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The effects of cognitive reappraisal on conditioned disgust in contamination-based OCD: An analogue study

Bunmi O. Olatunji*, Hannah Berg, Rebecca C. Cox, Amber Billingsley

Vanderbilt University, United States

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ABSTRACT

Experimental research has shown that conditioned disgust is resistant to extinction, which may account for the slower habituation to disgust relative to fear in contamination-based obsessive-compulsive disorder (OCD). However, few studies have examined the efficacy of interventions that may attenuate conditioned disgust responses. Studies of cognitive reappraisal have demonstrated that reinterpreting a stimulus can alter emotional responding. This technique is based on cognitive theories which suggest that anxiety disorders arise from biased cognitions; therefore, changing a person's thoughts will elicit durable changes in emotional responses. Given the demonstrated effectiveness of cognitive reappraisal, the present study examined whether cognitive reappraisal would attenuate conditioned disgust responses. We conditioned participants high in contamination fear (n = 55) using images of neutral food items (conditioned stimuli; CS) paired with videos of individuals vomiting (unconditioned stimuli; US) while we obtained subjective disgust reports. After conditioning, half of the participants were randomly assigned to cognitive reappraisal training aimed at decreasing their emotional response to the US and CS, while the other half received no such training. The findings showed that cognitive reappraisal participants demonstrated a reduction in learned disgust across sessions and further benefited from extinction. These findings suggest that cognitive reappraisal may be an effective strategy for attenuating learned disgust.

1. Introduction

Contamination concerns are a common theme associated with obsessive- compulsive disorder (OCD; Rasmussen & Tsuang, 1986; Summerfeldt, Antony, Downie, Richter, & Swinson, 1997), and studies have shown that up to 50% of people with OCD present with such concerns (Rachman & Hodgson, 1980; Rasmussen & Eisen, 1992). Ritualistic neutralizing behaviors (i.e., washing) associated with contamination concerns in OCD serve a negatively reinforcing function, as distress elicited by the obsessions is temporarily alleviated (Rachman, 1994, 2004). Although such neutralizing behaviors in OCD have traditionally been attributed to fear/anxiety, there is growing recognition that functionally impairing contamination concerns may also be driven by disgust. More specifically, disgust may function as a "danger signal" for those with OCD that indicates that the likelihood of contagion is high (Mitte, 2008; Verwoerd, Jong, Wessel, Wiljo, & van Hout, 2013). Evidence from multiple levels of analysis has now linked disgust to contamination-based OCD. For example, self-report questionnaires of disgust proneness correlate with self-report measures of symptoms of contamination-based OCD (Mancini, Gragnani, & D'Olimpio, 2001; Olatunji, 2010; Olatunji, Sawchuk, Lohr, & de Jong, 2004; Olatunji, Williams, Lohr, & Sawchuk, 2005). Disgust responses also predict avoidance of stimuli high in contagion potency among those with symptoms of contamination-related OCD (e.g., bedpans; Deacon & Olatunji, 2007; Olatunji, Lohr, Sawchuk, & Tolin, 2007; Tsao, & McKay, 2004). Lastly, neuroimaging research has shown that the neural substrates involved in disgust proneness may be relevant to the development of OCD, particularly the contamination/washing symptom dimension (Husted, Shapira, & Goodman, 2006; Shapira et al., 2003).

A role for disgust in contamination-based OCD may be understood from a conditioning framework (Armstrong & Olatunji, 2017). For example, disgust associations may form more easily (heightened disgust learning) among those with OCD compared to those without OCD, and frequent perceptions of contamination often endure despite the passage of time or ordinary hygiene procedures (impaired disgust extinction). It would be adaptive if novel or initially neutral stimuli rapidly evoke disgust when they are consistently associated with stimuli that could be contagious (Curtis, de Barra, & Aunger, 2011). This conditioning pathway would be robust, evolutionarily adaptive, and more relevant for contact contamination (which arises from tangible contact with unpleasant, disgusting, or dangerous substances, such as decaying

* Corresponding author at: Department of Psychology, Vanderbilt University, 301 Wilson Hall, 111 21st Avenue South, Nashville, TN 37240, United States.
E-mail address: olubunmi.o.olatunji@vanderbilt.edu (B.O. Olatunji).

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matter, bodily fluids and products, and germs) relative to mental contamination (where a feeling of internal dirtiness is caused by a psychological or physical violation that is not an external contaminant such as blood or dirt, but human interaction). Although fear is typically thought to be acquired through Pavlovian conditioning, disgust is believed to be acquired by evaluative conditioning (Schienle, Stark, & Vaitl, 2001). Pavlovian conditioning can be conceptualized as expectancy learning, whereby the CS becomes a reliable predictor of the US. Thus, Pavlovian conditioning is dependent on statistical contingency, such that learning will occur to the extent that the organism is able to predict the US occurrence. Evaluative conditioning, however, is based upon appraisal of stimuli along dimensions of like/dislike, good/bad, or pleasant/unpleasant (De Houwer, Thomas, & Baeyens, 2001). Thus, evaluative conditioning occurs through referential learning where the CS serves as a reference to the US but does not necessarily generate anticipation that the US will occur.

Experimental research to date has revealed robust disgust conditioning effects. For example, Olatunji, Forsyth, and Cherian (2007) examined individual differences in one conditioned stimuli (CS; a neutral word) that was never paired with a disgusting pictorial US (CS−) and one CS (another neutral word) that was always paired with a disgusting US (CS+). The results showed that during acquisition, the CS+ elicited stronger subjective disgust than the CS-. Using similar differential conditioning procedures, three subsequent studies successfully replicated the basic finding that contingent pairing of a neutral face (Engelhard, Leer, Lange, & Olatunji, 2014; Mason & Richardson, 2010) or a neutral word (Olatunji, Tomarken, & Punochar, 2013) with a disgusting picture resulted in heightened subjective disgust ratings of the CS+. Research has also shown that the disgust conditioned response is resistant to extinction (Mason & Richardson, 2010; Olatunji, Forsyth et al., 2007; Olatunji, Lohr et al., 2007). The resistance to extinction of disgust in basic research mirrors findings that have been observed in clinical research. More specifically, research has shown that the decay slope for fear during exposure-based treatment is significantly greater in comparison to that of disgust (Adams, Willems, & Bridges, 2011; Olatunji, Wolitzky-Taylor, Willems, Lohr, & Armstrong, 2009).

The available evidence suggests that disgust reactions in contamination-based OCD are either resistant to treatment or slower to respond to exposure interventions compared to fear responses (Mason & Richardson, 2012; McKay, 2006). The resistance to extinction of disgust among those with OCD may be facilitated by the persistence of the perception that an object is contaminated. In one study by Tolin, Worhunsky, and Maltby (2004), OCD patients were instructed to touch a clean pencil to an object that had been identified as being contaminated. A second “clean” pencil was then touched to the now “contaminated” pencil, with this procedure continued until a series of 12 pencils had been exposed. The results indicated that OCD patients reported a “chain of contagion” in which successive degrees of removal from the original pencil did not change their perceptions regarding the original degree of contamination. This stimulus generalization may render it difficult to extinguish disgust responses to specific stimuli.

Although disgust learning and extinction may contribute to the development and maintenance of contamination-based OCD, there remains a paucity of research examining interventions that may attenuate conditioned disgust responses and facilitate disgust extinction. Recent research suggests that counterconditioning (Engelhard et al., 2014) may be a promising approach to facilitating disgust extinction. However, no study to date has examined the effects of cognitive reappraisal on conditioned disgust responses. Cognitive reappraisal is an emotion regulation strategy that involves changing the trajectory of an emotional response by reinterpreting the meaning of the emotional stimulus (Ray, McRae, Ochsner, & Gross, 2010). Cognitive reappraisal is also a component of cognitive behavioral therapy, an effective treatment for OCD (Olatunji, Davis, Powers, & Smits, 2013). Cognitive reappraisal has been described as an antecedent-focused strategy that is implemented before the complete activation of emotion response tendencies (Gross, 2001). Previous research has shown that cognitive reappraisal can be effective in attenuating conditioned fear (Shurick et al., 2012). Although it has been initially theorized that the experience of disgust may be fairly impenetrable by cognition (Oaten, Stevenson, & Case, 2009), recent research suggests that cognitive reappraisal may effectively reduce verbal distress associated with disgust. For example, Olatunji, Berg, and Zhao (2017) found that for participants exposed to a fear-relevant video, change in emotional distress did not significantly differ between those that suppressed and those that reappraised. However, significantly less emotional distress was observed for those that reappraised compared to those that suppressed when exposed to a disgust-relevant video.

Previous experimental research has also examined the differences between reappraisal and suppression when watching a disgusting film. For example, Gross (1998) found that compared with a control condition, both reappraisal and suppression were effective in reducing emotion-expressive behavior. However, reappraisal decreased disgust experience, whereas suppression increased sympathetic activation. It has been suggested that as a potential intervention for disgust (Mason & Richardson, 2012; Rachman, 2004; Rozin & Fallon, 1987), reappraisal may also take the form of ‘conceptual reorientation' where the disgusting object takes on a new representation (e.g., thinking rotten milk is actually yogurt). However, the effects of reappraisal on the learning of disgust is unclear. Accordingly, the present study examines the extent to which cognitive reappraisal may attenuate conditioned disgust responses and facilitate disgust extinction in a sample that may be at risk for contamination-based OCD. It was hypothesized that compared to those assigned to a control condition, those assigned to cognitive reappraisal would demonstrate a reduction in conditioned disgust across sessions. Those assigned to cognitive reappraisal were also hypothesized to further benefit from an extinction procedure.

2. Method

2.1. Participant selection

Participants were selected from a large pool (n = 596) of psychology students based on their scores on the Padua Inventory (PI; Burns, Keortge, Formea, & Sternberger, 1996) contamination subscale. The PI has demonstrated excellent psychometric properties in non-clinical samples (i.e., Mancini, Gragnani, Orazi, & Pietrangeli, 1999; van Oppen, 1992). The PI contamination subscale also has adequate test-retest reliability over a 6–7-month interval (r = 0.72; Burns et al., 1996). Those scoring equal to and above the OCD washer patient mean (n = 165) reported on the PI contamination subscale (mean = 13.87; Burns et al., 1996) were invited to participate via an email solicitation. The final sample consisted of 57 participants that responded to the email solicitation (35% of eligible participants) who were mostly female (75%) with a mean age of 18.87 (SD = 0.93). The mean PI scores for those that were eligible (19.22) to participate did not significantly differ from those that did participate (18.63). Similar methods for identifying analogue contamination-based OCD groups have been employed in prior studies (e.g., Olatunji, Lohr et al., 2007), and there is compelling evidence that studies of analogue OCD samples are relevant to understanding OCD in clinical populations (see Abramowitz et al., 2014; Gibbs, 1996 for a review). For example, Burns, Formea, Keortge, and Sternberger (1995) found that non treatment-seeking individuals who scored highly on self-report measures of OC symptoms often met diagnostic criteria for OCD, evidenced stability of symptoms over time, and exhibited similar associated symptom features as patients diagnosed with OCD. Such findings are consistent with a growing consensus that OCD symptoms occur on a continuum of severity and have their origin in largely normal human processes, such as associative learning and negative reinforcement (Abramowitz et al., 2014). Under this approach, OCD-related phenomena can be observed and studied among analogue samples.

2.2. Measures

The *Padua Inventory* (PI; Burns et al., 1996) contamination fear subscale is a well-validated 10-item measure of contamination obsessions and washing compulsions.

The *Obsessive-Compulsive Inventory-Revised* (OCI-R; Foa et al., 2002) is a well-validated 18-item measure of washing, checking, obsessing, neutralizing, ordering, and hoarding symptoms of OCD.

The *Disgust Scale—Revised* (DS-R; Haidt, McCauley, & Rozin, 1994; modified by Olatunji, Forsyth et al., 2007; Olatunji, Lohr et al., 2007) is a well-validated 25-item questionnaire assessing core, animal-reminder, and contamination disgust proneness.

The *Disgust Propensity and Sensitivity Scale-Revised* (DPSS-R; van Overveld, de Jong, Peters, Cavanagh, & Davey, 2006) is a well-validated 16-item measure designed to assess the frequency and emotional impact of disgust experiences.

The *State-Trait Anxiety Inventory-Trait Form Y* (STAI-T; Spielberger, Gorsuch, Lushene, Vagg, & Jacobs, 1983) is a well-validated 20-item measure of the tendency to experience anxiety and the tendency to perceive stressful situations as threatening.

2.3. Materials

2.3.1. Conditioned stimulus (CS)

The CS consisted of two types of neutral images of food items (i.e., cheese and pita bread). The two food items were counterbalanced (i.e. both items were equally presented as the CS− and CS+). These CS have been validated with regards to being equivalently neutral and have been used as CS in previous disgust conditioning research (Borg, Bosman, Engelhard, Olatunji, & de Jong, 2016).

2.3.2. Unconditioned stimulus (US)

The disgust relevant US were sound-attenuated video clips depicting people vomiting. As a neutral outcome, neutral sound-attenuated films depicting nature scenes were employed. The videos depicting people vomiting have been shown in previous research to evoke the desired emotion of disgust, but not fear (Armstrong, McLenahan, Kittle, & Olatunji, 2014).[1]

2.3.3. Self-report affective assessment of CS and US

At the end of each conditioning stage, participants rated how disgusted, afraid, and aroused the CS made them feel using the unidimensional version of the Empirical Valence Scale (EVS; Lishner, Cooter, & Zald, 2008). This visual analog scale has verbal descriptors placed at empirically determined locations. The corresponding unit distance from the neutral 0-point for each descriptor was as follows: barely (7), slightly (12), mildly (24), moderately (38), strongly (70), extremely (85), and most imaginable (100)—and is designed to reduce floor effects for subtle responses and to limit ceiling effects for intense responses. Ratings can be made at any point along the scale using a mouse cursor. After acquisition, participants rated how disgusted, afraid, and aroused the US videos made them feel using the unidimensional version of the EVS.

2.4. Procedure

Participants first completed the series of measures described above to validate randomization and to ensure that there were no group differences on trait measures that may influence disgust learning. The experiment was then divided into two sessions. In the first session, participants completed a disgust conditioning paradigm followed by a cognitive reappraisal manipulation (cognitive reappraisal group) or a card-sorting task (control group). In the second session, participants returned 24 h later to repeat the conditioning paradigm as well as extinction. Participants were informed that the aim of the study was to examine the relationship between emotion and behavior.

In Session 1, participants underwent a partial reinforcement disgust conditioning paradigm that consisted of two phases: habituation and acquisition. Participants were randomly assigned to be presented with either the cheese image or the pita image as the CS+. The habituation phase consisted of 4 non-reinforced presentations (15 s) of each CS in random order. Participants were instructed to look directly at the CS. CS were preceded by a fixation cross (1.5 s) and followed by an intertrial interval (ITI; blank screen) that varied randomly between 12 s and 18 s. The CS were centered in the lower third of the screen. During acquisition, the CS were presented for 20 s in the lower third of the screen. After 5 s of presentation, the US video began playing in the center of the screen for the remaining 15 s of the CS presentation. The CS+ cued the videos which coterminated with the final 15 s presentation of the CS+. Similarly, the CS- cued videos of nature scenes which coterminated with the final 15 s presentation of the CS-. Participants were instructed to look directly at the CS until the video began, and then to watch the video. CS were preceded by a fixation cross (1.5 s) and followed by an ITI that varied randomly between 12 s and 18 s. There were two blocks of trials, each consisting of 4 presentations of CS+ trials and 4 presentations of CS- trials presented in random order. In 8 of these trials the CS- was paired with the video of nature scenes. Consistent with partial reinforcement, the CS+ was paired with US vomit videos for only 4 trials, and the CS+ was paired with video of nature scenes for 4 trials. Levels of disgust, fear, and arousal to the CS+ and CS−, as assessed by the EVS, were obtained after the habituation and acquisition phase. Participants then rated how disgusted, afraid, and aroused the videos made them feel using the EVS.

After conditioning, one image of the CS+, CS−, and the videos (presented as screen shots) were presented sequentially on the computer screen and participants were asked to report their levels of disgust and anxiety to each image. Participants were then randomized to the cognitive reappraisal or control condition. The reappraisal instructions and subsequent processing was facilitated directly through discussion with the experimenter. This discussion was targeted towards guiding the participants in being able to reinterpret the meaning of the US. Thus, rather than perceiving vomiting as merely aversive for example, one can reappraise such stimuli to reflect someone that is ill and engaging in a behavior that is relieving. US-revaluation refers to the observation that subsequent changes in the valence of a US after pairing it with a neutral CS also changes the valence of the associated CS. Cognitive reappraisal in this context may essentially function as a form of US-revaluation. Those in the cognitive reappraisal condition were asked to discuss the relationship between thoughts and feelings in the context of a cognitive restructuring task that took approximately 12–15 min to complete (see Shurick et al., 2012). These participants were then presented with a series of cartoon drawings on the computer screen and asked to discuss how the thoughts and feelings of the cartoon characters were related (e.g., how a character's knowledge about the situation impacted his emotional state). Participants were then asked to describe their thoughts and feelings about two ambiguous images and were then given new information that might positively or negatively affect their perception of the image. The experimenter then explained that during the conditioning paradigm, "catastrophizing" the US can make the task less pleasant. As with the cartoon drawings and ambiguous images, participants were asked to brainstorm alternative ways of thinking about the CS+ and the US they were exposed to during acquisition.

Participants in the control condition completed a cartoon rearrangement task from the Wechsler Adult Intelligence Scale – Revised for approximately 12–15 min. They were presented with a series of ten cartoon picture sets one set at a time and were asked to rearrange the

[1] Food items were selected as the CS and vomiting was selected as the US given prior research showing that a priori belongingness can enhance visceral response associations during conditioning (Hamm, Vaitl, & Lang, 1989).

cartoons in the correct order to tell a coherent story. This task was similar to the cognitive reappraisal task in physical proximity to the experimenter and the use of cartoon drawings, but different in that it required limited social interaction and did not require the participant to think about the association between thoughts and feelings.

In Session 2 conducted 24 h later with the same experimenter as in Session 1, all participants viewed one image of the CS+, CS−, and videos on the computer screen and were asked to write down any automatic thoughts and emotions they had while viewing the images. The cognitive reappraisal group was also asked to write down any alternative thoughts and emotions they could think of for each image. The acquisition phase of the disgust conditioning task was then repeated, and participants again rated how disgusted, afraid, and aroused the videos made them feel using the EVS. Participants then completed an extinction phase that consisted of CS presentation without US presentation (8 trials of CS+ and 8 trials of CS−). Levels of disgust, fear, and arousal to the CS+ and CS−, as assessed by the EVS, were obtained after the extinction phase. All participants completed both sessions.

3. Results

3.1. Participant characteristics

As shown in Table 1, participants in the cognitive reappraisal (n = 27) condition did not significantly differ in age, gender, and ethnicity from those in the control (n = 28) condition ($p > 0.05$). Scores on measures of contamination obsessions and washing compulsions (PI), OCD symptoms (OCI-R), disgust proneness (DS-R), disgust propensity and sensitivity (DPSS-R), and trait anxiety (STAI-T) also did not significantly differ between the two groups ($p > 0.05$).

3.2. Does cognitive reappraisal influence affective ratings of the CS?

3.2.1. Disgust

A 2 (Group: cognitive reappraisal, Control) X 2 (CS: CS+, CS−) X 4 (Phase: Habituation, Session 1 Acquisition, Session 2 Acquisition, Extinction) mixed factor ANOVA on disgust ratings of the CS revealed a significant main effect of Group [F (1, 53) = 6.86, $p < 0.02$, partial $\eta^2 = 0.12$], CS [F (1, 53) = 18.90, $p < 0.001$, partial $\eta^2 = 0.23$] and Phase [F (3, 159) = 15.97, $p < 0.001$, partial $\eta^2 = 0.23$]. The main effects were qualified by significant Group X Phase [F (3, 159) = 7.93, $p < 0.001$, partial $\eta^2 = 0.13$], CS X Phase [F (3, 159) = 23.70, $p < 0.001$, partial $\eta^2 = 0.31$], and Group X CS X Phase [F (3, 159) = 4.03, $p < 0.02$, partial $\eta^2 = 0.07$] interactions. In order to examine the significant Group X CS X Phase interaction, a 2 (Group) X 4 (Phase) mixed factor ANOVA on disgust ratings was conducted separately for the CS+ and CS−. For the CS+, the results revealed a significant main effect of Group [F (1, 53) = 5.95, $p < 0.02$, partial $\eta^2 = 0.10$] and Phase [F (3, 159) = 25.39, $p < 0.001$, partial $\eta^2 = 0.32$]. These main effects were qualified by a significant Group X Phase interaction [F (3, 159) = 7.48, $p < 0.001$, partial $\eta^2 = 0.12$]. Mutivariate analyses depicted in Fig. 1 shows that although the two groups did not significantly differ in disgust ratings of the CS+ during Habituation ($p = 0.460$, partial $\eta^2 = 0.01$) and Session 1 Acquisition ($p = 0.849$, partial $\eta^2 = 0.001$), the reappraisal group reported significantly lower ratings to the CS+ than the control group during Session 2 Acquisition ($p < 0.001$, partial $\eta^2 = 0.22$) and Extinction ($p < 0.002$, partial $\eta^2 = 0.20$). For the CS−, the mixed factor ANOVA on disgust ratings revealed a significant main effect of Phase [F (3, 159) = 4.17, $p < 0.006$, partial $\eta^2 = 0.07$]. However, the Group X Phase interaction was not significant [F (3, 159) = 1.99, $p = 0.119$, partial $\eta^2 = 0.04$]. These findings show that those who reappraised reported significantly less disgust to the CS+ compared to controls on the second day of acquisition. Means and standard deviations of disgust ratings for the CS are presented in Table 2.

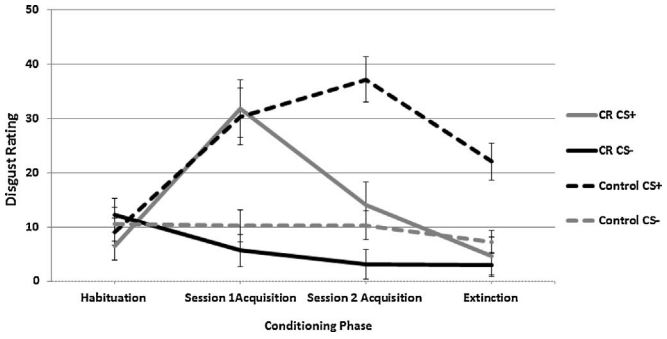

Fig. 1. Mean disgust rating for the CS+ (neutral stimulus classically conditioned to disgust) and CS– (neutral stimulus not classically conditioned to disgust) for the cognitive reappraisal (CR) and control groups across sessions. Error bars indicate standard error of the mean.

3.2.2. Fear

A 2 (Group: cognitive reappraisal, Control) X 2 (CS: CS+, CS−) X 4 (Phase: Habituation, Session 1 Acquisition, Session 2 Acquisition, Extinction) mixed factor ANOVA on fear ratings of the CS revealed a significant main effect of CS [F (1, 53) = 22.42, $p < 0.001$, partial $\eta^2 = 0.30$] and Phase [F (3, 159) = 8.43, $p < 0.001$, partial $\eta^2 = 0.14$]. The main effects were qualified by a significant CS X Phase interaction [F (3, 159) = 5.91, $p < 0.002$, partial $\eta^2 = 0.10$] and a significant Group X CS X Phase interaction [F (3, 159) = 2.78, $p < 0.05$, partial $\eta^2 = 0.05$]. In order to examine the significant Group X CS X Phase interaction, a 2 (Group) X 4 (Phase) mixed factor ANOVA on fear ratings was conducted separately for the CS+ and CS−. For the CS+, the results revealed a significant effect of Phase [F (3, 159) = 8.24, $p < 0.001$, partial $\eta^2 = 0.14$]. However, the Group X Phase interaction was not statistically significant [F (3, 159) = 2.12, $p = 0.085$, partial $\eta^2 = 0.04$]. For the CS-, the mixed factor ANOVA on fear ratings revealed a significant main effect of Phase [F (3, 159) = 3.97, $p < 0.01$, partial $\eta^2 = 0.07$]. However, the Group X Phase interaction was not significant [F (3, 159) = 0.57, $p = 0.634$, partial $\eta^2 = 0.01$]. These findings show that those who reappraised did not show statistically robust differences from controls in fear responding to the CS+ on the second day of acquisition. Means and standard deviations of fear ratings for the CS are presented in Table 2.

3.2.3. Arousal

A 2 (Group: cognitive reappraisal, Control) X 2 (CS: CS+, CS−) X 4 (Phase: Habituation, Session 1 Acquisition, Session 2 Acquisition, Extinction) mixed factor ANOVA on arousal ratings of the CS revealed a significant main effect of Phase [F (3, 159) = 4.77, $p <$ 0.003, partial

Table 1
Demographics and measures of contamination-related OCD, disgust proneness, and anxiety symptoms for the cognitive reappraisal (cognitive reappraisal) and control groups.

	Participant Group		
	Cognitive Reappraisal	Control	Statistic
Gender (% female)	71.4	81.5	$\chi^2 = 0.52$
Ethnicity (% Caucasian)	52.2	48.0	$\chi^2 = 0.67$
Age	18.65 (0.79)	19.07 (1.01)	$F = 2.79$
PI	17.69 (3.89)	19.50 (5.71)	$F = 1.81$
OCI-R	22.79 (12.72)	25.18 (11.11)	$F = 0.56$
DS-R	61.96 (14.48)	59.68 (13.86)	$F = 0.36$
DPSS-R	31.32 (9.56)	28.78 (6.58)	$F = 1.33$
STAI-T	35.18 (9.07)	37.04 (9.28)	$F = 0.57$

Notes: PI = Padua Inventory Contamination Subscale; OCI-R = Obsessive-Compulsive Inventory-Revised; DS-R = Disgust Scale-Revised; DPSS-R = Disgust Propensity and Sensitivity Scale-Revised; STAIT = State-Trait Anxiety Inventory-Trait Version.
ps > .05.

Table 2
Mean and standard deviation for CS+ and CS– ratings for disgust, fear, and arousal ratings by participant group.

	Cognitive Reappraisal Condition				Control Condition			
	Habituation	Session 1 Acquisition	Session 2 Acquisition	Extinction	Habituation	Session 1 Acquisition	Session 2 Acquisition	Extinction
CS +								
Disgust	6.47 (13.96)	31.73 (27.84)	14.12 (17.15)	4.66 (8.69)	9.09 (12.19)	30.30 (27.49)	37.10 (25.95)	22.00 (23.51)
Fear	3.26 (9.65)	15.20 (24.83)	4.15 (9.05)	0.64 (1.95)	3.73 (12.79)	11.80 (18.92)	13.37 (17.91)	4.25 (6.83)
Arousal	5.44 (12.53)	12.89 (16.76)	6.66 (13.02)	2.23 (5.44)	3.80 (6.22)	10.53 (17.92)	8.05 (16.44)	3.94 (9.03)
CS-								
Disgust	12.14 (16.75)	5.66 (11.09)	3.09 (8.25)	3.04 (6.32)	10.50 (16.38)	10.19 (18.79)	10.32 (18.43)	7.22 (14.60)
Fear	3.12 (9.91)	2.91 (10.17)	0.48 (1.76)	0.15 (0.57)	2.19 (4.36	5.10 (13.19)	1.22 (2.49)	0.42 (1.51)
Arousal	10.47 (18.14)	11.18 (19.04)	5.70 (12.78)	4.68 (12.16)	5.81 (12.02)	4.50 (10.19)	5.51 (13.41)	3.21 (6.12)

$\eta^2 = 0.08$]. The main effect was further qualified by a significant CS X Phase interaction [F (3, 159) = 3.11, $p < 0.03$, partial $\eta^2 = 0.06$]. However, the anticipated Group X CS X Phase interaction was not significant [F (3, 159) = 0.95, $p = 0.962$, partial $\eta^2 = 0.002$]. These findings show that those who reappraised did not significantly differ from controls in arousal responding to the CS+ on the second day of acquisition. Means and standard deviations of arousal ratings of the CS are presented in Table 2.

3.3. Does cognitive reappraisal influence affective ratings of the US?

3.3.1. Disgust

A 2 (Group: cognitive reappraisal, Control) X 2 (Video Type; vomit, nature) X 2 (Session: Session 1, Session 2) mixed factor ANOVA on disgust ratings for the videos revealed a significant main effect of Group [F (1, 53) = 6.03, $p < 0.02$, partial $\eta^2 = 0.10$], Video Type [F (1, 53) = 254.72, $p < 0.001$, partial $\eta^2 = 0.83$], and Session [F (1, 53) = 34.66, $p < 0.001$, partial $\eta^2 = 0.40$]. The main effects were qualified by significant Group X Video Type [F (1, 53) = 6.05, $p < 0.02$, partial $\eta^2 = 0.10$], Group X Session [F (1, 53) = 31.68, $p < 0.001$, partial $\eta^2 = 0.37$], and Video Type X Session [F (1, 53) = 24.98, $p < 0.007$, partial $\eta^2 = 0.32$] interactions. These interactions were further qualified by a significant Group X Video Type X Session interaction [F (1, 53) = 36.13, $p < 0.001$, partial $\eta^2 = 0.40$. In order to examine the significant Group X Video Type X Session interaction, a 2 (Group) X 2 (Session) mixed factor ANOVA on disgust ratings was conducted separately for the vomit videos (US) and the nature scene videos (control). For the vomit videos, the results revealed a significant main effect of Group [F (1, 53) = 6.17, $p < 0.02$, partial $\eta^2 = 0.10$] and Session [F (1, 53) = 33.98, $p < 0.001$, partial $\eta^2 = 0.38$]. These main effects were qualified by a significant Group X Session interaction [F (1, 53) = 37.50, $p < 0.001$, partial $\eta^2 = 0.41$]. Multivariate analysis depicted in Fig. 2 shows that although the two groups did not significantly differ in disgust ratings of the vomit videos during Session 1 ($p = 0.909$, partial $\eta^2 = 0.000$), the reappraisal group reported significantly lower disgust ratings than the control group during Session 2 ($p < 0.001$, partial $\eta^2 = 0.30$). For the nature scene videos, the mixed factor ANOVA on disgust ratings revealed only a marginally significant main effect of Session [F (1, 53) = 3.17, $p = 0.08$, partial $\eta^2 = 0.06$]. These findings show that those who reappraised reported significant less disgust to the US compared to controls on the second day. Means and standard deviations of disgust ratings of the videos are presented in Table 3.

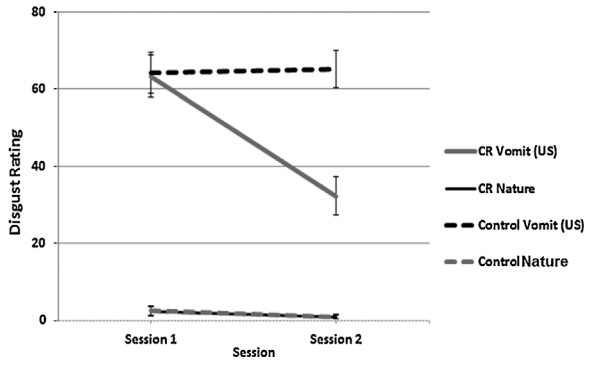

Fig. 2. Mean disgust rating for the vomit US (unconditioned stimulus) and control videos for the cognitive reappraisal (CR) and control groups across sessions. Error bars indicate standard error of the mean.

3.3.2. Fear

A 2 (Group: cognitive reappraisal, Control) X 2 (Video Type; vomit, nature) X 2 (Session: Session 1, Session 2) mixed factor ANOVA on fear ratings for the videos revealed a significant main effect of Video Type [F (1, 53) = 20.21, $p < 0.001$, partial $\eta^2 = 0.28$] and Session [F (1, 53) = 9.69, $p < 0.001$, partial $\eta^2 = 0.16$]. The main effects were qualified by a significant Group X Session [F (1, 53) = 10.77, $p < 0.003$, partial $\eta^2 = 0.17$] and a Group X Video Type X Session [F (1, 53) = 6.37, $p < 0.02$, partial $\eta^2 = 0.11$] interaction. In order to examine the significant Group X Video Type X Session interaction, a 2 (Group) X 2 (Session) mixed factor ANOVA on fear ratings of the videos was conducted separately for the vomit videos (US) and the nature scene videos (control). For the vomit videos, the results revealed a significant main effect of Session [F (1, 53) = 5.04, $p < 0.03$, partial $\eta^2 = 0.09$] that was qualified by a significant Group X Session interaction [F (1, 53) = 10.15, $p < 0.003$, partial $\eta^2 = 0.16$]. Subsequent multivariate analyses revealed that although the two groups did not significantly differ in fear ratings of the vomit videos during Session 1 ($p = 0.370$, partial $\eta^2 = 0.02$), the reappraisal group reported significantly lower fear ratings than the control group during Session 2 ($p < 0.04$, partial $\eta^2 = 0.09$). For the nature scene videos, the mixed factor ANOVA on fear ratings revealed only a significant main effect of Session [F (1, 53) = 10.33, $p < 0.003$, partial $\eta^2 = 0.16$]. These findings show that those who reappraised reported significant less fear to the US compared to controls on the second day. Means and standard deviations of fear ratings of the videos are presented in Table 3.

Table 3
Mean and standard deviation for disgust, fear, and arousal ratings of the videos by participant group.

	Cognitive Reappraisal Condition		Control Condition	
	Session 1	Session 2	Session 1	Session 2
Vomit (US)				
Disgust	63.33 (30.09)	32.22 (26.75)	64.20 (26.42)	65.21 (24.83)
Fear	17.50 (23.06)	6.21 (8.64)	12.21 (20.29)	14.17 (16.45)
Arousal	16.73 (21.49)	8.48 (16.08)	14.44 (21.57)	11.85 (19.48)
Nature				
Disgust	2.35 (5.54)	0.99 (3.10)	2.66 (7.15)	0.93 (2.07)
Fear	4.88 (8.13)	0.62 (2.25)	3.74 (5.98)	2.19 (4.12)
Arousal	12.96 (17.48)	8.40 (13.28)	10.05 (16.30)	8.42 (14.83)

3.3.3. Arousal

A 2 (Group: cognitive reappraisal, Control) X 2 (Video Type; vomit, nature) X 2 (Session: Session 1, Session 2) mixed factor analysis of variance ANOVA on arousal ratings for the videos revealed only a significant main effect of Session [F (1, 53) = 8.36, p < 0.005, partial η^2 = 0.14]. These findings show that those who reappraised did not significant differ from controls in arousal ratings of the US on the second day. Means and standard deviations of arousal ratings of the videos are presented in Table 3.

4. Discussion

The emotion of disgust has increasingly been implicated in the etiology of contamination-related OCD (Olatunji, Cisler, McKay, & Phillips, 2010). Relative to those without contamination-based OCD, disgust associations may be more readily acquired (heightened disgust learning) among those with contamination-based OCD, and these associations may persist despite the passage of time or provision of corrective information (impaired disgust extinction). In addition to explaining the persistence and generalizability of contamination appraisals in OCD, a disgust conditioning framework may also have important implications for treatment. For example, basic research suggests that disgust learning is resistant to extinction (Olatunji, Forsyth et al., 2007; Olatunji, Lohr et al., 2007), and clinical research has shown that disgust habituates at a slower rate than fear during exposure-based treatment of contamination-based OCD (Adams et al., 2011; McKay, 2006; Olatunji et al., 2009). The present study examined the extent to which cognitive reappraisal, an emotion regulation strategy, attenuates learned disgust. Consistent with predictions, results demonstrated a significant reduction in acquired self-reported disgust after participants cognitively reappraised. Importantly, this pattern of findings was relatively specific to disgust ratings of the CS+, as similarly robust effects were not observed for fear and arousal ratings. Although these findings suggest that the effects of cognitive reappraisal are relatively specific to disgust, it is important to note the pattern of effects were similar for fear. However, the effects for fear did not reach statistical significance. This may be because the study was underpowered due to the small sample size, or it may reflect the specificity of the conditioning and the reappraisal effects for disgust.

Although the present findings suggest that cognitive reappraisal may reduce the learning of disgust, greater confidence in this conclusion would require that disgust reactions to the CS also be assessed again in Session 2 prior to the acquisition period. In the absence of such an assessment, an alternative interpretation of the present findings is that cognitive reappraisal prevents the acquisition of learned disgust rather than reduced it. The present study also examined the effects of cognitive reappraisal on disgust extinction. Consistent with predictions, the cognitive reappraisal group reported significantly lower disgust ratings to the CS+ after extinction. Previous research has shown that disgust learning is resistant to extinction (Olatunji, Forsyth et al., 2007; Olatunji, Lohr et al., 2007), and recent efforts have focused on identifying approaches that may optimize disgust extinction (Bosman, Borg, & de Jong, 2016; Engelhard et al., 2014). The present findings suggest that cognitive reappraisal is one approach that may facilitate the extinction of disgust learning among those with symptoms of contamination-based OCD. Contamination involves the perceived transfer of disgust-relevant properties (e.g., dirty, infected, polluted, impure) through physical or symbolic contact (Rozin & Fallon, 1987). The perceived transfer may be potentiated by appraisals of looming vulnerability (Riskind, 1997), the belief that brief contact with disgusting stimuli results in rapid, spreading, and permanent infection (Riskind, Abreu, Strauss, & Holt, 1997). Although the transfer of disgust-relevant properties has been shown to be “stickier” (more resistant to extinction) than the transfer of fear-relevant properties (Mason & Richardson, 2010), the present findings suggest that cognitive reappraisal may be a useful complement to extinction procedures in facilitating disgust habituation.

Those in the cognitive reappraisal group were also found to report significantly lower disgust and fear ratings to the US of vomit videos at Session 2 than those in the control group. This suggests that cognitive reappraisal reduced negative emotional responding to the US, perhaps by encouraging reinterpretation of its meaning. It has previously been suggested that features of disgust render reactions immediate and compelling even in the face of their apparently irrational nature (Oaten et al., 2009). Features that render disgust automatic and cognitively impenetrable include the laws of sympathetic magic (Rozin & Fallon, 1987; Rozin, Millman, & Nemeroff, 1986). These laws are comprised of the law of contagion and the law of similarity. According to the law of contagion, disgusting objects transfer their disgusting properties to nondisgusting objects through contact. These disgusting properties remain even after physical contact has ceased and are dose-insensitive (“once in contact, always in contact”). The law of similarity states that objects that are physically similar to disgusting objects are deemed to be more disgusting. For example, fudge would be more acceptable food if shaped like a muffin than if it were shaped like feces (Rozin et al., 1986). Although the laws of sympathetic magic may contribute to rigid beliefs regarding the negative consequences of experiencing disgust (i.e., vomiting), the present findings suggest that such beliefs may not be cognitively impenetrable. In fact, the finding that those in the cognitive reappraisal group reported less disgust and fear ratings to the US at Session 2 is consistent with recent research showing that cognitive reappraisal dampens emotional distress associated with disgust (Olatunji et al., 2017).

Cognitive reappraisal may be conceptualized as a type of US-revaluation, an approach that has been posited to be effective in facilitating disgust extinction (Ludvik, Boschen, & Neumann, 2015). For instance, Baeyens, Eelen, Van den Bergh, and Crombez (1992) post-conditionally presented positive USs (faces) with negative adjectives and negative USs (faces) with positive adjectives. This revaluation procedure not only led to a reversal in the valence of the US, the affective quality of the CS also changed in the direction of the revaluated US. In the present study, cognitive reappraisal may have resulted in a US with a significant decrease in negative emotional intensity that resulted in the weakening of CS disgust response 24 h later. This suggests that the current value of US presentation is an important determinant of whether a conditioned response is elicited by CS. Cognitive reappraisal appears to be very effective in changing the value of a disgust-relevant US following established conditioning, and this change in value can modify the conditioned disgust response to the CS. However, the present study did not include assessments to ensure that participants in the experimental condition used the reappraisal techniques as prescribed. The inclusion of this manipulation check in future research may further clarify how reappraisal affects disgust learning and extinction.

The present study contributes to the existing literature on minimizing disgust learning and optimizing disgust extinction in several ways. First, the present study is unique in that it induced disgust and then trained participants to use individually generated reappraisals to change the meaning associated with the disgust-inducing stimulus. When participants were later reexposed to the stimulus, they applied these techniques to reduce disgust. Second, this study examined effects over an extended time window (24 h). Finally, rather than a nonclinical sample, the present study employed an analogue sample of participants high in symptoms of contamination-based OCD. In fact, the mean PI score for participants in the present study was higher than those reported by patients with contamination-related OCD (Burns et al., 1996). However, the use of an analogue sample is a limitation of the present study. While it is possible that some participants met diagnostic criteria for OCD given the reported mean scores on the PI, the absence of a diagnostic instrument limits generalization of the present findings to clinical samples. Although analogue OCD participants are similar to OCD patients in many respects (Abramowitz et al., 2014), replication of the present findings with OCD patients is needed before more definitive

inferences can be made. Given that the intervention is geared towards changing appraisals, another limitation of the present study is that changes in appraisals and related cognitions associated with the CS were not assessed. Assessment of appraisals and related cognitions in future research will prove useful in determining the specificity of the cognitive appraisal intervention.

The control group is also a limitation of the present study that should be noted. Indeed, the reappraisal group had more opportunity to think about the CS than the control group (independent of the instruction to reappraise). This makes it difficult to rule out alternative change mechanisms such as inhibitory learning/habituation. Future research comparing cognitive reappraisal to another active intervention may prove useful. As previously noted, the present study is also limited by the exclusive reliance on self-report to assess conditioned responding. This does make it difficult to fully rule out the extent to which the present findings may be influenced by demand characteristics. Indeed, it has previously been argued that conditioning effects may reflect demand artifacts based on participants' deliberate guesswork regarding the experimenter's hypothesis (Page, 1969, 1974). Although concerns about the possible role of demand characteristics have largely been abated by research that separates collection of the dependent measure from the conditioning phase of the experiment (Olson & Fazio, 2001) and previous research has shown that the type of learning (and unlearning) demonstrated in the present study can occur in the absence of the awareness of CS-US contingencies (Baeyens, Eelen, & van den Bergh, 1990), it is possible that participants became aware of experimental demands and behaved accordingly. The potential effects of demand characteristics may be limited in future research that employs multiple levels of analysis. Inclusion of facial electromyography, for example, as an implicit index of disgust responding and use of a more precise control group in future research may bolster confidence regarding the extent to which cognitive reappraisal results in robust changes in learned disgust responding.

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