eta^2_p = .36$ , and disgust,  $F(1, 75) = 10.24, p = .002, \eta^2_p = .12$ . Thus, while extinction was not complete for either CR, as reflected by discriminant responding after extinction, both aspects of disgust conditioning were *sensitive* to extinction, as reflected in the substantial reduction in CRs from acquisition to extinction.

**Oculomotor CRs.** There was not a significant main effect of CS on dwell time,  $F(1, 66) = 2.80, p = .099, \eta^2_p = .04$ , nor was there a significant block by CS interaction,  $F(1, 66) = 2.88, p = .095, \eta^2_p = .04$ .

**Extinction test.** From acquisition to extinction, there was a significant decrease in oculomotor avoidance of the CS+ compared to the CS-,  $F(1, 71) = 6.70, p = .012, \eta^2_p = .09$ .

## Discussion

As predicted, US pre-exposure had the paradoxical effect of enhancing acquisition of oculomotor avoidance in Experiment 2. The US pre-exposure appeared to exhaust the rubbernecking tendency, such that the predicted oculomotor avoidance disgust UR could be observed in the second block of acquisition, where it was absent in Experiment 1. By depleting the rubbernecking phenomenon, the US pre-exposure effectively fast-forwarded the acquisition of the oculomotor avoidance disgust CR; in Experiment 1, the CR was not observed until the second block of acquisition, whereas in the present experiment, the CR appeared in the first block of acquisition and was consistent across blocks. Although US pre-exposure led to enhanced acquisition of the oculomotor disgust CR, this CR still underwent extinction, consistent with Experiment 1. Thus, our findings again did not support previous reports suggesting that oculomotor avoidance is insensitive to extinction (Armstrong et al., 2014; Mason & Richardson, 2010).

## General Discussion

The present study advances research on the acquisition of disgust by establishing a novel paradigm that harnesses oculomotor avoidance as an objective disgust indicator (Armstrong et al., 2014). In line with past research, we found that disgusting stimuli elicit oculomotor avoidance, and that such avoidance can be learned in response to associated

neutral stimuli. However, we also found that oculomotor avoidance is not the immediate response to a novel disgusting stimulus. Consistent with the findings of Kron and colleagues (2014), we found increased viewing of the disgusting US on initial exposure, and this rubbernecking tendency appeared to suppress oculomotor avoidance for several trials as it gradually diminished. In Experiment 2, we successfully attenuated rubbernecking through US pre-exposure, which expedited the emergence of oculomotor avoidance as a disgust UR, and in turn, as a disgust CR. Neither experiment found evidence that disgust conditioning as revealed by oculomotor avoidance is resistant to extinction, even after improving the acquisition procedure through US pre-exposure in Experiment 2.

The finding that disgusting stimuli elicit competing approach and avoidance tendencies is consistent with a small body of research on the phenomenon of morbid curiosity (Oosterwijk, Lindquist, Adebayo, & Barrett, 2015; Turner & Sylvia, 2006; Zuckerman & Litle, 2006). Turner and Sylvia (2006) found that participants rated disgusting paintings (e.g., Francisco Goya's *Saturn Devouring His Son*) as unpleasant, yet highly interesting. In Sylvia's (2008) appraisal model, interest is elicited by novel stimuli that present the potential for expanding understanding. In a similar vein, Loewenstein (1994) defines curiosity as a state of deprivation, an "information gap" between what one knows and what one wants to know. There are multiple barriers to perceiving and contemplating disgusting stimuli that could lead to this state of informational deprivation. First, disgusting stimuli are often the subject of cultural taboos (Rozin & Fallon, 1987). Second, disgusting stimuli can potentially transmit diseases through contact (Tybur et al., 2013), prompting behavioral avoidance that prevents developing familiarity. Usually, the desire to avoid contact with disgusting stimuli overcomes our curiosity, but in certain



scenarios in which the threat of contact is reduced (e.g., driving by roadkill in a car, viewing a ghastly scene in a painting), we may briefly indulge our curiosity until our appetite for information is sated (or until the novelty of the stimulus wears off). This account of competing motivations is consistent with the cost-benefit analysis posited in Tybur and colleagues (2013) computational description of the disgust mechanism, and it closely fits the observed data in both Experiments of the present study, which suggest a transition from rubbernecking to oculomotor avoidance as disgusting stimuli become less novel.

In addition to its theoretical implications, the motivational conflict presented by disgusting stimuli has practical implications for research. Oculomotor avoidance is a promising objective disgust indicator, but it may elude measurement if there are not repeated exposures to a disgusting stimulus. Indeed, the rubbernecking phenomenon observed in this study may explain past failures to replicate Mason and Richardson's (2010) original finding of oculomotor avoidance as a disgust CR. For example, Armstrong and colleagues (2014) did not observe oculomotor avoidance as a CR after an initial acquisition procedure, but then observed the phenomenon after a later extinction procedure that was preceded by a block of re-acquisition trials. It is possible that oculomotor avoidance did not overtake rubbernecking towards the disgusting US until the re-acquisition block, explaining why the CR of oculomotor avoidance was observed after extinction, but not after initial acquisition. In another study, Armstrong (2014) failed to observe oculomotor avoidance as a CR following either acquisition or extinction, but this study employed 12 different disgust USs that were each presented only once. Ironically, this effort to prevent habituation of the oculomotor avoidance UR may have instead prevented habituation of the competing rubbernecking UR, thereby suppressing the

oculomotor avoidance UR and in turn the CR. Finally, Mason and Richardson were able to replicate their finding of oculomotor avoidance as a disgust CR in an unpublished study (see Mason & Richardson, 2012), but the effect was not as robust, perhaps because they employed fewer acquisition trials, and hence, there were fewer repeat exposures of the disgusting US prior to assessing the oculomotor avoidance CR. By employing US pre-exposure, future studies on oculomotor avoidance as a disgust CR should be able to observe the phenomenon with greater consistency. To our knowledge, this is the only instance in which pre-exposure to an unpleasant US *enhances* a defensive CR acquired in later conditioning.

Although both experiments in this study replicated prior findings of oculomotor avoidance as a disgust CR, neither experiment replicated prior findings that disgust CRs are resistant to extinction (Armstrong et al., 2014; Engelhard et al., 2014; Mason & Richardson, 2010; Olatunji et al., 2007). Disgust conditioning may undergo extinction more readily than previously believed. Alternatively, it is possible that our novel association learning task yields a form of disgust conditioning that is more susceptible to extinction. In the present task, the CS+ and CS- are distinguished by their spatial relation to the US+, whereas in all prior disgust conditioning tasks, the CS+ and CS- were distinguished by their temporal relation to the US+. These different types of contingency could lead to different levels of *expectancy* versus *evaluative* learning, the two forms of learning that underlie Pavlovian conditioning. In expectancy learning, the organism learns to prepare for an encounter with the US, whereas in evaluative learning, the organism learns an attitude or preference towards the CS in an apparent transfer of affective properties from the US to the CS.

Of these two processes, evaluative learning appears to be more resistant to extinction (De Houwer, Thomas, & Baeyens, 2001; c.f. Hofmann, De Houwer, Perugini, Baeyens, & Crombez, 2010).

In the present task, participants may have avoided looking at the CS+ because it acquired the negative affective property of the US+ and elicited aversion (evaluative learning). Alternatively, participants may have avoided looking at the CS+ because they expected it would morph into the US+ (expectancy learning), and they wanted to avoid looking at the US+. Indeed, the spatial contingency between the CS and US in the present study introduced an element of avoidance learning, in that how participants responded to the CSs had implications for their encounter with the US+. <sup>3</sup> This element of the task may have prioritized expectancy learning over evaluative learning. However, the self-report data suggest that our task produced both evaluative and expectancy learning, in light of the acquisition of increased self-reported disgust and US expectancy for the CS+. Future research employing US pre-exposure with a temporal-contingency-based disgust conditioning paradigm would help resolve these discrepant findings regarding disgust extinction.

The present findings should be interpreted with multiple limitations in mind. First, there were only two disgusting stimuli presented as USs. Given the novelty of the rubbernecking finding in the present study, future research is needed to determine if this

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<sup>3</sup> From one perspective, the element of avoidance learning in the present task would suggest that the CR of oculomotor avoidance would be *more* resistant to extinction. Conditioned avoidance learning has been found to be highly resistant to extinction because the non-occurrence of the US is attributed to the avoidance behavior, preventing learning of the new CS-US contingency during extinction trials (see Kryptos, Effting, Kindt, & Beckers, 2015). However, the present task differs critically in that avoiding the CS+ only limits exposure to the US+ (which occurs in the same spatial location as the CS+); it does not cause omission of the USs. Hence, even participants who entirely avoided viewing the US+ during acquisition could still note the presence of USs during acquisition and the absence of USs during extinction.

finding generalizes to all disgusting stimuli or only disgusting stimuli of certain domains or intensities. Another limitation of the present study is that self-report ratings of the CSs were given retrospectively at the end of each block or stage. Collecting these ratings after each trial (e.g., Mason & Richardson, 2010) would provide more insight into the dynamics of disgust acquisition observed in the present study. Our study would also have benefitted from trial-by-trial disgust ratings of the USs, which would add insight into the observed rubbernecking phenomenon. It could also be fruitful to collect trial-by-trial interest ratings of the disgusting US to confirm our competing motivations account of rubbernecking. Despite these limitations, the present study has established a new paradigm for studying the acquisition of disgust with an objective eye movement indicator. In addition, this study has shed new light on the understudied phenomenon of morbid curiosity and has revealed a rubbernecking phenomenon with important practical implications for research on oculomotor avoidance of disgusting stimuli.

## References

- Angyal, A. (1941). Disgust and related aversions. *The Journal of Abnormal and Social Psychology*, 36(3), 393.
- Armstrong, T. (2014). *Normative and pathological effects of aversive learning on spatial attention*. (Unpublished doctoral dissertation). Vanderbilt University, Nashville, TN.
- Armstrong, T., McClenahan, L., Kittle, J., & Olatunji, B. O. (2014). Don't look now! Oculomotor avoidance as a conditioned disgust response. *Emotion*, 14(1), 95.
- Armstrong, T., & Olatunji, B. O. (2012). Eye tracking of attention in the affective disorders: A meta-analytic review and synthesis. *Clinical Psychology Review*, 32, 704–723.
- Armstrong, T., & Olatunji, B. O. (2017). Pavlovian disgust conditioning as a model for contamination-based OCD: Evidence from an analogue study. *Behaviour Research and Therapy*, 93, 78-87.
- Armstrong, T., Sarawgi, S., & Olatunji, B. O. (2012). Attentional bias toward threat in contamination fear: Overt components and behavioral correlates. *Journal of Abnormal Psychology*, 121(1), 232.
- Badour, C. L., Feldner, M. T., Blumenthal, H., & Knapp, A. (2013). Preliminary evidence for a unique role of disgust-based conditioning in posttraumatic stress. *Journal of Traumatic Stress*, 26(2), 280-287.
- Boddez, Y., Baeyens, F., Luyten, L., Vansteenwegen, D., Hermans, D., & Beckers, T. (2013). Rating data are underrated: Validity of US expectancy in human fear conditioning. *Journal of Behavior Therapy and Experimental Psychiatry*, 44, 201-206.

- Borg, C., Bosman, R. C., Engelhard, I., Olatunji, B. O., & de Jong, P. J. (2016). Is disgust sensitive to classical conditioning as indexed by facial electromyography and behavioural responses?. *Cognition and Emotion*, 30(4), 669-686.
- Bosman, R. C., Borg, C., & de Jong, P. J. (2016). Optimising extinction of conditioned disgust. *PloS one*, 11(2), e0148626.
- Bouton, M. E. (2007). *Learning and behavior: A contemporary synthesis*. Sunderland, MA: Sinauer Associates.
- Bradley, M. M., Costa, V. D., & Lang, P. J. (2015). Selective looking at natural scenes: Hedonic content and gender. *International Journal of Psychophysiology*, 98(1), 54-58.
- Darwin, C. (1965). *The expression of the emotions in man and animals*. Chicago, IL: University of Chicago Press. (Original work published 1872).
- Davey, G. C. (2011). Disgust: the disease-avoidance emotion and its dysfunctions. *Philosophical Transactions of the Royal Society B: Biological Sciences*, 366(1583), 3453-3465.
- David, B., & Olatunji, B. O. (2011). The effect of disgust conditioning and disgust sensitivity on appraisals of moral transgressions. *Personality and Individual Differences*, 50(7), 1142-1146.
- De Houwer, J., Thomas, S., & Baeyens, F. (2001). Association learning of likes and dislikes: A review of 25 years of research on human evaluative conditioning. *Psychological Bulletin*, 127(6), 853.
- Duits, P., Cath, D. C., Lissek, S., Hox, J. J., Hamm, A. O., & Engelhard, I. M. (2015). Updated meta-analysis of classical fear conditioning in the anxiety disorders. *Depression and Anxiety*, 32, 239-253.

- Engelhard, I. M., Leer, A., Lange, E., & Olatunji, B. O. (2014). Shaking that icky feeling: Effects of extinction and counterconditioning on disgust-related evaluative conditioning. *Behavior Therapy, 45*, 708–719.
- Hess, U., Arslan, R., Mauersberger, H., Blaison, C., Dufner, M., Denissen, J. J., & Ziegler, M. (2017). Reliability of surface facial electromyography. *Psychophysiology, 54*(1), 12–23.
- Hildebrandt, T., Grotzinger, A., Reddan, M., Greif, R., Levy, I., Goodman, W., & Schiller, D. (2015). Testing the disgust conditioning theory of food-avoidance in adolescents with recent onset anorexia nervosa. *Behaviour Research and Therapy, 71*, 131–138.
- Hofmann, W., De Houwer, J., Perugini, M., Baeyens, F., & Crombez, G. (2010). Evaluative conditioning in humans: a meta-analysis. *Psychological Bulletin, 136*(3), 390.
- Inbar, Y., Pizarro, D. A., Knobe, J., & Bloom, P. (2009). Disgust sensitivity predicts intuitive disapproval of gays. *Emotion, 9*(3), 435.
- Kelly, M. M., & Forsyth, J. P. (2007). Observational fear conditioning in the acquisition and extinction of attentional bias for threat: An experimental evaluation. *Emotion, 7*, 324–335.
- Kron, A., Pilkiw, M., Goldstein, A., Lee, D. H., Gardhouse, K., & Anderson, A. K. (2014). Spending one's time: The hedonic principle in ad libitum viewing of pictures. *Emotion, 14*(6), 1087.
- Krypotos, A. M., Effting, M., Kindt, M., & Beckers, T. (2015). Avoidance learning: a review of theoretical models and recent developments. *Frontiers in Behavioral Neuroscience, 9*, 189.

- Lang, P.J., Bradley, M.M., & Cuthbert, B.N. (2008). *International affective picture system (IAPS): Affective ratings of pictures and instruction manual*. Technical Report A-8. University of Florida, Gainesville, FL.
- Lazarus, R. S. (1982). Thoughts on the relations between emotion and cognition. *American Psychologist*, 37(9), 1019.
- Lishner, D. A., Cooter, A. B., & Zald, D. H. (2008). Addressing measurement limitations in affective rating scales: Development of an empirical valence scale. *Cognition and Emotion*, 22, 180-192.
- Lissek, S., Biggs, A. L., Rabin, S. J., Cornwell, B. R., Alvarez, R. P., Pine, D. S., & Grillon, C. (2008). Generalization of conditioned fear potentiated startle in humans: Experimental validation and clinical relevance. *Behaviour Research and Therapy*, 46, 678–687.
- Loewenstein, G. (1994). The psychology of curiosity: A review and reinterpretation. *Psychological Bulletin*, 116(1), 75.
- Lundqvist, D., Flykt, A., & Öhman, A. (1998). The Karolinska directed emotional faces (KDEF). *CD ROM from Department of Clinical Neuroscience, Psychology section, Karolinska Institutet*, (1998).
- Malson, L. (1972) *Wolf children*. Monthly Review Press, New York, NY. Originally Les Enfants Sauvages. (Original work published 1964).
- Mason, E. C. & Richardson, R. (2010). Looking beyond fear: The extinction of other emotions implicated in anxiety disorders. *Journal of Anxiety Disorders*, 24, 63-70.
- Mason, E. C., & Richardson, R. (2012). Treating disgust in anxiety disorders. *Clinical Psychology: Science and Practice*, 19, 180–194.



- Nosek, B. A. (2007). Implicit–explicit relations. *Current Directions in Psychological Science*, 16(2), 65-69.
- Nussbaum, M. C. (2001). *Upheavals of thought: The intelligence of emotions*. New York: Cambridge University Press.
- Oaten, M., Stevenson, R. J., & Case, T. I. (2009). Disgust as a disease- avoidance mechanism. *Psychological Bulletin*, 135, 303–321.
- Öhman, A., & Dimberg, U. (1978). Facial expressions as conditioned stimuli for electrodermal responses: A case of "preparedness"? *Journal of Personality and Social Psychology*, 36(11), 1251.
- Olatunji, B. O., Forsyth, J. P., & Cherian, A. (2007). Evaluative conditioning of disgust: sticky form of relational learning that is resistant to extinction. *Journal of Anxiety Disorders*, 21, 820-834.
- Olatunji, B. O., Lohr, J. M., Smits, J. A., Sawchuk, C. N., & Patten, K. (2009). Evaluative conditioning of fear and disgust in blood-injection-injury phobia: Specificity and impact of individual differences in disgust sensitivity. *Journal of Anxiety Disorders*, 23(2), 153-159.
- Olatunji, B. O., Tomarken, A., & Puncochar, B. D. (2013). Disgust propensity potentiates evaluative learning of aversion. *Emotion*, 13, 881.
- Oosterwijk, S., Lindquist, K. A., Adebayo, M., & Barrett, L. F. (2015). The neural representation of typical and atypical experiences of negative images: Comparing fear, disgust and morbid fascination. *Social Cognitive and Affective Neuroscience*, 11(1), 11-22.

- Rodebaugh, T. L., Scullin, R. B., Langer, J. K., Dixon, D. J., Huppert, J. D., Bernstein, A., ... & Lenze, E. J. (2016). Unreliability as a threat to understanding psychopathology: The cautionary tale of attentional bias. *Journal of Abnormal Psychology, 125*(6), 840.
- Royzman, E. B., & Sabini, J. (2001). Something it takes to be an emotion: The interesting case of disgust. *Journal for the Theory of Social Behaviour, 31*(1), 29-59.
- Rozin, P., Millman, L., & Nemeroff, C. (1986). Operation of the laws of sympathetic magic in disgust and other domains. *Journal of Personality and Social Psychology, 50*(4), 703.
- Rozin, P., & Fallon, A. E. (1987). A perspective on disgust. *Psychological Review, 94*, 23-41.
- Schaller, M., & Park, J. H. (2011). The behavioral immune system (and why it matters). *Current Directions in Psychological Science, 20*(2), 99-103.
- Schienle, A., Stark, R., & Vaitl, D. (2001). Evaluative conditioning: A possible explanation for the acquisition of disgust responses? *Learning and Motivation, 32*(1), 65-83.
- Silvia, P. J. (2006). *Exploring the psychology of interest*. Oxford University Press.
- Stevenson, R. J., Oaten, M. J., Case, T. I., Repacholi, B. M., & Wagland, P. (2010). Children's response to adult disgust elicitors: Development and acquisition. *Developmental Psychology, 46*(1), 165.
- Turner, S. A., & Silvia, P. J. (2006). Must interesting things be pleasant? A test of competing appraisal structures. *Emotion, 6*(4), 670.
- Tybur, J. M., Lieberman, D., Kurzban, R., & DeScioli, P. (2013). Disgust: Evolved function and structure. *Psychological Review, 120*, 65.
- Vartanian, L. R., Trewartha, T., Beames, J. R., Azevedo, S. M., & Vanman, E. J. (2017). Physiological and self-reported disgust reactions to obesity. *Cognition and Emotion, 1-14*.

- Vrana, S. R. (1994). Startle reflex response during sensory modality specific disgust, anger and neutral imagery. *Journal of Psychophysiology*, 8, 211-211.
- Waechter, S., Nelson, A. L., Wright, C., Hyatt, A., & Oakman, J. (2014). Measuring attentional bias to threat: Reliability of dot probe and eye movement indices. *Cognitive Therapy and Research*, 38(3), 313-333.
- Waters, A. M., Theresiana, C., Neumann, D. L., & Craske, M. G. (2017). Developmental differences in aversive conditioning, extinction, and reinstatement: A study with children, adolescents, and adults. *Journal of Experimental Child Psychology*, 159, 263-278.
- Zuckerman, M., & Litle, P. (1986). Personality and curiosity about morbid and sexual events. *Personality and Individual Differences*, 7(1), 49-56.

Table 1. Means (*SDs*) for conditioned responding in Experiment 2

	Habituation		Acquisition				Extinction			
			<i>Block 1</i>		<i>Block 2</i>		<i>Block 1</i>		<i>Block 2</i>	
	CS+	CS-	CS+	CS-	CS+	CS-	CS+	CS-	CS+	CS-
<i>Oculomotor CRs</i>										
Dwell Time (ms)	2424.25 (374)	2339.08 (353.2)	2307.7 (528.64)	2360.08 (544.91)	2086.7 (693.15)	2527.22 (684.69)	2283.39 (682.4)	2373.28 (614.48)	2302.23 (584.93)	2419.39 (536.62)
Reliability ( $\alpha$ )	.33	.38	.67	.65	.74	.68	.80	.73	.65	.63
<i>Self-report CRs</i>										
US Expectancy	23.13 (23.11)	22.69 (20.3)	67.0 (26.21)	21.44 (22.01)	76.74 (27.04)	13.37 (20.39)	48.86 (26.28)	13.41 (17.02)	36.36 (26.97)	11.63 (17.54)
Disgust	17.09 (17.82)	16.66 (17.2)	--	--	33.54 (26.25)	10.58 (12.28)	--	--	23.18 (22.34)	10.38 (14.48)

*Note:* CS+ = conditioned stimulus paired with disgusting image; CS- = conditioned stimulus paired with neutral image; CR = conditioned response;

Table 2. Means (*SDs*) for conditioned responding in Experiment 2

	Habituation		Acquisition				Extinction			
	CS+	CS-	Block 1		Block 2		Block 1		Block 2	
			CS+	CS-	CS+	CS-	CS+	CS-	CS+	CS-
<i>Oculomotor CRs</i>										
Dwell Time (ms)	2468 (344)	2352 (339)	2136 (759)	2749 (761)	2084 (932)	2812 (1023)	2370 (743)	2513 (758)	2245 (664)	2616 (738)
Reliability ( $\alpha$ )	.38	.22	.76	.81	.82	.82	.75	.78	.70	.79
<i>Self-report CRs</i>										
US Expectancy	24.64 (25.22)	24.94 (23.56)	71.45 (26.33)	19.54 (22.01)	78.37 (24.61)	12.2 (17.65)	50.51 (27.98)	12.46 (17.93)	39.48 (27.22)	9.19 (17.35)
Disgust	12.69 (16.53)	15.89 (18.13)	--	--	33.49 (26.26)	11.31 (16.35)	--	--	25.34 (25.42)	11.26 (18.34)

*Note:* CS+ = conditioned stimulus paired with disgusting image; CS- = conditioned stimulus paired with neutral image; CR = conditioned response.

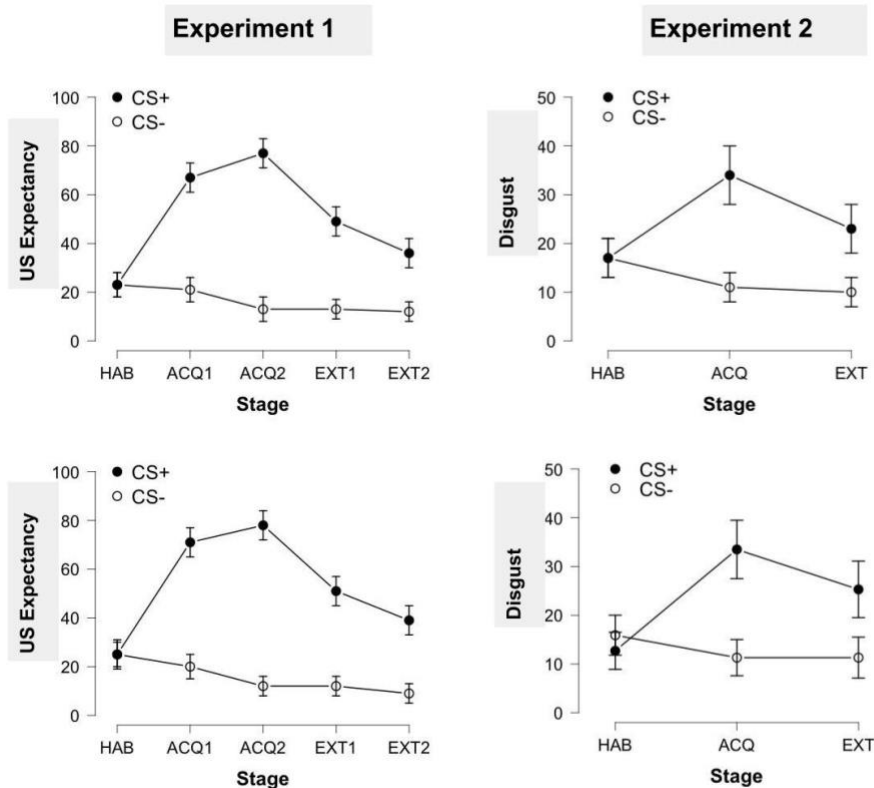


Figure 1. Self-report conditioned responses. CS+ = conditioned stimulus paired with disgusting image; CS- = conditioned stimulus paired with neutral image; HAB = habituation; ACQ = acquisition; EXT = extinction. Error bars represent 95% confidence interval.

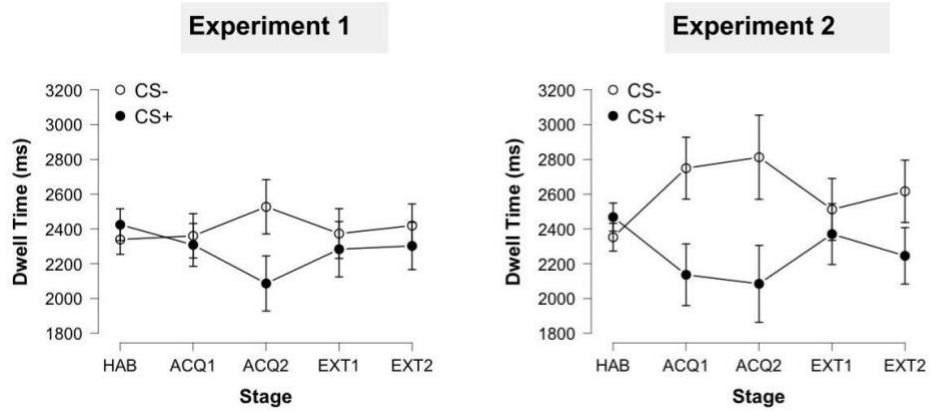


Figure 1. Oculomotor conditioned responses. CS+ = conditioned stimulus paired with disgusting image; CS- = conditioned stimulus paired with neutral image; HAB = habituation; ACQ = acquisition; EXT = extinction. Error bars represent 95% confidence interval.