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Orienting and Maintenance of Gaze in Contamination Fear: Biases for Disgust and Fear Cues

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Abstract

The present study examines the extent to which attentional biases in contamination fear commonly observed in obsessive-compulsive disorder (OCD) are specific to disgust or fear cues, as well as the components of attention involved. Eye tracking was used to provide greater sensitivity and specificity than afforded by traditional reaction time measures of attention. Participants high (HCF; $n = 23$) and low (LCF; $n = 25$) in contamination fear were presented with disgusted, fearful, or happy faces paired with neutral faces for 3 s trials. Evidence of both vigilance and maintenance-based biases for threat was found. The high group oriented attention to fearful faces but not disgusted faces compared to the low group. However, the high group maintained attention on both disgusted and fearful expressions compared to the low group, a pattern consistent across the 3 s trials. The implications of these findings for conceptualizing emotional factors that moderate attentional biases in contamination-based OCD are discussed.

Keywords

Eye Movements; Attention; Anxiety Disorders

Over two decades worth of research suggests that anxiety disorders are characterized by attentional biases to threat (for review, see Bar-Haim, Lamy, Pergamin, Bakermans-Kranenburg, & van IJzendoorn, 2007). The modal finding in such research is increased allocation of attention to threatening stimuli, through biases in the orienting of attention (vigilance; Mogg & Bradley, 1998), or in the continued engagement of attention (maintenance; Weierich, Treat, & Hollingworth, 2008). Biases are typically found for disorder-specific threats, for example, social stimuli in social anxiety (faces; Garner, Mogg, & Bradley, 2006), or spider stimuli in spider phobia (Rinck & Becker, 2006). Recent research suggests that attentional biases to threat may play an important role in the maintenance or etiology of anxiety (Koster, Fox, & MacLeod, 2009). Accordingly, experimental treatments that target attentional biases have been found to reduce symptom severity, as reflected in self-report measures and clinician ratings (Schmidt, Richey, Buckner, & Timpano 2009), as well as behavioral outcomes (Amir, Weber, Beard, Bomyea, & Taylor, 2008).

While attentional biases appear to be a cardinal feature of anxiety disorders, demonstrating such biases in obsessive-compulsive disorder (OCD) has been difficult (Summerfeldt & Endler, 1998). OCD is an anxiety disorder defined by persistent, unwanted thoughts or impulses

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(obsessions) that motivate rigid, excessive behaviors (compulsions) aimed at undoing obsession-related harm (Abramowitz, Khandker, Nelson, Deacon, & Rygwall, 2006). Many have noted that OCD is an anomalous anxiety disorder, and some have even suggested that the diagnoses be reclassified (Enright & Beech, 1990). The failure to demonstrate attentional biases to threat in OCD, across multiple studies (e.g. McNally, Riemann, Louro, Lukach, & Kim, 1992; Moritz et al., 2004; Moritz et al., 2008) may provide evidence for these positions. However, another possibility is that the heterogeneity of obsessive-compulsive (OC) concerns, as well as their idiosyncratic nature, has made the demonstration of attentional biases in OCD particularly difficult. Some null findings may be attributed to the use of the same or largely overlapping threat stimuli for patients with different types of OC symptoms (Kampman, Keijsers, Verbraak, Naring, & Hoogduin, 2002; Kyrios & Iob, 1998; Moritz et al., 2004). In contrast, most of the studies that have demonstrated attentional biases in OCD (Amir, Najmi, & Morrison, 2009; Foa, Ilai, McCarthy, Shoyer, & Murdock, 1993; Tata, Liebowitz, Prunty, Cameron, & Pickering; 1996) have matched threat stimuli with specific types of OC concerns.

Others have suggested that attentional biases in OCD occur only in the contamination-based subtype (Summerfield & Endler, 1998). Indeed, biases have been found most often in patient groups in which all (Foa et al., 1993; Tata et al., 1996) or a majority of individuals (Foa & McNally, 1986) have contamination concerns. Of the many OC symptom dimensions, contamination concerns are the most common (Rasmussen & Tsuang, 1986), reported by roughly 50% of patients (Rachman & Hodgson, 1980; Rasmussen & Eisen, 1992). Recent investigations of this symptom dimension have focused on the role of disgust, which is thought to serve a disease-avoidance function by motivating withdrawal from contamination threats (Matchett & Davey, 1991; Oaten, Stevenson, & Case, 2009). Some have suggested that contamination-based OC symptoms can be understood as a fundamental dysregulation of disgust (Olatunji, Lohr, Sawchuk, & Tolin, 2007). Indeed, increased disgust sensitivity (Haidt, McCauley, & Rozin, 1994) —a construct encompassing how frequently one experiences disgust, and how distressing one finds the experience—is predictive of OC symptom severity (e.g. Muris et al., 2000) and behavioral avoidance (e.g. Tsao & McKay, 2004), a finding replicated in many studies, including those that controlled for trait anxiety and depression (Deacon & Olatunji, 2007; Olatunji et al., 2007).

In light of these findings, the present study investigated the possibility of a disgust-specific attentional bias in individuals with elevated contamination fear. Given that threat should be more associated with disgust than fear in the context of this disorder, we hypothesized that increased allocation of attention would occur more for disgusted faces, compared to fearful or happy faces. Indeed, neural responses to disgusted expressions, but not fearful or happy expressions, were found to distinguish patients with contamination-based OCD from controls (Lawrence et al., 2007). Facial stimuli have been used in many studies on attentional biases in anxiety disorder (e.g. Mogg, Millar, & Bradley, 2000; Garner et al., 2006), in part because they allow experimenters to vary emotional content while holding other stimulus attributes constant. In addition, research on the neural substrates of fear and disgust recognition supports the notion that, through associative learning, facial expressions of emotion become capable of activating emotional appraisals and eliciting emotional responses (Philips et al., 2004).

Although increased attention to disgust cues in individuals with elevated contamination fear was hypothesized, it was unclear how this bias would manifest given competing accounts of the attentional components implicated in threat-related biases (Weierich et al., 2008). Increased allocation of attention could derive from facilitated detection, reflected in biased orienting towards threat (Mogg & Bradley, 1998); alternatively, increased attention could begin *after* detection with difficulty disengaging attention (Fox, Russo, Bowles, & Dutton, 2002), reflected in increased dwell time on threat. Weierich and colleagues note that the former "vigilance" hypothesis and the latter "maintenance" hypothesis need not be mutually exclusive, and could both account for increased allocation of attention to threat. To adequately assess both hypotheses, eye tracking technology was utilized to provide the sensitivity and specificity needed to parse components of attention.

Methods

Participants

Three large undergraduate classes at a Southern University (n = 368) were screened using the contamination and washing subscale of the Padua Inventory (PI; Burns, Keortge, Formea, & Sternberger, 1996), in order to identify students high and low in contamination concerns. Individuals one standard deviation or more above the sample mean were recruited for the high contamination fear (HCF) group (n = 23; mean age = 18.95, SD = .90; % female = 78.3), while individuals one standard deviation or more below the sample mean were recruited for the low contamination fear (LCF) group (n = 25; mean age = 19.17, SD = 1.27; % female = 60). Mean age and percent female did not significantly differ between groups. Means and standard deviations of PI scores for the HCF and LCF group are provided in Table 1. Reported levels of contamination fear in our analogue group were comparable to levels reported by individuals meeting diagnostic criteria for OCD; Burns et al. (1996) found that patients diagnosed with OCD had a mean PI score of 13.87.

Measures

The *Padua Inventory* (PI; Burns et al., 1996) contamination fear subscale is a 10-item measure of contamination obsessions and washing compulsions. The PI contamination fear subscale had an alpha coefficient of .96 in the present study.

The *Obsessive-Compulsive Inventory—Revised* (OCI–R; Foa et al., 2002) is an 18-item questionnaire assessing six types of OCD symptoms: Washing Concerns, Checking/Doubting, Obsessing, Mental Neutralizing, Ordering, and Hoarding. The OCI-R Washing concerns scale was used in the present study and had an alpha coefficient of .78.

The *State Trait Anxiety Inventory—Trait Version, Form Y* (STAI-T; Spielberger, Gorsuch, Lushene, Vagg, & Jacobs, 1983) is a 20-item scale that measures the enduring or chronic experience of anxiety. The alpha coefficient for the STAI-T was .91 in the present study.

The *Disgust Scale—Revised* (DS-R; Olatunji et al., 2007) is a 25-item questionnaire assessing sensitivity to a range of disgust elicitors, including core, animal-reminder, and contamination disgust. The DS-R had an alpha coefficient of .89 in the present study.

Public restroom behavioral avoidance task (BAT)

To further validate our analogue group with a more objective index, a behavioral measure of contamination fear was administered. Participants were led into a nearby public restroom, and were asked to touch surfaces that sampled a spectrum of perceived contamination risk. Participants were asked to touch inside of the sink, inside of the trashcan, on the seat of the toilet, and inside of the toilet (in that order). After each step, experienced distress was rated verbally on a 0 (no distress) to 10 (extreme distress) scale. If participants declined to complete a step, they were asked to imagine completing the step with their eyes closed, and then provide a rating.

Materials and Apparatus

Stimuli were selected from the NimStim set of facial expressions of emotion (Tottenham et al., 2009). Disgusted, fearful, happy, and neutral expressions for 8 individuals were chosen. All expressions were the open-mouth version. Images were converted to greyscale, and resized to subtend a visual angle of 5.4° × 3.6°. Each emotional expression (disgusted, fearful, happy) was paired twice with a neutral expression from the same individual, appearing once on each side in a 1 × 2 horizontal array. The paired images were presented against a white background, and separated by 10.1° of visual angle, from center to center (see Figure 1). Stimuli were presented using E-Prime version 1.0 software on a 17-in. widescreen monitor, with a resolution of 1280 × 1024, and a refresh rate of 60 Hz. Eye movements were recorded with the iView X RED-III system from SensoMotoric Instruments (SMI), a video-based eye tracker with a dark pupil tracking method. This system has a sampling rate of 60 Hz, and a spatial resolution of .5°-1°. Participants' heads were stabilized with a chinrest at a viewing distance of 60.5 cm.

Procedure

Following completion of measures, participants read instructions explaining the eye tracking task. The eye tracking cameras were said to measure pupil dilation during the task, to conceal the recording of gaze in order to reduce demand effects (Kellough, Beevers, Ellis, & Wells, 2008). Participants were asked to respond to the fixation target ("x" or "o") by pressing the corresponding labeled key—a task included to further obscure the purpose of the study (Caseras, Garner, Bradley, & Mogg, 2007). The fixation image offset after participants responded, or after 700 ms, depending on which occurred first. A pair of faces was then presented for 3 s, followed by an inter-trial interval of 1500, 2000, or 2500 ms, varied randomly to mitigate the monotony of the task (Garner et al., 2006). Participants were instructed to fixate on the central target prior to stimulus onset. During stimulus presentation, participants were asked to view the faces as they please, not to look away from the monitor, and not to continue looking at the fixation cross location. To minimize signal loss, participants were asked to blink only during the ITI. There were 16 practice trials, in which participants viewed pairs of neutral faces not used in the actual trials. After the practice trials, a 12-point calibration procedure was completed, followed by validation. There were 64 experimental trials, divided into 4 blocks of 16. Each block was balanced in terms of the Nimstim individual, the emotions expressed, and the sides each emotion was presented on. Stimuli were presented in a pseudo random order, in 4 distinct orders between subjects that balanced the presentation order of stimuli. After each block prior to the last, participants were given a brief resting period, and then the calibration procedure was repeated. After the procedure, participants were presented with each of the 32 pictures used in the experiment, and provided ratings on how pleasant the pictures made them feel, using a bipolar scale ranging from 0 (extremely unpleasant) to 6 (extremely pleasant). Participants then completed the BAT.

Eye movement data reduction

Eye movement events (saccades, fixations, blinks) were defined using BeGaze 1.0 software from SensoMotoric Industries (SMI). Gaze direction was sampled every 16.7 ms, with a fixation classified as 80 ms or more in which gaze was stable within a 1.4° radius of visual angle. Areas of interest were defined as the area of each image, as well as a circle with 1.5° radius at the location of the fixation target (central region). Inline with previous eye tracking studies (e.g. Garner et al., 2006), trials were excluded if gaze was not directed at the region of the fixation target during picture onset, if eye movements away from the central region occurred within 80 ms of picture onset, or if no eye movements were made during the trial. After removing blocks of trials with unacceptable calibration (2.83% of trials), invalid first fixations occurred on 5.82% of trials, and no eye movements were made in 0.49% of trials. This percentage of missing eye movement data is comparable to percentages reported in similar studies (e.g., Garner et al., 2006; Mogg et al., 2000). Independent samples *t*-tests revealed that the amount of missing trials overall and for each emotional expression did not significantly differ between groups, *t*s (46) < .74, *p*s > .46. Kolmogorov–Smirnov tests revealed that for the eye tracking data used in analyses distributions did not significantly differ from normality.

Variables were formed to measure biases in vigilance and maintenance of attention for each emotional face (disgusted, fearful, happy). Vigilance was measured by examining the direction and speed of initial fixation. Directional bias was computed by counting the number of trials in which the emotion of interest captured the initial fixation, and dividing this sum by the total number of valid trials containing the emotion of interest (Garner et al., 2006). The resulting scores ranged from 0–1, with .5 (i.e. 50%) representing no bias, and scores higher than .5 reflecting a tendency to orient attention towards the emotion of interest. For trials in which the emotion of interest captured the initial fixation, the average latency to initial fixation was also computed, to assess how quickly the face was detected (Mogg et al., 2000). Biases in the maintenance of attention were measured by assessing relative gaze duration at multiple intervals across the trial. Time spent fixating the emotion of interest, minus time spent fixating the accompanying neutral face, was computed for 6 time intervals: 0–500, 500–1000, 1000–1500, 1500–2000, 2000–2500, 2500–3000 ms (Hermans, Vansteenwegen, & Eelen, 1999; Rinck & Becker, 2006).

Results

Validation of group membership

Self-report measures—Independent samples *t*-tests revealed that in addition to their higher scores on the PI [t (46) = 20.42, $p < .001$] the HCF group was significantly higher in washing symptoms assessed by the OCI-R [t (46) = 7.49, $p < .001$]. In addition, the HCF group was higher in trait anxiety [t (46) = 3.72. $p < .001$], and in disgust sensitivity [t (46) = 5.74, $p < .001$]. This would suggest that our clinical analogue HCF participants are distinct from the LCF individuals (see Table 1). [1]

Valence ratings of faces—A 2 (group: HCF, LCF) × 4 (emotional expression: disgusted, fearful, happy, neutral) mixed-factor Analysis of Variance (ANOVA) revealed a significant main effect of emotion [F (3, 126) = 188.01, $p < .001$, ${}_p\eta^2 = .82$], qualified by a group by emotion interaction [F (2, 92) = 5.00, $p < .01$, ${}_p\eta^2 = .11$]. As shown in Table 1, independent-samples *t*-tests revealed that HCF individuals rated the disgusted face as marginally more unpleasant, compared to LCF individuals [t (42) = 1.93, $p = .06$]; HCF individuals also rated the happy face as significantly more pleasant [t (42) = 2.08, $p < .05$]. There were no group differences for ratings of fearful [t (42) = 1.35, $p > .05$] or neutral [t (42) = .721, $p > .05$] faces.

Behavioral avoidance of contamination—As predicted, independent-samples *t*-tests revealed that HCF individuals completed significantly fewer steps overall [t (43) = 6.55, $p < .001$], and experienced significantly more distress overall [t (43) = 8.92, $p < .001$] in the public restroom (see Table 1).

Vigilance bias: direction and speed of orienting to threat

To assess vigilance for threat, orienting biases were first analyzed by entering the directional bias scores for disgusted-neutral, fearful-neutral, and happy-neutral face pairs into a 2 (group: HCF, LCF) × 3 (emotional expression: disgusted, fearful, happy) mixed-factor ANOVA. Main effects were non-significant for group [F (2, 92) = 1.57, $p > .05$, ${}_p\eta^2 = .03$] and emotional expression [F (2, 92) = 1.54, $p > .05$, ${}_p\eta^2 = .03$]. As predicted, there was a significant group by emotional expression interaction [F (2, 92) = 3.82, $p < .03$, ${}_p\eta^2 = .08$]. However, a between-groups difference occurred only in the fearful face condition. As shown in Figure 2, HCF individuals oriented to the fearful face on 61% of fear trials, while LCF individuals oriented to the fearful face on 51% of trials [t (46) = 2.88, $p < .01$]. However, subsequent analysis

[1]Due to delays setting up the eye tracker, 4 participants were not able to complete the ratings, and 5 participants were not able to complete the behavioral avoidance task.

revealed that this interaction was no longer statistically significant when controlling for group differences in trait anxiety [F (2, 90) = 2.22, $p > .05$, $_{p}\eta^2 = .05$]. A 2 (group: HCF, LCF) × 3 (emotional expression: disgusted, fearful, happy) mixed-factor ANOVA on latency to first fixation did not reveal the predicted interaction of group and face [F (2, 92) = 1.64, $p > .05$, $p\eta^2 = .02$]. Group means for directional bias and latency to initial fixation are shown in Table 2.

Maintenance bias: dwell time on threat

A 2 (group: HCF, LCF) × 3 (emotional expression: disgust, fear, happy) × 6 (time interval: 0–500, 500–1000, 1000–1500, 1500–2000–1500, 1500–2000–2500, 2500–3000 ms) mixed-factor ANOVA on relative fixation duration for emotional faces at 6 time intervals was conducted to examine the maintenance of attention across the time course of the trial. There was a significant main effect of time interval [F (5, 230) = 8.83, $p < .001$, $p\eta^2 = .16$] such that participants showed greater dwell time on emotional faces at earlier compared to later time intervals. The main effects of group [F (1, 46) = 2.23, $p > .05$, $p\eta^2 = .05$] and emotional expression [F (1, 46) = 2.85, $p > .05$, $p\eta^2 = .06$] were not significant. However, there was a significant interaction of group and emotional expression [F (2, 92) = 9.18, $p < .001$, $p\eta^2 = .17$], which was further qualified by a significant three-way interaction of group, emotional expression, and time [F (10, 460) = 3.05, $p < .001$, $p\eta^2 = .06$]. Contrary to the vigilance effects, these maintenance findings remained significant when controlling for trait anxiety. [2]

To investigate the significant group X emotional expression X time interval interaction, separate 2 (group: HCF, LCF) X 6 (time interval: 0–500, 500–1000, 1000–1500, 1500–2000–1500, 1500–2000–2500, 2500–3000 ms) mixed-factor repeated-measures ANOVAs were conducted for each emotional expression. These analyses revealed a significant main effect of group in the disgusted expression condition [F (1, 46) = 7.63, $p < .01$, $_{p}\eta^2 = .14$], and in the fearful expression condition [F (1, 46) = 5.29, $p < .03$, $_{p}\eta^2 = .10$], such that HCF individuals showed increased maintenance of attention on disgusted and fearful expressions, compared to LCF individuals, as reflected in longer fixation durations across the course of the trial, compared to accompanying neutral expressions. There was no main effect of group in the happy expression condition [F (1, 46) = 1.55, $p > .05$, $_{p}\eta^2 = .03$]. Group means for total dwell time are shown in Table 2.

Main effects of time interval for each emotional expression were also observed [disgusted: F (5, 230) = 8.47, $p < .001$, $_{p}\eta^2 = .16$; fearful: F (5, 230) = 2.97, $p < .03$, $_{p}\eta^2 = .06$; happy: F (5, 230) = 2.43, $p < .04$, $_{p}\eta^2 = .05$]. This main effect was qualified by a group by time interval interaction only in the happy expression condition, [F (5, 230) = 4.07, $p < .001$, $_{p}\eta^2 = .08$]. In the HCF group, there was a significant linear trend [F (1, 24) = 5.36, $p < .03$, $_{p}\eta^2 = .18$] indicating that dwell time on the happy face decreased from earlier to later time intervals. In the LCF group, there was also a significant linear trend [F (1, 24) = 5.74, $p < .03$, $_{p}\eta^2 = .21$], however, in the opposite direction, indicating that dwell time on the happy face increased from earlier to later time intervals (see Figure 3). Group comparisons at each time interval revealed that significant differences emerged in the last second of the trial, with no significant differences during the first 2000 ms, but significant difference from 2000–2500 ms [t (46) = 2.88, $p < .01$] and from 2500–3000 ms [t (46) = 2.88, $p < .04$], such that the LCF group dwelled more on the happy face compared to the HCF group. Group means for dwell time during each interval are shown in Table 3.

[2]Given the relevance of emotional faces in social anxiety, it could be argued that increased social anxiety in the HCF group could be responsible for the observed biases. However, these effects remained significant when controlling for symptoms of social anxiety, as measured by the Brief Fear of Negative Evaluation Scale (Leary, 1983).

Discussion

To our knowledge, this is the first study to employ eye tracking methods to investigate attentional biases in contamination fear that may be relevant to OCD. The finding of an orienting bias for fearful but not disgusted expressions in the HCF group was not predicted, but is consistent with research suggesting that fearful faces more efficiently convey threat when processing resources are limited (Jiang & He, 2006; Yang, Zald, & Blake, 2007). In the present study, facial stimuli were presented at 5.05° of retinal eccentricity, well outside the 2° limit of foveal processing, and at the farthermost limit of parafoveal processing (Rayner, 1998). It is possible that only fearful expressions can elicit orienting at this eccentricity, as fearful expressions can be registered through a few basic physical features (i.e. the enlarged sclera or whites of the eyes; Whalen et al., 2004) while disgusted expressions require the integrations of more complex features (e.g. wrinkling of the nose combined with gaping or raising of the lip; Rozin & Fallon, 1987). Although the HCF group's "attentional control settings" (Öhman, Flykt, & Esteves, 2001; Folk, Remington, & Johnston, 1992) may facilitate orienting to both disgusted and fearful cues, at the limits of parafoveal vision, perhaps only fearful faces can trigger these settings. However, the orienting bias for fearful expressions in the HCF group, relative to those in the LCF group, became non-significant when controlling for trait anxiety. This finding may be understood in the context of research showing that trait anxiety is associated with increased amygdala activity in response to unattended fearful expressions (Etkin et al., 2004), and that amygdala activity underlies orienting to fearful expressions (Adolphs et al., 2005; Gamer & Büchel, 2009). Thus, while orienting to fear cues may be potentiated in individuals high in contamination fear, it is likely attributable to heightened levels of trait anxiety associated with the trait.

Subsequent to the initial orienting of attention, a bias in the maintenance of attention emerged for both disgusted and fearful expressions in the HCF compared to LCF group. HCF individuals dwelled on the disgusted and fearful expressions longer, across the course of the trial, seen in increased fixation durations on disgusted and fearful expressions. Time course analysis revealed that increased dwell time to disgusted and fearful expressions in the HCF group was relatively consistent across the course of the trial, as the main effect of group was not qualified by time interval for the separate analysis of either emotion. However, a group by time interval interaction did occur for the happy expression. As the trial progressed, HCF individuals showed decreased dwell time on the happy expressions, while LCF individuals showed the opposite pattern, with increased dwell time on the happy expression in later intervals. This finding raises the possibility that vigilance for threat interferes with elaborative processing of 'safety' signals. Research on visual search in anxiety disorders suggests that speeded detection of threat depends on faster disengagement from non-threatening stimuli (Rinck, Reinecke, Ellwart, Heuer, & Becker, 2005). In anxious individuals, a tendency to quickly disengage from safety signals may work in tandem with facilitated detection of threat to increase perceptions of vulnerability.

Although the predicted maintenance bias for disgusted expressions was confirmed, the bias did not show the hypothesized specificity, as fearful expressions also held attention longer in the HCF compared to LCF group. This finding appears to be highly consistent with a similar study employing a spatial cueing paradigm, in which a single image is presented as a valid or invalid cue for the location of a subsequent probe. Cisler and Olatunji (2010) found that individuals high in contamination fear had difficulty disengaging attention from (i.e., maintained attention longer on) both disgusting and frightening images when they were presented as invalid cues. Covariation bias research into contamination fear may provide insight into these findings. Connolly, Lohr, Olatunji, Hahn, and Williams (2007) found that HCF individuals overestimate the co-occurrence of both disgusted and fearful expressions with images of contamination. This finding suggests that individuals with high-levels of contamination fear may associate both disgust- and fear-relevant outcomes with contamination threat. These associations could derive from affective experience, as the response to contamination threat may consist of both disgust (at the stimulus) and fear (at the potential consequences of exposure to the stimulus).

Interpretation of the maintenance bias for fear and disgust observed in the present study may require consideration of the heterogeneity of contamination fear. Indeed, a distinction between components of contamination and their affective consequences has been made in the classification of patients with OC contamination concerns (Rachman, 1994). As Cougle, Wolitzky-Taylor, Lee, and Telch (2007) note, whereas some individuals are more bothered by perceptions of "dirtiness" related to contamination, others are more bothered by illness-threat; in the former group, disgust is more prominent in the response to contamination, whereas in the latter, fear appears to be more prominent. Future research should examine whether components of OC contamination concerns differentially bias attention to affective cues, such that concern with dirtiness is related to a disgust cue bias, and concern with illness is related to a fear cue bias.

Another possibility is that the maintenance biases associated with contamination fear in the present study were based on stimulus valence (pleasantness-unpleasantness), as opposed to contamination relevance. Valence would appear to be the simplest property that unites disgusting and fearful (unpleasant) expressions, while differentiating them from happy (pleasant) expressions. If maintenance biases in the HCF group were not determined by the contamination-relevance of stimuli, it would suggest that these biases are not associated with contamination fear, per se, but instead a more general trait, such as negative affect or neuroticism, that is associated with contamination fear. However, the observed maintenance biases were not significantly attenuated when symptoms of trait anxiety were included as a covariate, suggesting that the biases were indeed associated with contamination fear, and thus more likely due to contamination-relevance.

The sustained nature of the maintenance bias observed in this study may distinguish contamination fear from other anxiety-related conditions. In eye tracking research on trait anxiety (Rohner, 2002), spider phobia (Hermans, Vansteenwegen, & Eelen, 1997; Rinck & Becker, 2006), and social anxiety (Garner et al., 2006), increased allocation of attention to threat, though present initially, was found to give way to avoidance. For example, Rohner (2002) found that while anxious individuals initially showed increased dwell time on angry faces, the pattern reversed 1800 ms into the trial; for the last 1000 ms of the 3 s trial, high trait anxiety individuals looked at angry faces *less* compared to low trait anxiety individuals. One possible reason that attentional avoidance was not found in the present study may be attributable to the use of *cues* of threat, as opposed to objects of threat that may be more specific to contamination fear. Disgusted and fearful expressions may convey a probable risk of contamination, whereas images of contaminated objects convey an unequivocal, immediate risk. The ambiguity of threat cues may prompt increased maintenance of attention on the cue, in order to glean information regarding their referent. Further, disgust and fearful expressions, being possible contamination cues as opposed to actual contaminants, are less potent, and may lack the aversiveness required to motivate attentional avoidance.

The use of eye tracking methodology in the present study with individuals high in contamination fear may inform the available literature on attentional processes in OCD. However, these findings should be interpreted with multiple limitations in mind. Although mean scores for the HCF group on the PI contamination fear subscale were well-above the clinical cutoff, these findings require replication with a community sample of patients meeting diagnostic criteria for OCD. While this limitation may prompt concern regarding the generalizability of the present findings, it is attenuated by evidence that studies of analogue OCD samples (i.e., university students scoring highly on measures of OC symptoms) are relevant to understanding OCD symptoms in clinical populations (see Gibbs, 1996 for a review). A growing literature supports the notion that OCD symptoms occur on a continuum of severity and have their origin in largely normal human processes, such as biased thinking and negative reinforcement. Thus, the model predicts that these OCD-related phenomena also occur in the general population. A series of studies investigating the use of non-patient samples in the study of OCD supports this assumption. 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. However, future research utilizing patient samples, and employing images of contamination itself (and other threat-relevant stimuli), as opposed to contamination cues, would further clarify the nature of attentional biases in contamination-based OCD.

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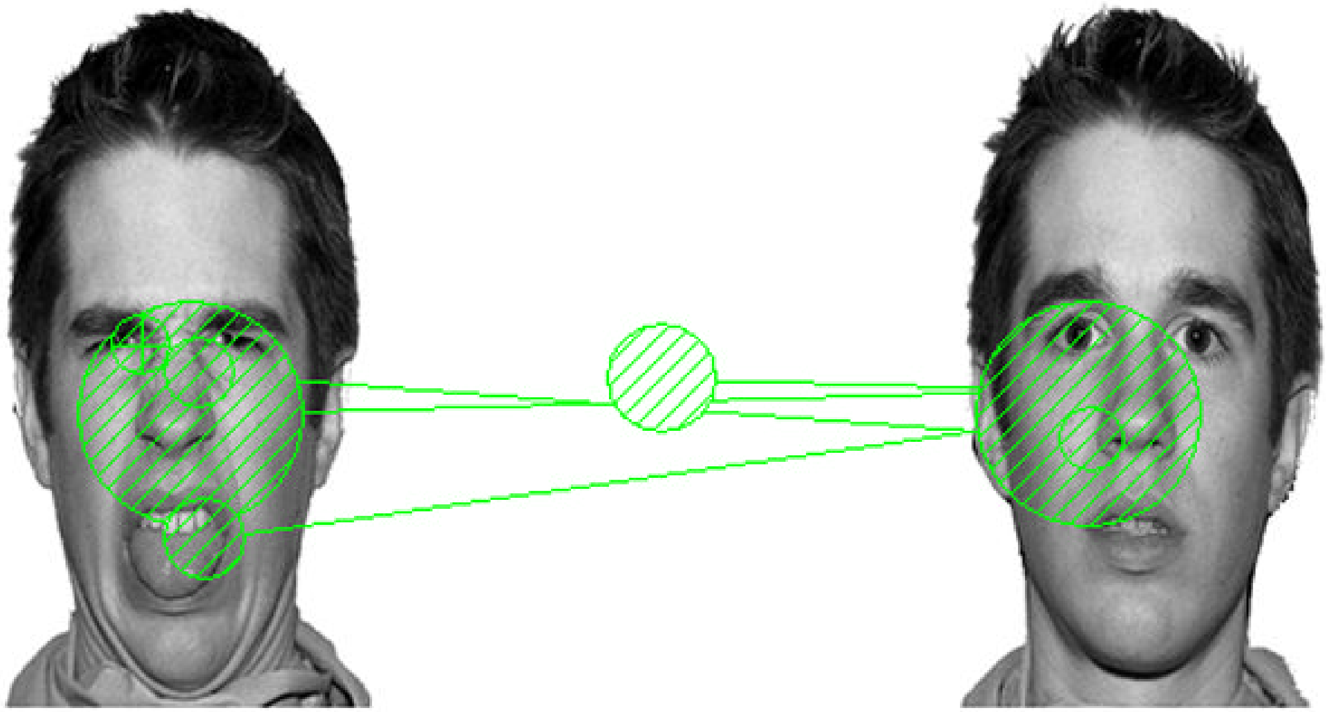

Figure 1.
Eye movement data for a high contamination fear participant, selected randomly from a trial with the disgusted expression. Circles indicate fixations; diameter represents fixation duration; lines illustrate saccade sequence.

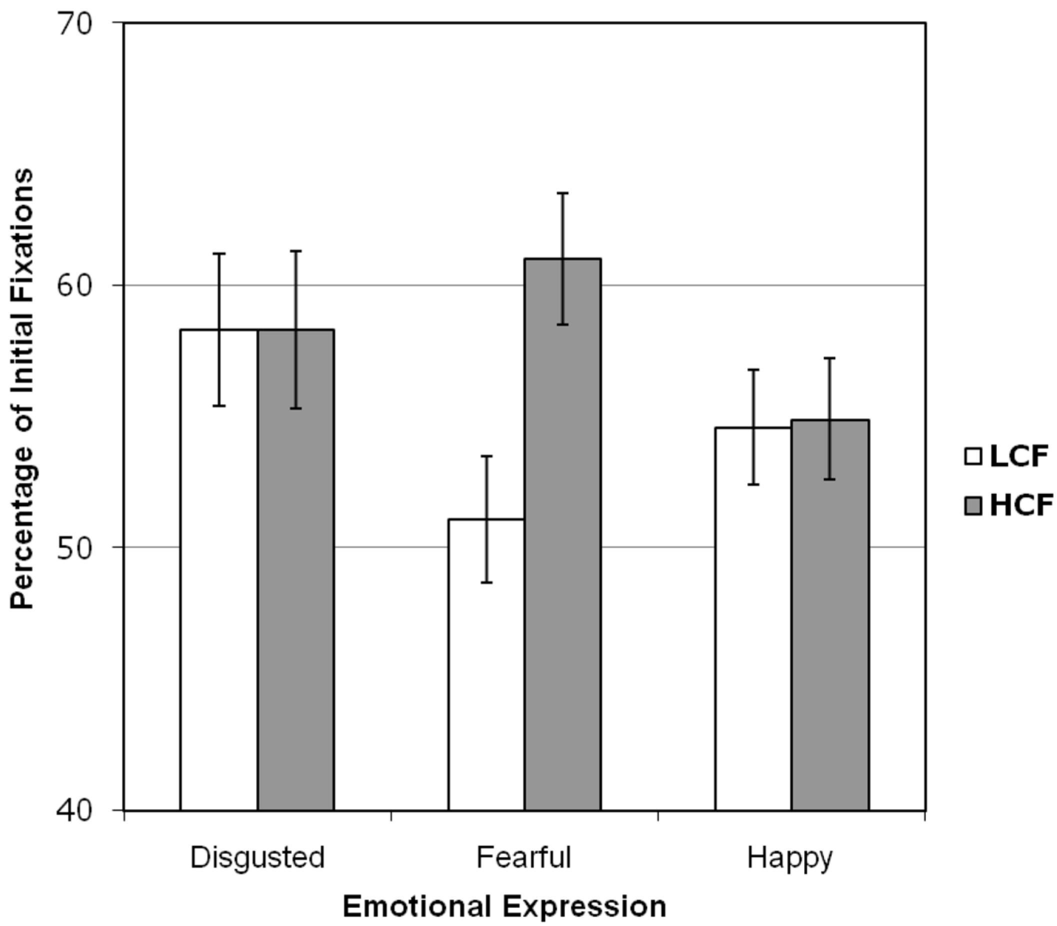

Figure 2.
Group differences in orienting bias for disgusted, fearful, and happy facial expressions. Error bars represent standard error.

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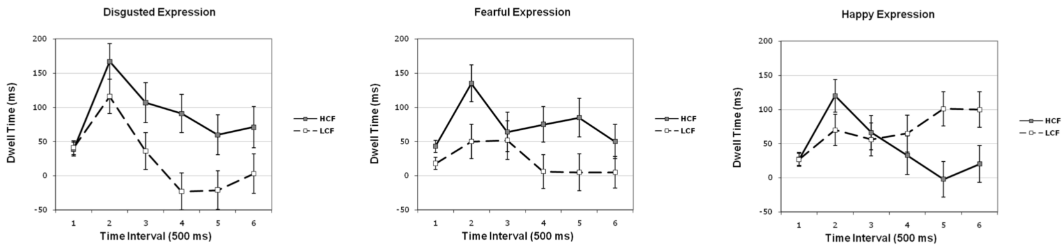

Figure 3.
Group differences in time course of maintenance bias for disgusted, fearful, and happy facial expressions. Error bars represent standard error.

Table 1

Means (SDs) of measures of self-reported symptoms, valence of facial stimuli, and behavioral avoidance by participant group.

Self-Report Measures	**HCF**	**LCF**	
Measure	***M (SD)***	***M (SD)***	***t***
PI	21.35 (4.76)	1.56 (1.26)	19.68***
OCI-R Washing	4.43 (2.23)	0.48 (1.36)	7.49***
DS-R	64.65 (12.62)	42.64 (13.87)	5.74***
STAI-T	45.37 (6.67)	37.91 (7.19)	3.72**

Valence Ratings of Expressions			
Emotion	***M (SD)***	***M (SD)***	***t***
Disgusted	1.00 (.89)	1.56 (1.09)	1.93‡
Fearful	1.67 (1.15)	2.07 (.81)	1.35
Happy	4.85 (.72)	4.34 (.88)	2.08*
Neutral	2.63 (.60)	2.76 (.64)	0.72

Behavioral Avoidance in a Public Restroom			
Outcome	***M (SD)***	***M (SD)***	***t***
% Completion	43% (23)	85% (20)	6.55***
Reported distress	24.68 (7.19)	8.92 (7.43)	7.17***

Note. HCF = High Contamination Fear, LCF = Low Contamination Fear, OCI-R = Obsessive-Compulsive Inventory—Revised, DS-R = Disgust Scale—Revised, STAI-T = State Trait Anxiety Inventory—Trait Version, Form Y,

‡ $p < .07$,

* $p < .05$,

** $p < .01$,

*** $p < .001$.

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Table 2

Means (SDs) for measures of vigilance bias and maintenance bias

Measure	Bias	Expression		
Percentage of initial fixations	Vigilance	Disgusted	Fearful	Happy
HCF		58.3 (14.2)	61 (10.0)	55.9 (11.0)
LCF		58.3 (14.5)	51 (13.0)	55.6 (11.0)
Latency to initial fixation (ms)	Vigilance			
HCF		306 (59)	366 (224)	323 (96)
LCF		327 (138)	327 (107)	314 (97)
Dwell time (ms)	Maintenance			
HCF		535 (419)	450 (345)	264 (364)
LCF		152 (528)	135 (568)	418 (477)

Note. HCF = High Contamination Fear, LCF = Low Contamination Fear; dwell times for emotional expressions are relative to accompanying neutral expression.

Table 3

Means (SDs) for dwell time during 6 intervals of 3000 ms trial

		Time Interval					
Expression	**Group**	**0–500 ms**	**500–1000 ms**	**1000–1500 ms**	**1500–2000 ms**	**2000–2500 ms**	**2500–3000 ms**
Disgusted	HCF	39 (47)	167 (105)	107 (124)	91 (150)	60 (108)	71 (123)
	LCF	41 (52)	116 (142)	36 (148)	−23 (110)	−21 (161)	3 (159)
Fearful	HCF	43 (38)	135 (110)	64 (125)	75 (106)	85 (106)	49 (98)
	LCF	18 (48)	49 (141)	52 (152)	6 (137)	5 (153)	5 (125)
Happy	HCF	27 (44)	120 (120)	66 (120)	33 (132)	−2 (114)	20 (124)
	LCF	27 (48)	69 (106)	56 (121)	65 (134)	100 (132)	100 (137)

Note. HCF = High Contamination Fear, LCF = Low Contamination Fear; dwell times for emotional expressions are relative to accompanying neutral expression.