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Disgust, Fear, and the Anxiety Disorders: A Critical Review

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Abstract

Anxiety disorders have traditionally been conceptualized as reflecting the emotions of fear and anxiety. A developing program of research demonstrates a relation between disgust and three specific anxiety disorders: blood-injection-injury (BII) phobia, spider phobia, and contamination-related obsessive-compulsive disorder (OCD). This review serves three purposes. First, the authors review the response patterns predicted to be observed if the emotional response in these disorders involved disgust versus fear. The review suggests specific response patterns that characterize disgust and fear in the domains of heart rate, facial expression, neural activity, and cognitive processes. Second, the authors review extant research employing measures of these domains in spider phobia, BII phobia, and contamination-related OCD. The evidence suggests that both fear and disgust characterize each of these disorders, but the magnitude at which the emotions characterize the disorders may depend on the response domain measured. For example, disgust may be more involved in spider phobia in appraisals and facial expression, but less involved in neural correlates or heart rate domains. Third, the authors suggest guidelines for future research, including concurrent use of specific measures as well as examining whether the different emotions in different response domains respond to similar interventions (e.g., exposure).

Keywords

fear; disgust; contamination fear; spider phobia; blood-injection-injury

Introduction

An anxiety disorder is typically conceptualized as an interrelated pattern of responding that reflects two emotions; fear and anxiety (Barlow, 2002; 2000; Rosen & Schulkin, 1998). Recent research suggests that fear is an organism's defensive response to a present threat, whereas anxiety is an organism's preparatory response to contexts in which a threat may occur (Barlow, 2002; Davis, 2006; Lang, Davis, & Öhman, 2000; Quinn & Fenselow, 2006; Walker & Davis, 1997). Although research investigating the etiology and maintenance processes of particular anxiety disorders has focused primarily on these two emotions, recent research suggests that some anxiety disorders (e.g., spider phobia, contamination-related obsessive compulsive disorder, blood-injury-injection phobia) may be associated with an additional emotion, disgust (Woody & Teachman, 2000). Indeed, in clinical (McKay, 2006; Olatunji & Sawchuk, 2005; Woody & Teachman, 2000) and basic research (Rozin & Fallon, 1987; Rozin, Fallon, & Augustoni-Ziskind, 1984; Rozin, Fallon, & Mandell, 1984), interest on disgust has grown immensely over the past 20 years, prompting McNally (2002) to announce 'disgust has arrived.'

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Given the wealth of data collected on disgust and fear in spider phobia, blood-injection-injury (BII) phobia, and contamination-related obsessive-compulsive disorder (OCD), it is necessary to examine the relative contributions of disgust and fear in these disorders. Elucidating the magnitude to which disgust and fear contribute to these anxiety disorders will serve several purposes. First, this line of inquiry critically examines the growing program of research on disgust and certain anxiety disorders (e.g., b & McKay, 2007; Olatunji & Sawchuk, 2005; Woody & Teachman, 2000). If disgust functions in anxiety disorders to a comparable magnitude as fear, this growing program of research may develop into a viable paradigm by which particular anxiety disorders (e.g., spider phobia) are conceptualized. Second, this line of inquiry critically examines previous assertions that disgust may play a minor role compared to fear in these anxiety disorders (Edwards & Salkovskis, 2006; Rachman, 2006; Thorpe & Salkovskis, 1998). For example, Edwards and Salkovskis (2006) found that presenting vomit (i.e., a disgust stimulus) during exposure therapy for spider phobia did not lead to a return of self-reported anxiety towards spiders. These authors concluded that “although disgust clearly can be part of the emotional reaction to some phobic stimuli, the presents results suggest that this reaction may be secondary to fear” (p. 69). Critical examination of this competing assertion is important in development of the disgust program of research. Third, this line of inquiry would facilitate the development of theories by which these disorders are developed and maintained. For example, Antony and Barlow’s (2002, p.408) model of the development of specific phobia does not, at least explicitly, include a component of disgust. Conversely, Armfield’s (2006) recent theory of cognitive vulnerabilities towards developing fear posits that perceptions of disgust are a pivotal factor in the development of fear towards particular objects/situations. Elucidation of the relative contributions of disgust and fear in these disorders would facilitate comprehensive models of how these disorders are developed and maintained. Fourth, this line of inquiry may begin to suggest therapeutic techniques to enhance treatment efficacy. For example, extant treatments of specific phobia are efficacious (Choy et al., 2007; Wolitzky-Taylor, *in press*), yet effect sizes tend to be variable (Wolitzky-Taylor et al., *in press*). If disgust does play a prominent role in these anxiety disorders, the inclusion of procedures to target disgust may lead to more consistent treatment effects.

The purpose of the current review is to examine the relative contributions of fear and disgust in spider phobia, BII phobia, and contamination-related OCD. This purpose is specifically pursued by examining the degree to which the emotional response towards disorder-relevant stimuli in these anxiety disorders is characteristic of disgust or fear. For example, to what degree does the emotional response towards spiders in spider phobia resemble a disgust response? To what degree does the emotional response towards spiders in spider phobia resemble a fear response? The review focuses on the relative contributions of disgust and fear in the emotional response of these disorders because of the common conceptualization of these disorders as fear and anxiety based (e.g., Antony & Barlow, 2002; Rachman, 2006). Moreover, treatments of these disorders based on fear and anxiety conceptualizations do not include procedures to target disgust (e.g., see Öst and colleagues’ treatments for spider and BII phobia; Öst, Fellenius, & Sterner, 1991; Öst, 1997). If disgust is indeed a part of the emotional response in these disorders, conceptualizations and treatments of the disorders may need to be modified in order to account for disgust. The current review does not examine the relative contributions of disgust and fear in the *etiology* of these anxiety disorders. Although the role of disgust in the etiology of these disorders is theoretically interesting in its own right (see, for example, an interesting study by Muris et al., 2008), the literature on the role of disgust in the etiology of these anxiety disorders is currently limited and conclusions would be difficult to derive. The review is focused on spider phobia, BII phobia, and contamination-related OCD because they have received the most empirical and theoretical attention (Olatunji & Sawchuk, 2005; Woody & Teachman, 2000).

There are three sections to the current review. First, elucidating the relative contributions of disgust and fear necessitates an elucidation of the specific response topographies expected to be observed if the emotional response is fear or disgust. These specific response components then directly facilitate an examination of the relative contributions of disgust and fear. That is, if the emotional response involves disgust, it follows that disgust specific response domains would be observed; if the emotional response involves fear, it follows that fear specific response domains would be observed. Second, research employing specific measures of disgust and fear in spider phobia, BII phobia, and contamination-related OCD is critically examined in order to elucidate the relative magnitude to which the emotional response reflects fear and disgust. Finally, guidelines for future research investigating the relation between disgust and anxiety-related pathology are put forward to facilitate a progressive program of investigation.

Distinguishing Disgust from Fear

Theoretical background of operational definitions

Fear is characterized by an organism's defensive response to imminent threat (Barlow, 2002; 2000; Quinn & Fenselow; 2006). At the phenomenological level, fear is typically defined by three response systems (Lang, 1968; Lipp, 2006; Kozak & Martin, 1982): overt behavior, verbal-cognitive, and physiological. For example, an individual's fear of spiders may be exhibited by inhibited approach towards a spider in a behavioral approach task (i.e., overt behavioral system), verbally reported subjective units of distress (SUDs) ratings in the presence of spiders or attentional bias towards spiders (i.e., verbal-cognitive system), and a heightened heart rate in the presence of spiders (i.e., physiological system).

Disgust is characterized by a revulsion response towards potential contamination (Olatunji & Cisler, *in press*; Olatunji & Sawchuk, 2005; Rozin & Fallon, 1987; Rozin, Haidt, & McCauley, 2000). At the phenomenological level, researchers studying disgust typically define disgust in the same three systems as fear (Olatunji & Cisler, *in press*; Woody & Teachman, 2000). Woody and Teachman (2000) differentiate fear and disgust along the dimensions of behavioral intentions, appraisal, and physiological processes. They argue that avoidance characterizes both fear and disgust, but for different reasons: "fear-motivated avoidance protects the person from perceived danger, while disgust-motivated avoidance may be more often linked to sensation or imagery" (p. 293). The authors do not provide a means to differentiate the reasons for avoidance, and consequently researchers are left with the same indicator of avoidance to define both fear and disgust. One problem with using avoidance to define both fear and disgust is that the topographical form of the avoidance is similar for both fear and disgust. For example, if disgust motivates avoidance on a behavioral approach task (BAT), it will result in a low score on the BAT. If fear motivates avoidance on a BAT, it will also result in a low BAT score. Even if one emotion (e.g., fear) results in a lower BAT score than the other emotion (e.g., disgust), the fact that the scores are in the same metric leads to the possibility that disgust did not really motivate avoidance; rather what was labeled 'disgust' was really a subdued fear response. Given that the topographical features of avoidance for disgust and avoidance for fear are apparently quite similar, the observation of avoidance cannot differentiate disgust from fear. Avoidance, then, does not appear to be a useful means to examine the relative contributions of disgust and fear.

Woody and Teachman (2000) state that "appraisals of a stimulus as potentially threatening or dangerous is associated with a fear response... but disgust appraisals seem to focus more specifically on the threat of contamination (p. 295). Appraisals/cognitive processes of disgust and fear may be topographically distinct and appear to be useful in examining the relative contributions of disgust and fear. Physiological systems also appear to offer a viable indicator to differentiate fear and disgust. Woody and Teachman (2000) suggest that heart rate acceleration characterizes fear, whereas heart rate deceleration characterizes disgust, indicating

that physiology can differentiate fear from disgust. The topography of heart rate response is distinct for fear and disgust, which suggests that heart rate response is a useful indicator to examine the relative contribution of disgust and fear.

Emotion theorists offer a perspective of identifying and measuring emotions that extends the popular three systems model of fear (e.g., Lang, 1968, Lipp, 2006). Izard (1993; 1992) suggests that basic emotions are characterized by unique neural substrates and expressive components. Ekman (1992) argues that basic emotions can be differentiated based on the signal of the emotion (e.g., facial expression) and physiology. Based on Ekman (1992), Izard (1993; 1992), and Woody and Teachman's (2000) analyses, there are four response domains where disgust and fear would be expected to produce specific response topographies: physiology, neural substrate, facial expressions, and appraisals/cognitive processes. The following sections review basic research on the distinctness of the topography of disgust and fear responses in the domains of heart rate, neural substrate, facial expression, and appraisals/cognitive processes. Again, the purpose of the review is to elucidate the expected response topographies if the emotion is fear or disgust (e.g., what is the expected heart rate topography if the emotion is disgust?).

Heart rate

Ekman and colleagues (1983) directed participants to contort their face into emotional configurations (i.e., directed facial action task) or asked participants to relive particularly salient emotional experiences in their past (i.e., relived emotions task). Regardless of task, results revealed greater heart rate acceleration for fear compared to happiness, and heart rate deceleration for disgust compared to all other emotions. The authors did not report if the deceleration for disgust was significantly different from zero (i.e., disgust results in heart rate deceleration compared to baseline and not just to other emotions). These results suggest that a particular pattern of autonomic nervous system (ANS) activity can differentiate fear from disgust: fear results in heart rate acceleration relative to positive emotions; disgust results in heart rate deceleration compared to positive emotions. The differentiation of fear and disgust based on heart rate has since been replicated. For example, Levenson, Ekman, and Friesen (1990) found that participants engaged in a directed facial action task or relived emotions task displayed heart rate acceleration for fear, but "unchanged or small decelerations in heart rate during disgust" (p. 380). Levenson, Carstensen, Friesen, and Ekman (1991) found greater heart rate acceleration among elderly adults during fear compared to disgust emotion-eliciting activities, but disgust was not associated with a decrease in heart rate. The finding of heart rate acceleration for fear is consistent with much research and theory¹ (see e.g., Barlow, 2002; Lang, 1968; Lipp, 2006), and as a result, the review will focus on the physiological correlates of disgust.

The Ekman and colleagues (Ekman et al., 1983; Levenson et al., 1991; 1990) studies are limited in that they reveal differential heart rate responding between fear and disgust only during two emotion eliciting activities (see Boiten, 1996 for a critique of the directed facial action task). Other research, however, has found heart rate deceleration towards ecologically valid stimuli. Olatunji, Haidt, and McKay (*in press*) found that scores on a measure of the propensity to respond with disgust were negatively correlated with heart rate responding during videos depicting vomit or blood draws. Importantly, that a similar decrease was found across two types of disgust stimuli suggests that the heart rate deceleration may be robust across types of

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¹One limitation to dissociating fear and disgust based on heart rate increase or decrease is that a heart rate increase is also indicative of the behavioral activation system and subsequent active avoidance (Fowles, 1980; 1988). Similarly, heart rate decrease may be indicative of the behavioral inhibition system and subsequent passive avoidance. Accordingly, whether fear or disgust is associated with a heart rate increase or decrease may be dependent on whether the organism displays active versus passive defensive responses to the fear or disgust stimuli.

disgust stimuli. Stark, Walter, Schienle, and Vaitl (2005) presented non-selected individuals with neutral, disgusting, or mutilation pictures and found heart rate deceleration for the disgusting and mutilation pictures compared to neutral pictures. Also, they found that the deceleration of heart rate correlated positively with the subjective ratings of disgust for the pictures. Thus, greater heart rate deceleration accompanies greater subjective experiences of disgust. Klorman, Weissberg, and Wiesenfeld (1977) found greater heart rate deceleration among females during mutilation slides compared to neutral slides. Klorman and Ryan (1980), however, found that males did not differ in heart rate response to mutilation compared to neutral slides. Hare, Wood, Britain, and Shadman (1971) found greater heart deceleration among non-selected male individuals during pictures of homicide scenes compared to picture of nude models or neutral scenes. Lang and colleagues (1993) found decreased heart rate towards disgust compared to fear and neutral pictures among non-selected individuals. Finally, Rohrmann and Hopp (2008) found decreased heart rate during an amputation film compared to a neutral film.

The results of physiological studies examining heart rate suggests a robust heart rate deceleration for disgust compared to fear, and a moderately consistent heart rate deceleration for disgust compared to neutral stimuli with only two studies yielding no differences between disgust and neutral (Klorman & Ryan, 1980; Levenson et al., 1991). The finding of slower heart rate for disgust compared to neutral stimuli is important in that it suggests that the heart rate component of the disgust response does not resemble a fear response of smaller magnitude. Instead, the disgust response likely involves a decreased heart rate compared to neutral stimuli, whereas fear involves an increase. The finding of heart rate deceleration for disgust has been theorized to reflect parasympathetic activation (Page, 1994). Rohrmann and Hopp (2008) found support for this assertion, but also found mild evidence for sympathetic activation during disgust inductions. Future research is necessary to clarify the autonomic nervous processes underlying disgust.

There have been two studies showing heart rate acceleration towards disgust stimuli compared to neutral stimuli (Prkachin, Williams-Avery, Zwaal, & Mills, 1999; Vrana, 1993), but these studies used guided imagery as opposed to pictorial stimulus presentation. According to McKay and Tsao (2005), “the studies reporting increased sympathetic activation relied on imagery, which may better address *anticipatory* reactions. In this case participants may label the anticipatory reaction as anxiety, leading to sympathetic activation, while live exposure more likely produces the diphasic reaction, with parasympathetic arousal then occurring as well” (p. 356; italics added). The interpretation of heart rate acceleration towards particular disgust stimuli explains the data in a manner that does not contradict the findings of heart rate deceleration towards disgust stimuli. This differential pattern of heart rate suggests that if the emotion of disgust is present, it could be expected that a heart rate deceleration would be observed; if fear is present, it could be expected that heart acceleration would be observed.

Neural Correlates

Calder, Keane, Manes, Antoun, and Young (2000) reported data on a neurological patient with a lesion largely specific to the insula. This individual had selective deficits in recognizing disgust, but not other emotions (e.g., fear). Moreover, this individual’s deficits in recognizing disgust extended across sensory modalities. The patient also scored low relative to controls on an individual difference measure of the propensity to experience disgust. This case study implicates the insula as a neurological substrate necessary for both disgust perception and experience.

Neuroimaging techniques have also been employed to test the neural substrates underlying disgust and fear. Phillips et al. (1997) presented individuals with pictures of fearful, disgusting, or neutral faces. Functional magnetic resonance imaging (fMRI) revealed greater activation of

the amygdala for fear faces compared to neutral faces, and greater activation of the anterior insula for disgust faces compared to neutral faces. The insular cortex is heterogeneous in function (Augustine, 1996), thus it is important that Phillips and colleagues found activation for disgust faces in a specific region of the insula (i.e., the anterior insula). Phillips and colleagues also found that the amygdala did not respond to disgust faces, and the insula did not respond to fear faces. Phillips and colleagues (1998) replicated these results in a subsequent study. Williams and colleagues (2005) similarly presented individuals with fear and disgust faces and found amygdala activation towards fear faces and insula activation towards disgust faces. These results suggest a double dissociation between neural substrate and stimulus type, which is consistent with the theory of basic emotions (Ekman, 1992; Izard, 1993; 1994), which posit unique neural substrates for the basic emotions. Given that the function of disgust is theorized to be avoidance of contamination (Rozin & Fallon, 1987), the finding that a neural region associated with gustatory perception (i.e., the anterior insula) is activated by disgust facial expressions strongly suggests that this region may be a critical neural substrate underlying disgust (also see Calder, Lawrence, and Young, 2001). The finding of amygdala activation in response to fear stimuli is consistent with a large body of data implicating the amygdala in the fear response (Calder et al., 2001; LaBar & Cabeza, 2006; LeDoux, 2000; Phan, Wager, Taylor, & Liberzon, 2004; 2002; Phelps & LeDoux, 2005).

The studies mentioned above (Phillips et al., 1998; ¹⁹⁹⁷; Williams et al., 2005) are limited to revealing specificity of the insula only for facial expressions as stimuli, which limits the degree to which the results suggest that the insula is involved in experiencing disgust, as opposed to merely being involved in recognizing disgust. However, the finding of anterior insula activation specificity towards disgust facial expressions has been replicated using ecologically valid types of disgust stimuli. Wright, He, Shapira, Goodman, and Liu (2004) compared neural activation between contamination, mutilation, and fear-related pictorial stimuli among non-clinical participants. Results revealed greater anterior insula activation for both contamination and mutilation stimuli compared to neutral stimuli and the insula did not respond to fear pictures. Adding further evidence, Fitzgerald and colleagues (2004) found that participants asked to recall and re-experience recent disgusting situations exhibited insula activation but not amygdala activation. These data further support the hypothesis that the insula is a specific neural substrate for the experience of disgust and not just the perception of disgust faces.

The double dissociation hypothesis has not, however, been consistently supported. For example, Schienle and colleagues (2002) found activation of the insula *and* the amygdala in response to various disgusting stimuli (e.g., maggots, cadavers, dirty toilets, vomit). They also found activation of the insula in response to fear stimuli. An important inconsistency across studies investigating the neural regions underlying fear and disgust is that the region of the insula under investigation is not reported in all studies. For example, Phillips et al. (1997) and Wright et al. (2004) report specificity of the anterior insula for disgust, but some studies revealing non-specificity of the insula do not report the region of the insula investigated (Schienle et al., 2002; Shafer et al., 2005; Stark et al., 2004). These inconsistencies make their results difficult to interpret. In fact, recent meta-analyses of positron emission tomography (PET) and fMRI studies (Murphy, Nimmo-Smith, & Lawrence, 2003; Phan et al., 2004; 2002) lend support to the double dissociation hypothesis. Although these studies found that both the amygdala and insula can respond to either fear or disgust stimuli, a high percentage of studies support specificity (e.g., disgust and the insula; fear and the amygdala) compared to the percentage of studies suggesting non-specificity. Thus, there is a higher probability of observing anterior insula activation in response to disgust stimuli compared to amygdala activation (also see Cisler & Olatunji, *in press* for a recent review of neuroimaging studies of disgust). Accordingly, anterior insula activation would be expected if the emotion was disgust, and amygdala activation would be expected if the emotion was fear. One limitation of using anterior insula activation as an indicator of disgust is that the anterior insula has also been

implicated in interoceptive processes (Critchley et al., 2004). Accordingly, disgust responding would be expected to produce anterior insula activation, but generic interoceptive awareness may also produce anterior insula activation. As with the other response domains, conclusions based on neural activation must be made with caution.

Facial expression

Yartz and Hawk (2002) presented individuals with fear, disgust, positive, and neutral pictures and found greater levator labii and corrugator muscle activation based on electromyogram (EMG) recordings for disgust compared to all other picture types, and less corrugator muscle activation for fear compared to all other muscle picture types. Vrana (1994; 1993) asked individuals to imagine disgust, anger, or neutral scenarios and found that activation in the levator labii was greater during disgust compared to anger and neutral imagery, and activation in the corrugator was greater for disgust compared to neutral stimuli. Lang, Greenwald, Bradley, and Hamm (1993) did not measure levator labii activation but found greater corrugator muscle activation in response to disgust pictures compared to fear, but not neutral pictures. Findings regarding specificity of the corrugator to disgust, however, are not consistent. Several studies have found increased corrugator muscle activation in response to fear compared to pleasant or neutral emotions (Sinha & Parson, 1996; Schwartz, Ahern, & Brown, 1979; Dimberg, 1990; 1986, see Dimberg, 1990 for a review). Given that both fear and disgust are associated with increased corrugator activation, the observation of increased corrugator activation does not appear able to reliably differentiate fear from disgust.

More promising, however, is the levator labii. Only one study failed to find increased levator labii activation for disgust (Wolf et al., 2005), compared to three studies (Vrana, 1994; 1993; Yartz & Hawk, 2002) across different sensory modalities that did find increased levator labii activation for disgust. Moreover, Yartz and Hawk found that fear stimuli did not result in levator labii activation. The observation of levator labii activation in response to a stimulus, then, seems to indicate the emotion of disgust and not fear. Consequently, it would be predicted that if a stimulus elicits disgust, then levator labii muscle activation is likely to be observed. Additionally, the levator labii is a muscle used in raising the upper lip, which is involved in rejecting food from the mouth and consistent with the evolutionary function of disgust in protecting from disease/contagion (Rozin & Fallon, 1987; Rozin et al., 2000).

Cognitive processes

There has been limited research on normative cognitive processes in disgust (Williams et al., *in press*). Moreover, there has been limited research comparing the cognitive processes of disgust and fear. The limited research on cognitive processes in disgust is included in this review in light of the importance of appraisals (Armfield, 2006; Teachman, 2006; Woody & Teachman, 2000) and cognitive processes in general (Mathews & MacLeod, 2005) in understanding disgust and fear. This section outlines the empirical evidence of possible cognitive processes in disgust, and then describes existing theories that differentiate cognitive processes of disgust and fear.

Rozin, Millman, and Nemeroff (1986) presented participants recruited from either a university or the community with two glasses of different juices. A dead and sterilized cockroach was then dropped into one of the glasses and then removed. Participants were notified that the cockroach was sterilized and perfectly safe. Participants rated their desire of drinking the 'roached' juice significantly less after the 'roaching.' Similarly, Rozin, Markwith, and McCauley (1994) found in a questionnaire study that college students were less willing to wear a thoroughly laundered sweater after it had been worn by a man with AIDS compared to a man without AIDS. These studies illustrate the law of contagion; that is, the disgust-related appraisal that 'once in contact, always in contact' (Rozin & Fallon, 1987).

Rozin and colleagues (1986) presented participants with fudge shaped to resemble dog feces and rubber fake vomit. Participants were less willing to eat the fudge shaped to resemble dog feces relative to the same type of fudge shaped into a disc, and participants were less willing to place the rubber fake vomit in their lips relative to a rubber stopper. This study illustrates the law of similarity; that is, the disgust-related appraisal that the images resembling a noxious object are also noxious (Rozin & Fallon, 1987).

Woody and Teachman (2000) suggest that disgust appraisals differ from fear appraisals in that disgust appraisals center on the threat of contamination, whereas fear appraisals may be more centered on broad estimations of danger. These authors' reasoning derives from Rozin and colleagues (Rozin et al., 1986; Rozin et al., 1994) research on the laws of contagion and similarity. Teachman (2006) expanded on the disgust appraisal processes theorized in Woody and Teachman (2000 and proposed an interesting analogy to Salkovskis' (1996) discussion of primary and secondary appraisals in OCD. Teachman theorized that primary appraisals in disgust reflect beliefs about 1) disgusting properties of an object (e.g., 'that spider is gross'), or 2) the degree to which a situation or object will elicit disgust (e.g., 'that spider will make me feel disgusted'). Secondary appraisals in disgust reflect individuals' beliefs about the perceived consequences if the primary appraisals are true (e.g., 'if I feel disgusted, I won't be able to cope or manage'). The important concept common to Teachman (2006) and Woody and Teachman's (2000) analyses that is relevant to the current review is that the primary appraisals for disgust and fear are likely to be where differences emerge. That is, primary appraisals of disgust (e.g., 'that thing is gross,' 'that fly will contaminate my drink') center on attributes of the stimulus/situation that are topographically quite distinct from appraisals of fear (e.g., 'that snake is dangerous,' 'I might crash if I fly in a plane). Secondary appraisals of disgust and fear may be similar and both revolve around individuals' beliefs in whether they can cope if their primary appraisals are true.

Research and theory on cognitive processes suggest three manners in which disgust and fear differ: 1) disgust involves the law of contagion, 2) disgust involves the law of similarity, and 3) disgust primary appraisals involve beliefs about the object/situation as disgusting, contaminating, or able to elicit the feeling of disgust. Fear appraisals, in contrast, center on estimations of danger/harm.

However, appraisals do suffer from one limitation in regards to their specificity. Woody and Teachman (2000) discuss what they refer to as the Imprecise Emotional Label model, in which the link between fear and disgust is caused by the confusion of fear and disgust. Thus, even if an individual appraises a stimulus as dangerous, the actual emotion eliciting the appraisal may be disgust, but the individual merely confuses the emotion and uses the wrong linguistic appraisal. Conversely, even if an individual appraises a stimulus as contaminating, the actual emotion eliciting the appraisal may be fear, but the individual merely confuses the emotion and uses the wrong linguistic appraisal. Similarly, verbally reported levels of disgust or fear (i.e., subjective units of distress [SUDs] ratings for the emotion of disgust or fear) also have been used to measure the cognitive system of disgust and fear in analogue-clinical populations (Olatunji, Smits et al., 2007; Sawchuk et al., 2002; Smits et al., 2002). A SUDs rating of disgust could be conceptualized as a primary appraisal of disgust² (i.e., a SUDs rating measures individuals' beliefs that the object/situation has disgust eliciting properties). Research has shown that SUDs ratings of disgust are highly correlated with SUDs ratings of fear (also see Olatunji & Cisler, *in press*), with reported *r* values of .68 (Olatunji, Smits, et al., 2007), .83 (Sawchuk, Lohr, Westendorf, Meunier, & Tolin, 2002), .86 (Smits et al., 2002; BAT 2), .89

²An alternative conceptualization of SUDs ratings is simply as self-reported emotional experiences. SUDs ratings will be considered appraisals in this paper in order to 1) be consistent with Teachman's (2006) theory of appraisals in disgust, and 2) provide another indicator of possible cognitive processes in disgust and fear.

(Olatunji & Deacon, 2008), and .90 (Smits et al., 2002; BAT 1). Consequently, the observation of elevated SUD ratings for one emotion could actually be due to causally prior elevations of the other emotion. Although appraisals and SUDs of disgust and fear are topographically distinct and therefore useful in examining the relative contributions of disgust and fear, there appear to be slight problems with specificity. Accordingly, appraisals and SUDs will be used in the current review, but conclusions must be tempered by these limitations.

Summary

There appear to be four response domains in which the specific topographies for disgust and fear are expected to differ. If the stimulus elicits disgust, it follows that heart rate deceleration, anterior insula activation, levator labii activation, and appraisals centering on disgusting properties or transmission of contagion will be observed. Importantly, these response topographies generally converge well with the theorized evolutionary function of disgust - avoidance/rejection of contagions. That is, the levator labii is a muscle involved in rejecting food from the mouth, the anterior insula is involved in gustatory processes (Calder et al., 2001), and implausible beliefs about the transmission of contagion (e.g., 'once in contact always contaminated') and appraisals of objects as disgusting all appear related to the similar function of avoiding harmful disease or contagion carrying substances. It is difficult to explain why disgust would be associated with a decrease in heart rate. Analogously, Page (1994) suggested that the fainting response in BII phobia may actually not have an evolutionary advantage. It may also be the case that a heart rate deceleration is a correlate of disgust and not functionally involved in achieving the evolutionary purpose of disgust. Alternatively, Stark and colleagues (2005) suggested that decreased heart rate in disgust may be intertwined with increased attention towards disgust stimuli, given that increased attention is also associated with heart rate decrease. Future research and theory on this issue is needed.

The review suggests that if the stimulus elicits fear, it follows that heart rate acceleration, amygdala activation, and appraisals centering on danger will be observed. These response topographies also converge well with the theorized evolutionary function of fear - avoiding/escaping danger (e.g., Öhman & Mineka, 2001). Note, however, that there may not be a specific facial expression indicator for fear (Kring & Bachorowski, 1999). Given that the reliability of any one measure is questionable (e.g., Klorman & Ryan, 1980; Levenson et al., 1991; Schienle et al., 2002; Wolf et al., 2005; Woody & Teachman, 2000), future research investigating whether disgust operates in anxiety disorders should include multiple indicators (e.g., heart rate and facial muscle tension) in order to most accurately account for the presence and absence of both emotions.

A Critical Review of Disgust-Related Anxiety Research

The previous sections identified specific indicators of disgust and fear across four response systems. The following sections review extant research employing these specific measures among spider phobia, BII phobia, and contamination-related OCD. The review is limited to studies using these emotion indicators to examine emotional responding towards disorder-relevant stimuli. This limitation is to keep the review focused on examining the relative magnitude to which disgust and fear characterize the emotional response in these disorders. A summary of the review is provided in Table 1.

Spider Phobia

Facial Expression—de Jong, Peters, and Vanderhallen (2002) assessed facial muscle activation during spider-related guided imagery and disgust-related imagery among spider fearful and control women. Results revealed greater levator labii muscle activation during both disgust and spider-related guided imagery compared to another muscle region, and importantly,

the spider phobic group displayed greater levator labii muscle tension during spider-related imagery compared to the control group. Vernon and Berenbaum (2002) measured facial expression during BAT towards a live tarantula through coding videotapes of participants' reactions during the BAT. Spider fearful individuals exhibited greater disgust (e.g., raised upper lip, which indicates levator labii muscle activation) and fear (e.g., brow raised, lips tense) facial expressions compared to non-fearful individuals. There were no differences in the frequency of disgust and fear facial expressions.

Heart Rate—Hare (1973) found that subclinical spider fearful participants displayed heart rate acceleration towards spider-related pictures but not towards neutral stimuli, and also that a control group did not display heart rate acceleration towards spider-related pictures. This finding of heart rate acceleration among spider fearful individuals has been replicated (Fredrikson, Wik, Annas, & Ericson, 1995; Sarlo, Palomba, Angrilli, & Stegagno, 2002; see Table 1). Sarlo and colleagues (2002) observed an initial heart rate increase followed by a statistically significant decrease among spider phobics during viewing of a spider film. This pattern is notably similar to the diphasic heart rate response in BII phobia (see section *BII phobia* below), which has been theorized to reflect parasympathetic activity and the emotion of disgust (Page, 1994). Importantly, Sarlo and colleagues found that sustained sympathetic activity predicted the heart rate response across time in spider phobics, but the relation between sympathetic activity and heart rate response among BII phobics became weaker across time and during the second phase heart rate decline. Thus, the heart rate pattern among spider phobics in this study appears to reflect sympathetic activity, and consequently fear, as opposed to parasympathetic activity and disgust.

Neural Substrate—Several studies have examined neural responses to disorder relevant stimuli in spider phobia (see Table 1). Goossens and colleagues (*in press*) found greater amygdala activation towards spider stimuli compared to a control group, but this difference disappeared after exposure therapy. However, the results also demonstrated greater insula cortex activation compared to control participants pre-treatment and this difference also disappeared after treatment. These results suggest that fear *and* disgust may characterize spider phobia. Straube, Mentzel, and Miltner (2006) found that spider phobics display amygdala *and* insula activation when attending to spider pictures, but only amygdala activation when the spider pictures are present but not part of the primary experimental task. The finding of amygdala activation when the spider was not part of the primary task suggests automaticity, such that conscious control and effort were not necessary (Moors & de Houwer, 2006). That fear appeared to be automatic whereas disgust did not suggests that the fear response may come first, which is later followed by disgust. Automaticity of only the fear response also demonstrates the comparative ease with which spiders elicit fear relative to disgust. However, these interpretations must be tempered by the fact that they are based on one isolated study. Larson and colleagues (2006) found that immediate amygdala activation in response to spider stimuli differentiated between spider phobics and control participants, which further suggests a key role of the amygdala, and fear, in spider phobia. Overall, neuroimaging studies suggest that both fear and disgust are present in spider phobia, but that the fear response may be automatic, whereas the disgust response may not. One limitation to these studies is that they did not document that insula cortex activation was specific to the anterior insula, thus it is difficult to discern what function of the insula the significant activation actually indicates.

Cognitive Processes—A few studies demonstrate that individuals with spider phobia exhibit the 'law of contagion' appraisal towards spiders. Mulken, de Jong and Merckelbach (1996) found that women with spider phobia were significantly less likely to eat a cookie after a spider had walked across it compared to women without spider phobia. Importantly, the two groups did not differ in their likelihood of drinking a contaminated cup of tea, suggesting that

there were no differences between the groups in general sensitivity to dirtiness. This study illustrates that spider phobia may be characterized by appraisals of disgust, specifically the law of contagion (i.e., 'once in contact, always in contact'). Other studies have since replicated this law of contagion effect in spider phobia (de Jong and Muris, 2002; Woody, McLean, & Klassen, 2005). One limitation of these studies is that they do not offer an appropriate comparison for fear-related cognitive processes, thus the relative contributions of disgust and fear cannot be compared.

Some studies have used experimental tasks (Implicit Association Tasks [IAT], expectancy bias paradigm) that assess whether spider phobic individuals associate spiders with disgust-related stimuli or fear-related stimuli. These experimental designs provide some evidence of whether the cognitive processes in spider phobia involve disgust and/or fear. For example, associating spiders with disgust outcomes provides evidence, albeit indirectly, that spiders are appraised as disgusting. Importantly, these studies assess associations/expectancies for both fear and disgust related stimuli, thus allowing an estimate of the relative contributions of fear and disgust. Teachman, Gregg, and Woody (2001) used an IAT with pictures of spiders as the target stimuli and disgust attributes (e.g., gross) and fear attributes (e.g., harm) as separate categories. Results revealed that spider fearful individuals associated spiders with both disgust and fear attributes to a greater degree than an anxious control group. Huijding and de Jong (2007) employed an IAT with pictures of spiders as the target stimuli and disgust attributes (e.g., 'dirty') and fear attributes (e.g., 'attacking') as separate categories. Results revealed that individuals with spider phobia associated spiders with both fear and disgust attributes to a greater degree than did non-phobic individuals. The magnitude of disgust associations did not appear to differ from the magnitude of fear associations. van Overveld, de Jong, and Peters (2006) asked participants to rate whether they expected pictures of spiders, maggots, dogs, and rabbits to be followed by disgust outcomes (i.e., drinking a distasteful fluid), fear outcomes (i.e., an electric shock), or no outcome. The authors found that high spider fearful individuals expected both disgust and fear outcomes to follow spiders to a greater degree than low spider fearful individuals. There was no difference between the magnitude of expectancies for disgust or fear outcomes. However, expectancies of disgust outcomes following spiders significantly predicted self-reported spider fear, but fear-expectancies did not. Using a similar methodology, de Jong and Peters (2007a) found that spider fearful individuals expected a disgust outcome to follow spider pictures, but did not expect a fear outcome to follow spider pictures.

Some studies have also asked participants to rate how disgusted and frightened they feel during exposure to spiders/spider-related stimuli. These types of assessments provide some evidence of the types of primary appraisals individuals make about spiders and their responses towards spiders. Olatunji and Deacon (2008) engaged spider fearful and nonfearful individuals in a BAT task towards a realistic looking, but fake, tarantula. Spider fearful individuals self-reported significantly more fear and disgust compared to non-fearful individuals. Spider fearful individuals reported more fear than disgust, but it was not reported whether this difference was significant. Vernon and Berenbaum (2002) also found greater self-reported fear and disgust during a BAT towards a live spider, but there was a trend for greater self-reported disgust compared to self-reported fear. Sawchuk and colleagues (2002) presented spider fearful and nonfearful individuals with spider pictures, measured self-reported fear and disgust, and found greater fear and disgust in the spider fearful compared to non-fearful individuals. Spider fearful individuals also exhibited greater self-reported fear relative to disgust. Tolin and colleagues (1997) used a similar methodology and found that spider fearful participants again rated more fear and disgust towards spider pictures relative to non-fearful individuals, but there were no differences in self-reported ratings between fear and disgust towards spiders. Finally, Thorpe and Salkovskis (1998) also found that individuals with spider phobia rated pictures of spiders as more disgusting and frightening compared to non-phobic individuals; differences between fear and disgust ratings were not reported.

Summary: Facial expression data indicate both fear and disgust, but there is more consistent evidence for a disgust facial expression. Cognitive measures generally implicate both disgust and fear, with a slight trend favoring disgust among the IAT/expectancy bias studies. In contrast, heart rate studies and neuroimaging studies generally suggest a dominant role for fear and a less robust role for disgust. Moreover, one fMRI study (Straube et al., 2006) suggests automaticity of the fear response, but not the disgust response. The limitation that no studies have revealed specific activation of the anterior region of the insular cortex further weakens the neuroimaging evidence for the role of disgust in the emotional response in spider phobia. As such, the evidence suggests that the degree to which the emotional response reflects fear or disgust may depend on the response domain measured. One possible theory explaining the dissociation between emotion observed and response domain measured is that spiders may initially elicit fear in physiological domains (e.g., neural substrate, heart rate), whereas disgust may emerge later during more controlled processes (i.e., appraisals, facial expression). Thus, it would be predicted that amygdala and heart rate acceleration may be observed towards masked (i.e., not-consciously recognized) spider-stimuli, but a disgust facial expression or evidence of the law of contagion would only be expected to be observed towards consciously recognized spider stimuli. This dissociation may occur in order to motivate 1) immediate escape from spiders given that some may be dangerous, and 2) avoid future contact with objects in close proximity to spiders given the possibility for contagion transmission (e.g., Matchett & Davey, 1991). Indeed, this would explain why fear may be automatically elicited from spiders (i.e., to quickly avoid/escape) and disgust may occur in more controlled domains (i.e., appraisals of disgust and contamination may motivate passive avoidance of objects touched by spiders). Future research concurrently measuring all response domains is necessary to further explore how disgust and fear differentially emerge across the response systems. Finally, the observation that physiological measures indicate fear whereas more controlled processes indicate disgust suggests that both emotions may need to be targeted during treatment, but possibly through distinct techniques (e.g., exposure for fear, re-appraisal for disgust).

BII phobia

Facial Expression—Lumley and Melamed (1992) videotaped BII phobic and non-phobic individuals' facial expressions while viewing surgery film clips and neutral film clips. The facial expressions were rated by observers on whether the participants furrowed their eyebrows or raised their upper lip; rising of the upper lip indicates levator labii muscle activation. Results revealed that BII phobic individuals displayed more facial expressions of disgust compared to non-phobic individuals during the surgery films. These results suggest that BII phobic individuals respond with the emotion of disgust during exposure to disorder-relevant stimuli.

Some research has investigated facial expression in BII phobia towards disgusting stimuli (Schienle et al., 2005) and to neutral stimuli paired with disgusting stimuli (Schienle et al., 2001). However, these studies do not demonstrate which type of facial expression BII phobics display towards disorder-relevant stimuli. Thus, these studies are not appropriate to test whether BII individuals respond predominantly with fear or disgust.

Heart Rate—One of the most promising pieces of evidence for disgust in BII phobia is the unique heart rate response to phobic-related stimuli. The heart rate response to phobogenic stimuli in BII is characterized by a diphasic response (Page, 1994; Sarlo et al., 2002; Thyer, Himle, & Curtis, 1985), in which there is a rapid acceleration of heart rate followed by a sharp decrease in heart rate. This heart rate response is specific to disorder-relevant stimuli; BII phobic individuals do not display a diphasic response while experiencing generic stress (Dahllof & Öst, 1998). The latter half of the diphasic reaction seems responsible for the fainting response that sometimes occurs with BII phobia (Öst, Sterner, & Lindahl, 1984; see Page, 1994 for a detailed discussion). For example, Öst and colleagues (Dahllof & Öst, 1998; Öst et

al., 1984; see Table 1) presented BII phobics with surgery films and found an initial increase in heart rate, followed by a rapid decline in heart rate. Similarly, Sarlo and colleagues (2002) presented BII phobics with surgery films and also found an initial heart rate increase followed by a decrease. Sarlo and colleagues found that sympathetic activation predicted the initial heart rate increase, but the influence of sympathetic activation became weaker over time. This suggests that the latter heart rate decrease is mediated by parasympathetic activation and disgust. Page (1994) argues that the unique heart rate response in BII phobia is mediated by parasympathetic activity and suggests that the diphasic heart rate response in BII phobia reflects disgust. However, even if the latter heart rate decrease is mediated by disgust and parasympathetic activity, the initial heart rate increase is likely mediated by sympathetic activity (Page, 1994; Sarlo et al., 2002), thus implicating fear. As such, the diphasic heart rate response towards disorder-relevant stimuli in BII phobia may reflect both fear and disgust.

The diphasic heart rate response has not, however, been consistently demonstrated in BII phobia. Ritz and colleagues (2005) found that only 2 of 12 BII phobics demonstrated the diphasic heart rate response during viewing of surgery films, although they failed to find a significant diphasic response among their entire BII phobia sample. It is important to note that Ritz and colleagues' null results may be due to their strict definition of diphasic responding; they defined a diphasic response as an increase in heart rate towards the BII film compared to a generally unpleasant film and a subsequent decrease in heart rate towards the BII film compared to a neutral film. These strict criteria may have minimized false positives but consequently also maximized false negatives. Similarly, Gerlach and colleagues (2006) observed a rapid heart rate increase among BII phobics during an actual venopuncture but did not observe a subsequent heart rate deceleration. A difference between this study and studies documenting a diphasic response is the type of stimulus used. In previous studies the stimulus was a surgery film, but in the Gerlach study it was a venopuncture. It may be the case that venopuncture stimuli are weaker elicitors of the diphasic response.

The diphasic response may be specific to a subset of BII phobics. Vogeles and colleagues (2003) found a rapid increase in heart rate, followed by a decrease in heart rate, during viewing of a surgery video only among BII phobics with a history of fainting. BII phobics without a history of fainting did not display this diphasic heart rate response. A history of fainting may explain previous null findings of the diphasic response, such that previous studies may have used samples with mostly non-fainters. These latter results also suggest that the diphasic response may not be intrinsic to BII phobia *per se*, but rather only to the fainting response. If this were true, it would call into question whether disgust is only relevant in BII phobics with a history of fainting. Further investigation of response specificity and the consistent role of disgust is needed.

Neural Substrate—Only one study presented BII phobic individuals with disorder relevant study and examined neural substrate activation (see Table 1). Hermann, Schafer, Walter, Stark, and Schienle (2007) found that BII phobic individuals display diminished medial prefrontal cortex activity in response to disorder relevant pictures compared to the control group. They did not find evidence of insula activation towards disorder-relevant pictures, but found marginally significantly greater activation of the amygdala towards disorder-relevant compared to neutral pictures. The medial prefrontal cortex has been implicated in the down-regulation of emotional processing (Bishop, *in press*; Phelps & LeDoux, 2005), thus suggesting that BII phobia may be characterized by a generalized diminished ability to regulate negative emotions elicited from BII-relevant stimuli. As such, diminished medial prefrontal cortex activity could be consistent with either fear, disgust, or both underlying BII phobia.

Cognitive Processes—There are no studies testing whether individuals with BII phobia display appraisals related to the laws of contagion or similarity towards disorder-relevant

objects. There have been some studies investigating primary appraisals (i.e., self-reported fear and disgust) towards disorder-relevant materials. Sawchuk and colleagues (2002) presented participants with surgery pictures and found that BII fearful individuals self-reported more fear and disgust relative to non-fearful individuals. BII fearful individuals' self-reported disgust was greater than their self-reported fear. Tolin and colleagues (1997) similarly found that BII fearful individuals self-reported greater fear and disgust towards surgery pictures compared to non-fearful individuals. Again, self-reported disgust was greater than self-reported fear.

There has been one study examining the associations between BII-related stimuli and disgust versus fear-related stimuli. de Jong and Peters (2007b) presented BII phobic individuals and non-phobic individuals with pictures of either neutral stimuli (e.g., rabbits) or disgust stimuli (e.g., pictures of blood-donations). Presentation of these pictures was followed by one of three possible outcomes: a shock, drinking a disgusting fluid, and nothing. Results revealed that both high and low phobic individuals expected both a fear and disgust-related outcome with equal probability. There were no differences between groups.

Summary: One facial expression study demonstrates disgust and not fear. Heart rate data appear to suggest both disgust and fear. It is important to note that the response pattern of the diphasic heart rate response in BII phobia begins with an increase (i.e., fear), which is followed by a decrease (i.e., disgust). An alternative interpretation of the heart rate data in BII phobia is that the initial heart rate activation indicates anxiety about a pending disgust response (McKay & Tsao, 2005). Indeed, Lumley and Melamed (1992) argue that “what may be feared [in BII phobia] is the highly uncomfortable feelings of nausea or faintness...” (pg. 433). When viewed in this light, the primary emotional response is disgust and the initial heart rate activation is merely anticipatory anxiety about the imminent disgust response. The evidence from both facial expression and heart rate data then appear to suggest a dominant role of disgust. Appraisal data suggests both disgust and fear in the emotional response of BII phobia, but two studies (Sawchuk et al., 2002; Tolin et al., 1997) found that the disgust appraisals were greater than the fear appraisals. Thus, data from facial expressions, heart rate, and appraisals all converge in suggesting a dominant role of disgust and a minimal role of fear. One fMRI study failed to corroborate a role for either disgust or fear in BII phobia. In contrast to spider phobia, there is evidence for a role of disgust in BII phobia across all response systems except for neural substrate, but this conclusion must be tempered by the limited number of studies. One theoretically interesting line of inquiry could be in investigating Lumley and Melamed's (1992) assertion that what is feared in BII phobia is responding with disgust. This assertion is consistent with the current findings that fear may emerge in more controlled processes such as appraisals. It may be the case that the fear arises due to appraisals stating that feeling disgusted is bad/uncomfortable; as opposed to fear arising in response to the BII stimulus per se. Future research is necessary to test possible interactions between fear and disgust in BII phobia.

Contamination-related OCD

Facial Expression—No studies have examined facial muscle activity in contamination fear.

Heart Rate—Only one study has investigated heart rate response in contamination fear. Hornsveld, Kraaimaat, and Van Dam-Baggen (1979) presented high contamination fear individuals and psychiatric controls with in vivo ideographic stimuli selected to be ‘dirty.’ The authors did not report examples of stimuli used. They found that the anticipation of touching a dirty stimulus resulted in greater heart rate acceleration compared to baseline among contamination fearful but not control participants. During actual touching of the stimuli, neither group exhibited a change in heart rate compared to baseline. These results are difficult to interpret. On one hand, the contamination fearful individuals displayed a heart rate increase while anticipating dirty stimuli, thus suggesting a fear response. On the other hand, this

anticipatory response could be deemed anxiety about an impending threatening situation (see McKay & Tsao, 2005 for a similar discussion pertaining to disgust, heart rate, and anticipation). Additionally, if contamination fearful individuals respond with fear towards phobogenic stimuli, then it follows that a heart rate increase compared to baseline would be observed when touching the phobogenic stimuli. The results did not support this hypothesis. Thus, the results do not strongly suggest fear or disgust. It is difficult to discern what these results say in regards to the questions underlying this review.

Neural Substrate—Several studies have investigated the neural substrates underlying contamination fear (see Table 1). Some studies suggest that disgust may be the predominant emotional response. For example, Phillips and colleagues (2000) presented individuals with contamination fears with disorder-relevant pictures and found heightened insula, but not amygdala activation. Similarly, Shapira and colleagues (2003) found heightened insula and not amygdala activation towards generally disgusting pictures among a contamination fear sample.

Some studies suggest that both fear and disgust may underlie contamination fears. Schienle, Schafer, Stark, Walter, and Vaitl (2005) used a heterogeneous OCD sample (i.e., not ‘pure’ contamination fear OCD) and found enhanced insula activation while viewing disorder relevant pictures, but amygdala activation towards these pictures correlated positively with a self-report measure of contamination fear as well as with the experience of disgust. Maitaix-Cols and colleagues (2004), however, used a heterogeneous OCD sample and found enhanced amygdala activation during a contamination fear provocation task, but that insula activation correlated with a self-report measure of contamination fear. Similarly, Breiter and colleagues (1996) found both insula *and* amygdala activation in response to contaminated objects among contamination fearful individuals. Finally, two studies found neither insula nor amygdala activation towards disorder-relevant objects (McGuire et al., 1994; Rauch et al., 1994), and one study found only amygdala, and not insula, activation towards disorder-relevant pictures (van den Heuvel et al., 2004). Thus, neuroimaging studies of contamination fear generally indicate both disgust and fear, but may indicate a more consistent and dominant role of disgust (see Table 1). However, inconsistent findings limit the degree of confidence placed in this conclusion.

Cognitive Processes—One study has investigated the law of contagion appraisal in contamination-related OCD. Tolin, Worhunsky, and Maltby (2004) asked individuals with contamination-related OCD, other anxiety disorders, and non-anxious controls to identify the most contaminated object in the building. The experimenter then rubbed a new pencil on the object and asked participants how contaminated the pencil was. The experimenter then rubbed another new pencil on the previous pencil and again asked how contaminated this new pencil was. This process was repeated for 12 pencils. Results revealed that the anxious and non-anxious controls evidenced nearly a 100% decrease in appraisals of contamination across the 12 pencils, but the contamination-related OCD group displayed only a 40% reduction. The groups performed the same task on a non-threat object (i.e., a piece of candy) and all groups demonstrated nearly a 100% reduction in ‘candy contagion’ across the pencils. Thus, individuals with contamination-related OCD exhibit the law of contagion appraisal uniquely towards possible sources of contamination.

Connolly and colleagues (*in press*) used a covariation paradigm (i.e., a task in which the perceived covariation between a CS and different types of UCS’s is measured) and found that individuals with elevated contamination fear overestimated the pairings of contamination-related pictures (e.g., vomit, dog feces) with pictures of fear facial expressions and disgust facial expressions to a greater degree than with neutral facial expressions. There were no differences in the estimations of pairings between fear facial expressions and disgust facial

expressions. Additionally, individuals with elevated contamination fear exhibited greater estimations of pairings between the contamination pictures and the fear facial expressions compared to individuals with low contamination fear, but the two groups did not differ in associations between contamination pictures and disgust facial expressions.

Finally, Cougle and colleagues (2007) investigated primary threat appraisals of participants with elevated contamination fear on a self-report questionnaire. They found that 41% of their sample ($N = 27$) endorsed a primary contamination threat of being overwhelmed by feelings of disgust and that 37% of the sample endorsed a primary threat of being concerned with illness or harm to the self. These data suggest that contamination fearful individuals appraise contamination-related situations as disgust eliciting (i.e., a disgust primary appraisal) and dangerous (i.e., a fear primary appraisal). The degree to which these primary threat appraisals covaried was not reported.

Summary: No studies have examined facial expression in contamination-related OCD. One heart rate study (Hornsveld et al., 1979) suggests the emotion of disgust, but data from this study are difficult to interpret. Contamination-related OCD is generally associated with anterior insula activation towards disorder-relevant stimuli, although this effect is not always consistent. Contamination-related OCD strongly demonstrates the law of contagion appraisal (Tolin et al., 2004), but two other studies suggest appraisals of both disgust and fear. It is difficult to draw conclusions from such a limited number of studies, but the data overall suggest a dominant role of disgust. Moreover, the data more strongly indicate disgust across the response systems that have been more thoroughly investigated (i.e., appraisals, neural substrate). These data on contamination-related OCD is in contrast to Rachman's (2006; 2004) assertion that contamination-related OCD is predominantly fear based, and not disgust based. Instead, the current data largely implicate disgust and minimally implicate fear. As with BII phobia, it may be the case that the fear component involved in contamination-related OCD is best conceptualized as fear or discomfort experiencing disgust (e.g., Cisler et al., 2007; Cougle et al., 2007). Alternatively, the fear could be associated with a fear of contracting an illness (Cougle et al., 2007), which is also actually consistent with the evolutionary function of disgust (i.e., motivating avoidance of disease/contagions). However, conclusions based on the current review are limited to a few neuroimaging and appraisal studies. Further research across indicators is necessary to corroborate the evidence from these response systems.

General Summary

The review of specific measures of disgust and fear in spider phobia, BII phobia, and contamination-related OCD largely suggests that both fear and disgust are involved in the emotional response towards disorder-relevant stimuli in these disorders. Indeed, Table 1 demonstrates that many studies found evidence for both fear and disgust in each of the disorders across many of the response domains. These data provide strong support for the growing program of research on disgust in anxiety disorders. However, the relative contribution of disgust and fear appears to differ across the disorders. Spider phobia may be characterized by a fear response in more automatic response domains (e.g., neural activation) and a disgust response in more controlled response domains (e.g., facial expression). BII phobia appears to be characterized most strongly by a disgust response, but cognitive processes may indicate both disgust and fear. Contamination-related OCD appears to be characterized most strongly by a disgust response and the inconsistent evidence for fear may indicate a weaker role of fear in this disorder. The role of disgust and fear may differ in these disorders because of the nature of the disorder-stimuli. That is, spiders are *moving* objects in the environment. Accordingly, it may be adaptive to quickly increase physical distance away from the spider, thus necessitating a fear response and rapid physiological mobilization. Disgust may be involved in order to motivate passive avoidance of stimuli that has come in contact with spiders. For BII phobia

and contamination-related OCD, however, the stimuli are relatively *static*. The potential for harm from these stimuli may be more related to disease or contagion possibility; thus, rapidly increasing the physical proximity from these stimuli may not be necessary. Instead, it may only be necessary to prevent physical contact with these stimuli, thus necessitating a disgust response. Fear may be involved due to discomfort experiencing the aversive sensations of disgust. This line of reasoning would explain why the role of disgust and fear in the different response domains may differ across the disorders.

A recurring theme in this section is the limited number of studies employing specific measures of disgust and fear in spider phobia, BII phobia, or contamination-related OCD samples. It is difficult to place confidence in conclusions drawn from such a limited number of studies. The current review also highlights another problem in establishing an integral role of disgust in anxiety. Some of the research described above suggests that the emotion observed may be dependent on the response domain measured. It is difficult to explain why this may be the case. As noted above, it may be that this pattern indicates that fear or disgust may emerge in automatic or controlled response domains, depending on the disorder. Even if this were true, it is difficult to discern what this means about the role of disgust or fear in these disorders. For example, if disgust only emerges in controlled processes in spider phobia, does that mean that disgust is less important or dominant than fear? This is not necessarily so and it could also be the case that the more controlled processes and disgust are better predictors of avoidance (e.g., Woody et al., 2005; Olatunji, Cisler, et al., 2008). Future research should compare the ability of fear and disgust in each of the response domains to predict avoidance and distress during exposure. Research along this line would assist in developing theories about how disgust is functionally relevant in these disorders.

Future directions

Concurrent use of emotion indicators

Research may benefit from concurrent use of the available specific measures in order to provide a multimodal assessment of emotional responding. Research along this line would be able to additionally examine convergence across indicators. For example, if the diphasic heart rate response in BII phobia correlates with insula activation, then this would strongly indicate disgust in BII phobia. Similarly, concurrent use of emotion indicators could also be used to compare the ability of each of the indicators to predict *in vivo* emotional responding (e.g., distress, avoidance). Research along this line could determine which emotion in which response system is most related to emotional responding in these disorders.

In a related vein, there is a general lack of research investigating heart rate, facial expression, and neural substrate across the disorders. Similarly, there are few studies examining appraisals in contamination-related OCD. Future research should employ these measures in more studies, preferably concurrently.

Investigate whether fear and disgust across response domains respond to similar types of interventions

Exposure is widely recognized as the treatment of choice for specific phobia (Barlow et al., 2002; Choy et al., 2007), and exposure and response prevention is also recommended as a first choice treatment for OCD. However, recent research has shown that disgust responding may be slower to extinguish during exposure relative to fear (Smits et al., 2002; Olatunji, Forsyth, et al., 2007; Olatunji, Smits, et al., 2007; Olatunji, Wolitzky-Taylor, et al., *in press*). The response domain measured in these studies was almost exclusively self-reported feelings of disgust. Future research is necessary to examine whether other response domains of disgust are similarly resistant to extinction via exposure. It may be the case that cognitive re-appraisal

of disorder-relevant stimuli would effectively reduce self-reported feelings of disgust towards disorder-relevant stimuli and potentiating the efficacy of exposure-based treatments. In any case, the finding that the magnitude to which disgust and fear characterize the emotional response may depend on the response domain measured necessitates research on whether the different emotions and different response domains respond the same to similar treatments. This line of research would begin to incorporate disgust into treatment conceptualizations of the disgust-related anxiety disorders.

Conclusions

Research demonstrates that disgust is involved in spider phobia, BII phobia, and contamination-related OCD. The current review sought to examine the relative contributions of disgust and fear to the emotional response in these disorders. The review elucidated the response topographies specific to fear and disgust in the domains of heart rate, facial expression, neural substrate, and cognitive processes. Extant research employing these specific measures suggests that spider phobia is predominantly characterized by fear in more automatic response domains, whereas disgust may emerge during more controlled processes. BII phobia and contamination-related OCD appear to be predominantly characterized by disgust across response systems, while fear also emerges in more controlled response systems. An overarching finding from the review is the need for more research using specific measures, preferably employing concurrent use of these measures. Additionally, given that fear and disgust are both implicated in these disorders, researchers need to test whether therapeutic procedures differentially affect fear versus disgust response domains.

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Summary of neural correlate, facial expression, heart rate and appraisal responses towards disorder-relevant stimuli among spider phobia, BII phobia, and contamination-related OCD.

Table 1

Disorder	Emotion indicator	Author	stimulus type	disgust	fear
Spider phobia					
	Neural substrate	Larson et al. 2007	disorder-relevant Pictures	n.a.	+
	Neural substrate	Straube et al. 2006	disorder-relevant Pictures	+	+
	Neural substrate	Goossens et al. <i>in press</i>	disorder-relevant Pictures	+	+
	Facial expression	de Jong et al. 2002	disorder-relevant Pictures	+	-
	Facial expression	Vernon & Berenbaum 2002	disorder-relevant object	+	+
	Heart rate	Hare, 1973	disorder-relevant Pictures	-	+
	Heart rate	Fredrikson et al. 1995	disorder-relevant Pictures	-	+
	Heart rate	Sarlo et al. 2002	disorder-relevant Pictures	+	+
	Cognitive	de Jong & Muris, 2002	disorder-relevant Scripts	+	+
	Cognitive	Huijding & de Jong, 2007	disorder-relevant Pictures	+	+
	Cognitive	van Overveld et al., 2006	disorder-relevant Pictures	+	+
	Cognitive	Mulkens et al., 1996	disorder-relevant Object	+	n.a.
	Cognitive	Woody et al., 2005	disorder-relevant Objects	+	n.a.
	Cognitive	Olatunji & Deacon 2008	disorder-relevant Objects	+	+
	Cognitive	Vernon & Berenbaum 2002	disorder-relevant Objects	+	+
	Cognitive	Sawchuk et al. 2002	disorder-relevant Pictures	+	+
	Cognitive	Tolin et al, 1997	disorder-relevant Pictures	+	+

Disorder	Emotion indicator	Author	stimulus type	disgust	fear
BII phobia	Cognitive	Thorpe & Salkovskis 1998	disorder-relevant Pictures	+	+
	Cognitive	de Jong & Peters 2007	disorder-relevant Pictures	+	-
	Cognitive	Teachman et al. 2001	disorder-relevant Pictures	+	+
	Neural substrate	Herman et al. 2007	disorder-relevant Pictures	-	* +
	Facial expression	Lumley & Melamed	disorder-relevant	+	-
	Heart rate	Öst et al. 1984	disorder-relevant Film	+	+
	Heart rate	Ritz et al. 2005	disorder-relevant Film	-	+
	Heart rate	Vogele et al. 2003	disorder-relevant Film	+	+
	Heart rate	Sarlo et al. 2002	disorder-relevant Film	+	+
	Heart rate	Dahllof & Öst 1998	disorder-relevant Film	+	+
	Cognitive	Sawchuk et al. 2002	disorder-relevant Pictures	+	+
	Cognitive	Tolin et al. 1997	disorder-relevant Pictures	+	+
	Cognitive	de Jong & Peters 2007b	disorder-relevant Pictures	+	+
	Neural substrate	Breiter et al. 1996	contaminated object	+	+
	Neural substrate	Phillips et al. 2000	disorder-relevant pictures	+	-
Contamination fear	Neural substrate	Shapira et al. 2003	generally disgusting pictures	+	-
	Neural substrate	McGuire et al. 1994	disorder-relevant objects	-	-
	Neural substrate	van den Heuvel et al. 2004	disorder-relevant pictures	-	+
	Neural substrate	Rauch et al. 1994	disorder-relevant objects	-	-
	Neural substrate				

Disorder	Emotion indicator	Author	stimulus type	disgust	fear
	Facial expression	no available studies			
	Heart rate	Hornsveld et al. 1979	'dirty' objects	-	-
	Cognitive	Tolin et al. 2004	disorder-relevant Object	+	n.a.
	Cognitive	Connolly et al. <i>in press</i>	disorder-relevant Pictures	+	+
	Cognitive	Cogle et al. 2007	none	+	+

Note. A '+' in the 'disgust' or 'fear' column indicates that the emotion indicator suggests the emotion of disgust or fear, respectively; a '-' indicates the emotion measure did not indicate the emotion. The neuroimaging OCD studies are limited to studies using homogeneous contamination fear OCD samples (i.e., the contamination concerns were the primary obsession or compulsion), except for Rauch et al. 1994 whose sample consisted of 75% pure contamination fear participants (i.e., 6 out of the 8 participants).

* indicates a marginally significant finding. 'n.a.' = not available.