NORMATIVE AND PATHOLOGICAL EFFECTS

OF AVERSIVE LEARNING ON SPATIAL ATTENTION

By

Thomas Armstrong

Dissertation

Submitted to the Faculty of the

Graduate School of Vanderbilt University

in partial fulfillment of the requirements

for the degree of

DOCTOR OF PHILOSOPHY

In

Psychology

August 2014

Nashville, Tennessee

Approved:

Bunmi O. Olatunji, PhD

David H. Zald, PhD

Adriane E. Seiffert, PhD

Jennifer Blackford, PhD

ACKNOWLEDGMENTS

ABSTRACT

Classical learning theories of anxiety have been criticized for their failure to capture the full complexity of anxiety disorders. To address this limitation, contemporary learning theories have emerged, which acknowledge organismic factors that affect conditioning in its role in the etiology and maintenance of anxiety disorders. However, extant research on learning processes and associated organismic factors in anxiety disorders remains limited. First, there is an exclusive focus on fear learning, despite research suggesting that disgust is the primary emotional response to threat in certain anxiety disorders. Second, relatively little is known about the effects of aversive learning on attention, despite the large body of research on attentional biases for threat, which includes recent findings suggesting that attentional biases are a disease mechanism. Third, it is unclear how individual differences in traits that confer vulnerability for anxiety disorders contribute to dysfunctional fear or disgust learning. The present line of research sought to address these limitations by examining both normative and pathological effects of fear and disgust learning on spatial attention. The first aim was to contrast the acquisition and extinction of attentional biases for conditioned disgust and fear stimuli, and to explore traits that may differentially moderate these learning processes. The second aim was to examine these learning processes in the context of anxiety disorders in which they may be most relevant: the effects of disgust learning on attention were examined in contamination-based obsessive-compulsive disorder, and the effects of fear learning on attention were examined in post-traumatic stress disorder, The present research provides insight into the origins of attentional biases, and suggests a novel stress-diathesis model of associative learning in the etiology of anxiety-related disorders.

LIST OF TABLES

LIST OF FIGURES

TABLE OF CONTENTS

CHAPTER I

INTRODUCTION

Learning theories of anxiety disorders

Anxiety disorders are the most frequently diagnosed category of disorders in the

Diagnostic and Statistical Manual of Mental Disorders (DSM–5; American Psychiatric

Association, 2013), affecting nearly one third of the U.S. population at some point during the life

span (Kessler, Berglund, Demler, Jin, & Walters, 2005). These disorders can have devastating

effects on daily functioning and quality of life (Olatunji, Cisler, & Tolin, 2007), and are estimated

to cost up to $50 billion dollars annually in direct and indirect costs in the U.S. alone (Konnopka,

Leichsenring, Leibing, & König, 2009). Although empirically-validated treatments for anxiety

disorders have been developed, many individuals either do not respond to treatment or experience

symptom relapse, suggesting that there is considerable room for improving interventions

(McManus, Grey, & Shafran, 2008). Translational research into etiological mechanisms may

advance treatment of anxiety disorders, either by refining existing approaches or by inspiring new

treatment targets (e.g., Najmi & Amir, 2010).

Learning theory has provided the foundation for a large body of translational research in

anxiety disorders. As Lissek et al. (2005) note, early founders of the behaviorist movement in

psychology (Pavlov, 1927; Watson & Rayner, 1920) speculated that human neuroses could be

understood and treated according to basic learning principles. In particular, classical or Pavlovian

conditioning has provided a useful framework for understanding the origin and maintenance of

fear and anxiety (e.g., Mineka & Zinbarg, 2006). Classical conditioning occurs when an organism

learns that an object or event (conditioned stimulus; CS) predicts a motivationally-relevant

outcome, such as a reward or punishment (unconditioned stimulus; US) and begins to respond to

1

the CS with a response more appropriate to the US (conditioned response; CR). According to learning theorists, one might develop pathological anxiety after being bit by a dog or humiliated at school, due to the strong association formed between the CS (i.e., dog or social interaction) and the US (i.e., pain or rejection) that allows the CS to elicit a potent CR (i.e., fear or anxiety). The plausibility of classical conditioning as a cause of anxiety disorders draws support by observations of post-traumatic stress disorder (PTSD) in response to wartime trauma (Flanagan, 1948), by reports of specific phobia following a traumatic encounter with the phobic object (Di Nardo et al., 1988), and by a few rare cases in which children subjected to classical conditioning experiments developed phobias for the CS (e.g. "Little Albert"; Watson & Rayner, 1920).

Classical conditioning may also provide insight into the maintenance of anxiety disorders. A general principle of learning is that conditioned responses attenuate with repeated exposure to the CS in the absence of the US (Myers & Davis, 2007). This process of fear "extinction" may be impaired by avoidance of the CS once it develops the capacity to elicit CR's. For example, a spider phobic's consistent avoidance of spiders may prevent her from learning that a spider's presence does not predict pain or bodily harm, thereby maintaining the CS-US association as well as CRs to spiders. Consistent with the principle of extinction, treatments based in exposure to feared stimuli have been found to reduce fear responses across anxiety disorders (Foa & Kozak, 1986).

While many of the core tenets of behaviorism remain intact in contemporary learning theories of anxiety, several findings have proven irreconcilable with "first wave" theories (see Rachman, 1991). For example, learning has been found to occur through verbal instruction or vicarious observation, or through later re-evaluation of previously encountered stimuli (Mineka & Zinbarg, 2006). Accordingly, learning theorists no longer insist that fear conditioning only results from the direct experience of the CS and US in close temporal contiguity. In addition, there appear

to be considerable individual differences in fear learning following a traumatic event (e.g.,

witnessing war or being attacked by an animal). For example, whereas 50-60% of individuals will

experience a traumatic event in their lifetime, only 7-8% of the population will develop PTSD

(e.g., Kessler, Sonnega, Bromet, Hughes, & Nelson, 1995). Although some of this variation may

be accounted for by prior learning experiences (Bouton, Mineka, & Barlow, 2001), intrapersonal

factors (e.g., temperament) also appear to explain individual differences in fear conditioning

(Mineka & Zinbarg, 2006). Accordingly, learning theories of anxiety now accommodate

organismic factors that influence learning and may thereby confer vulnerability to anxiety

disorders (Mineka & Zinbarg, 2006). Indeed, one of the more fruitful lines of contemporary

research from the learning perspective has focused on individual differences in acquisition and

retention of conditioned responses (see Lissek et al., 2005).

Limitations of contemporary learning theories of anxiety

Although learning theories have been repeatedly elaborated to accommodate the

complexity of anxiety disorders, they remain limited by an exclusive focus on fear learning.

Accounts of emotional processing in anxiety disorders (e.g., Foa & Kozak, 1986) have

traditionally been restricted to fear; however, recent research suggests that disgust is the primary

response to threat in certain disorders, for example, blood-injection-injury (BII) phobia and

contamination-based obsessive-compulsive disorder (OCD; Olatunji, Cisler, McKay, & Phillips,

2010). Disgust is a basic emotion originating in the distaste reaction, which is abstracted through

socialization to target a broad class of disease risks (Rozin & Fallon, 1987). Whereas fear

motivates avoidance of urgent threats to physical safety, disgust motivates avoidance of less

demanding threats to hygiene and purity (Woody & Teachman, 2001). Disgust may also be

distinguished from fear in that it motivates avoidance of "mental contact" with certain stimuli by

causing displeasure at merely perceiving, imagining, or contemplating these stimuli (e.g., invasive

3

surgical procedures, taboo sexual behaviors; Royzman & Sabini, 2001). Accordingly, disgust is conceptualized as protecting the mind in addition to the body (Rozin & Fallon, 1987).

Although there has been considerable research on conditioned taste aversion and nausea (e.g., Burish & Carey, 1986), research on conditioning of disgust per se is in its infancy. However, the extant research has yielded intriguing findings. First, disgust associations appear to be more resistant to extinction, compared to fear associations (Olatunji, Forsyth, & Cherlon, 2007), in line with research documenting the persistence of conditioned taste aversion (see Bouton, 2007). Also, individual differences in disgust sensitivity (Haidt, McCauley, & Rozin, 1994), a trait capturing how often and how intensely one experiences disgust, have been found to predict the acquisition of disgust associations (Olatunji, Tomarken, & Puncochar, 2013). This would suggest that disgust sensitivity may be a vulnerability factor for developing anxiety disorders in which disgust plays a prominent role. However, research on disgust learning in the context of specific anxiety disorders is lacking, and the few preliminary findings—all from studies of BII phobia—have been mixed. Shienle, Stark, and Veitl (2001) did not find an association between disgust sensitivity and disgust conditioning, and also did not find compelling evidence of increased disgust conditioning in BII fearful versus non-fearful individuals. Likewise, Olatunji, Lohr, Sawchuk, and Westendorf (2005) failed to find increased disgust conditioning in BII fearful versus non-fearful participants. However, in a study with a larger sample size, Olatunji, Lohr, Smits, Sawchuk, and Patten (2009) did find increased disgust conditioning in BII fearful versus non-fearful participants, and further found that disgust sensitivity was associated with stronger disgust conditioning.

Conditioning research in anxiety disorders is also limited in terms of the CRs examined. Studies of anxious populations have focused almost exclusively on self-report and psychophysiological indices of fear (Lissek et al., 2005). However, research using unselected samples suggests that fear CRs may extend to attention allocation. These studies have observed an

attentional bias toward CS+s following fear conditioning (e.g., Pischek-Simpson, Boschek, Neumann, & Waters, 2009) that attenuates with extinction (e.g., Van Damme, Crombez, Hermans, Koster, & Eccleston, 2006), consistent with other CRs. Although some of these studies have observed a positive correlation between trait anxiety and acquisition of attentional bias for fear CS+s (Lee, Lim, Lee, Kim, & Choi, 2009), there have been no direct investigations of the effects of fear learning on attention in patients with anxiety disorders. Assessing more distal forms of conditioned responding, such as attention allocation or behavioral avoidance, is important because these responses may provide a mechanism through which conditioned emotional responses contribute to the etiology or maintenance of anxiety disorders (Beckers et al., 2013).

The lack of research on aversive learning and attentional bias is surprising, given the vast amount of research on attentional bias towards threat in anxiety disorders (Bar-Haim, Lamy, Pergamin, Bakermans-Kranenburg, & van IJzendoorn, 2007). It has been well-established that attentional biases towards threat characterize anxiety disorders and attenuate following successful treatment of anxiety. However, only recently have researchers sought direct evidence that attentional biases are a causal mechanism as opposed to a mere symptom of anxiety disorders. Computerized training procedures that attempt to "reverse" attentional bias toward threat have been found to provide lasting symptom relief (Amir, Beard, Burns, & Bomyea, 2009). Indeed, a recent meta-analysis found symptom reduction following bias attenuation to be a reliable phenomenon (Hakamata et al., 2010). While it is possible that symptom amelioration results from the effect of training on attentional control, as opposed to the reduction of bias towards threat specifically, training procedures that *induce* biases toward threat have been found to increase vulnerability to distress (MacLeod, Rutherford, Campbell, Ebsworthy & Holker, 2002; although see Klumpp & Amir, 2009), suggesting that a tendency to attend to threat could contribute to the etiology and maintenance of anxiety. Research into the effects of aversive learning on attentional

5

biases could provide insight into the origins of attentional bias, and in turn provide a deeper understanding of the etiology of anxiety disorders.

Clinical research applications

Contamination-based OCD may be a good starting point for examining the effects of disgust learning on attention in anxiety disorders. OCD is an anxiety disorder characterized by intrusive thoughts (obsessions) that motivate ritualistic behavior (compulsions) that function to relieve distress or tension related to obsessions (APA, 2013). Phenomenologically, OCD consists of a small set of subtypes or symptom dimensions, of which the most commonly observed is contamination concerns (reported by about half of OCD patients; Rasmussen & Eisen, 1992). A normative function of disgust is to mediate between contamination appraisal and behavioral avoidance (Rozin & Fallon, 1987), suggesting that disgust could play an important role in contamination-based OCD. Indeed, disgust propensity has been found to uniquely predict severity of contamination obsessions and washing compulsions (see Olatunji et al., 2010), and to mediate symptom reductions following successful cognitive behavioral therapy for OCD (Olatunji, Tart, Ciesielski, McGrath, & Smits, 2011).

In addition to being characterized by excessive disgust, contamination-based OCD is the subtype of OCD most reliably characterized by attentional bias for threat (Summerfeldt & Endler, 1998). An early attentional bias toward threat has been found in multiple studies of contamination-based OCD (e.g., Tata, Liebowitz, Prunty, Cameron, & Pickering, 1996), and this bias has been found to have proximal effects on behavioral avoidance (Armstrong, Sarawgi, & Olatunji, 2012; Najmi & Amir, 2010). However, this early bias may be more strongly related to fear versus disgust; Armstrong and colleagues (2012) found that fear ratings of contamination threat images were a stronger predictor of orienting bias than disgust ratings of these images. Indeed, basic research suggests that disgust and fear may have divergent effects on attention (Krusemark & Li,

6

2011); for example, a preliminary study examining the effect of disgust conditioning on attention found attentional avoidance of disgust CS+s (Mason & Richardson, 2010). Thus, it is possible that contamination-based OCD is also characterized by excessive attentional avoidance of disgust elicitors, a phenomenon which could contribute to excessive contamination obsessions and washing compulsions by preventing disgust habituation and stimulus re-appraisal (Weierich, Treat, & Hollingworth, 2008). However, only one published study (e.g., Mason & Richardson, 2010) has attempted to isolate the effects of disgust on selective attention over time; further, this effect has not been examined in patients with OCD.

Similarly, a natural starting point for examining the role of fear learning in anxiety disorders is PTSD. PTSD is an anxiety disorder in which intrusive reminders of a traumatic event disrupt functioning by causing excessive arousal and avoidance of trauma cues (APA, 2013). According to conservative estimates, PTSD develops in 8% of soldiers exposed to combat in Operation Enduring Freedom and Operation Iraqi Freedom (Smith et al., 2008). PTSD is unique among the anxiety-related disorders, in that its diagnostic criteria involve a specific etiology, a traumatic event that elicits intense feelings of fear and helplessness (APA, 2013). The original trauma in PTSD (e.g. explosion) may be conceived of as a potent US, and many of the triggers (e.g., sounds and odors) for later symptoms of PTSD may be CSs associated with the initial US. Given the relatively seamless application of learning theories to traumatic stress, it is not surprising that the majority of studies applying fear conditioning to the study of anxiety disorders have focused on PTSD (Lissek et al., 2005).

Although there appear to be no published studies using aversive learning paradigms to study attentional bias for learned threat cues in PTSD, a number of studies have documented attentional bias for other threat stimuli in the disorder. For example, Individuals with PTSD (or high-symptom analogues) show an attentional bias towards trauma-related words (e.g., Pineles,

Shipherd, Mostoufi, Abramovitz, & Yovel, 2009) and images (e.g., Kimble, Fleming, Bandy, Kim, & Zambetti, 2010). Although some individual studies have only found a bias for trauma-related stimuli in PTSD, a review of studies using the emotional Stroop task (Cisler et al., 2011) found that trauma-exposed controls also display a bias for trauma-related words; interestingly, PTSD patients were distinguished from trauma-exposed controls by an additional bias for generally threatening words. Cisler and colleagues (2011) suggest that this general bias for threat could exist prior to trauma and confer risk for PTSD (Cisler et al., 2011). In line with this hypothesis, a recent study of soldiers deploying for Iraq found that a gaze bias related to fear expressions conferred risk for PTSD following subsequent combat stress (Beevers, Lee, Wells, Ellis, & Telch, et al., 2011). This general threat bias could reflect an underlying tendency to allocate attention to threat cues after fear learning.

Trait moderators of conditioning

In examining the effects of fear and disgust learning on attention in anxiety disorders, it may be useful to consider emotional traits that could moderate these learning processes. Individual differences in the propensity to experience anxiety (trait anxiety; Spielberger, Gorsuch, Lushene, Vagg, & Jacobs, 1983) have been found to predict skin conductance responses (SCRs) to fear CS+s (e.g., Davey and Matchett, 1994). In addition to being associated with the formation and expression of fear associations, trait anxiety is also associated with attentional biases for threat. Numerous studies with intrinsic threat stimuli (e.g., angry faces; Mogg, Garner, & Bradley, 2007), as well as a few studies with conditioned threat stimuli (e.g., Lee et al., 2009) have found greater attentional biases toward threat in individuals with elevated trait anxiety.

However, there are several studies that have failed to observe relations between trait anxiety and fear conditioning (see Beckers et al., 2013), as well as studies failing to observe relations between trait anxiety and the acquisition of attentional bias through fear conditioning

(e.g., Notebaert et al., 2011). One hypothesis is that traits representing broad emotional propensities, such as trait anxiety or neuroticism, fail to show a reliable relationship to aversive conditioning because they are too general. Such a relationship may only be observed for specific emotional sensitivities that increase reactivity to particular classes of unconditioned stimuli. For example, anxiety sensitivity, a trait which encompasses the fear of bodily sensations related to anxious arousal (Naragon-Gainey, 2010; Olatunji & Wolitzky-Taylor, 2009), has been found to predict unique variance in the development of PTSD symptomatology when controlling for one's general propensity to experience negative affect (Feldner, Lewis, Leen-Feldner, Schnurr, & Zvolensky, 2006). Anxiety sensitivity may uniquely contribute to the etiology of PTSD by increasing fear reactivity and hence fear conditioning (Feldner et al., 2006).

Although fewer studies have examined disgust conditioning or attentional biases related to disgust, a similarly specific trait may be related to both phenomena. Disgust sensitivity, a trait that encompasses how easily and how intensely one experiences disgust (Haidt et al., 2004), has been found to predict the acquisition of self-reported disgust in response to disgust CS+s (Olatunji, Tomarken, & Puncochar, 2013). In addition, disgust sensitivity has been linked to an attentional bias for disgust-related stimuli, as revealed by longer color-naming latencies for disgust words in individuals with elevated disgust sensitivity (Charash & McKay, 2002). Accordingly, it appears that anxiety sensitivity and disgust sensitivity could have specific effects on aversive learning processes as well as aversive stimulus processing. Although these effects may be relatively independent, another possibility is that emotional traits contribute to attentional biases for aversive stimuli in part through their effects on aversive learning. Indeed, this may be one mechanism through which anxiety sensitivity and disgust sensitivity confer vulnerability to anxiety disorders.
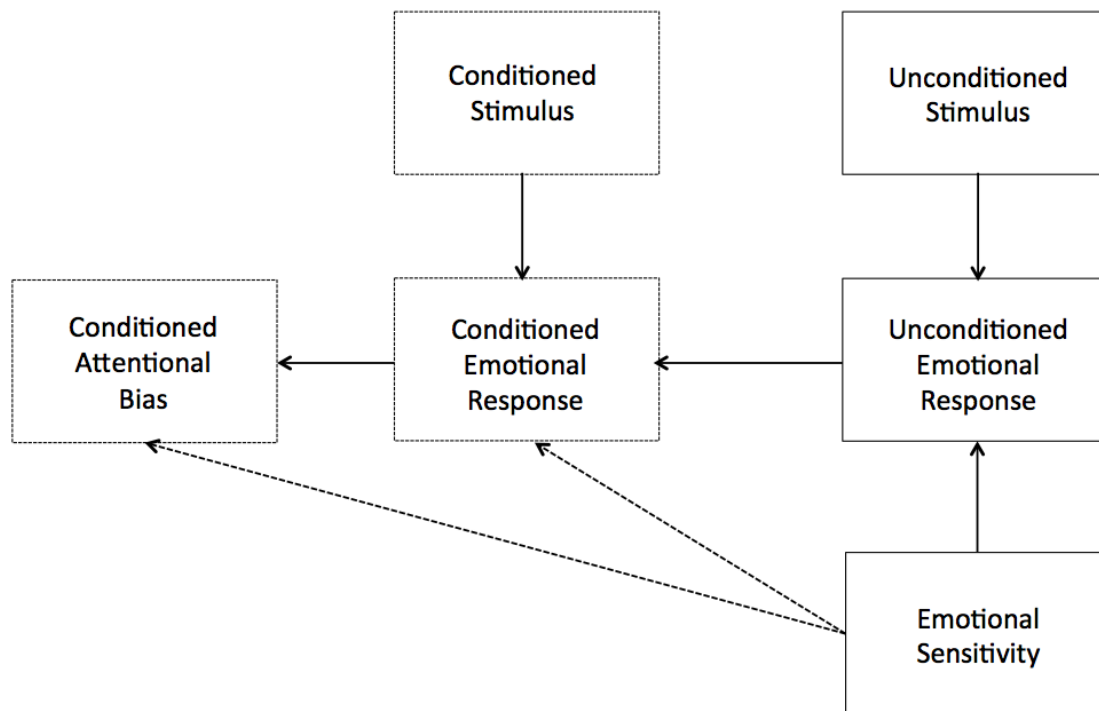
Figure I. A model of possible relations between specific emotional sensitivities, components of Pavlovian conditioning, and attentional bias.

Figure 1 presents a general model of these hypothesized effects. Under this account, emotional sensitivities have direct effects on unconditioned responding, which in turn lead to indirect effects on conditioned emotional responding, and subsequently, conditioned attentional bias. This general model can be further specified for the cases of disgust and fear learning. In the present research program, it was predicted that disgust sensitivity would increase unconditioned disgust responding, leading to greater conditioned disgust and greater conditioned attentional *avoidance*. In contrast, it was predicted that anxiety sensitivity would increase unconditioned fear, which in turn would lead to greater conditioned fear and greater conditioned *vigilance* for threat. Whereas the former disgust-based model should be relevant to the etiology of contamination-based OCD, the latter fear-based model should be relevant to the etiology of PTSD.

Further methodological considerations

This dissertation research also sought to overcome the methodological limitations of prior research on emotional learning and attentional bias. These prior studies have relied heavily on manual reaction time (RT) measures of attention, such as the emotional Stroop (Lee et al., 2009), modified dot probe (Pischek-Simpson et al., 2009) and spatial cueing tasks (Van Damme et al., 2006). These measures sample attention at just one point in time, making it difficult to parse components of attention or to delineate the time course of attentional biases. In addition, manual reactions have a considerably indirect relation to attention allocation, and may be confounded by the effects of emotional stimuli on intervening processes such as response execution (Algom, Chajnut, & Lev, 2004). In light of these limitations, recent reviews (Bar-Haim et al., 2007; Weierich et al., 2008) have recommended the use of eye tracking to further delineate the time course and components of attentional biases for threat in anxiety disorders. Eye tracking allows for the direct and continuous measurement of saccadic eye movements, which select stimuli for high-resolution vision through the fovea (Findlay & Gilchrist, 2004). Although eye tracking does not capture covert shifts of attention assessed by RT measures, in most naturalistic settings, eye movements are the primary means of allocating visual attention, whereas covert shifts of attention are relegated to guiding eye movements to locations of interest (Findlay & Gilchrist, 2004; Liversedge & Findlay, 2000). In addition, saccade latencies can be used as a more direct measure of covert attention compared to manual RTs in commonly used paradigms such as the spatial cueing task (e.g., Van Damme et al, 2006).

Overview of dissertation research

In light of these limitations in conditioning research on anxiety disorders, the present research had two aims. The first aim was to delineate the normative effects of disgust and fear conditioning on attention (Experiment 1). Although disgust and fear are both negatively-valenced, avoidance-related emotions, they may have distinct effects on attention. Given that attentional biases may be a disease mechanism, understanding the differential effects of disgust and fear on attention could provide insight into anxiety disorders in which these emotions are prominent. However, without a basic understanding of the normative effects of fear and disgust learning on attention, it is difficult to proceed with research on the dysfunction of these processes in specific disorders. The second aim of the proposed research was to build on the exploratory research in Experiment 1 by examining the effects of fear and disgust learning in the context of disorders in which they may be most relevant. Experiment 2 extended research on the role of disgust in contamination-based OCD (see Olatunji et al., 2010) by examining the effects of disgust learning on gaze towards CSs in OCD, as well as relations between disgust learning and disgust sensitivity. Similarly, Experiment 3 extended research on fear learning in PTSD (see Lissek et al., 2005) by examining attentional bias as a CR in a classical fear learning paradigm, and by assessing anxiety sensitivity in addition to broader emotional traits. Together, these experiments provided the first systematic investigation of the normative and pathological effects of fear and disgust learning on attention and also shed light on the relations between specific emotional sensitivities and aversive learning in OCD and PTSD, respectively.

CHAPTER II

EXPERIMENT 1: BASIC EFFECTS OF AVERSIVE CONDITIONING ON ATTENTION

Pavlovian fear conditioning is regarded as one of the most successful paradigms in translational research on anxiety disorders (Beckers, Krypotosa, Boddezb, Effting, & Kindta, 2013). This classic procedure involves repeated pairing of an inherently aversive stimulus (unconditioned stimulus; US), such as an electrodermal shock, with a neutral stimulus (conditioned stimulus; CS). According to contemporary accounts (Bouton, 2007), an association forms between the US and the CS that allows the CS alone to activate the mental representation of the US, and thereby elicit an aversive response. The aversive response elicited by the CS (conditioned response; CR) often consists of an unpleasant anticipatory state related to the expectation of the US, as well as an evaluative response to the CS itself, caused by the apparent transfer of affective properties from the US to the CS ("affective" or "evaluative" learning; Hermans, Crombez, Vansteenwegen, Baeyens, & Eelen, 2002). Individuals with anxiety disorders have been found to exhibit a variety of fear learning abnormalities, including increased acquisition and impaired extinction of CRs (see Lissek et al., 2005), overgeneralization of CRs (Lissek et al., 2010), and failure to inhibit CRs to safety cues (Lissek et al., 2009).

While conditioning research on anxiety disorders has focused mainly on fear-eliciting USs (e.g., CO_2-enriched air, Forsyth & Eifert, 1998; a loud scream, Indovina, Robbins, Núñez-Elizalde, Dunn, & Bishop, 2011), it may be fruitful to examine learning related to disgust-eliciting USs, as well. Disgust is a basic emotion that motivates avoidance of contact with pathogen sources such as rotting food, bodily fluids, and rodents, and thus may have evolved to prevent disease transmission (Matchett & Davey, 1991; Oaten, Stevenson, & Case, 2009). There is mounting evidence suggesting that disgust plays a role in the etiology and maintenance of certain anxiety

disorders (Olatunji, Cisler, McKay, & Phillips, 2010). For example, how easily and how intensely

one experiences disgust, an individual difference known as *disgust sensitivity* (Haidt, McCauley,

& Rozin, 1994), has been found to predict symptoms of obsessive-compulsive disorder (OCD),

blood-injection-injury (BII) phobia, and spider phobia, even when controlling for negative affect

(Olatunji et al., 2010). Disgust sensitivity may confer risk for certain anxiety disorders by

enhancing the acquisition and retention of disgust responses to stimuli associated with these

disorders. Although few studies have examined Pavlovian learning of disgust, disgust sensitivity

has been found to be associated with greater acquisition of self-report disgust CRs (Olatunji, Lohr,

Smits, Sawchuk, & Patten, 2009), and individuals high in BII fear have been found to acquire

more disgust, but not fear, to the CS+ in a study using BII stimuli as USs (Olatunji et al., 2009).

In order to fully understand the role of disgust learning in anxiety disorders, it is important

to delineate the proximal mechanisms through which disgust may contribute to dysfunction.

Recent findings suggest that attentional biases are a potential disease mechanism in anxiety

disorders, as inducing attentional biases that characterize anxiety disorders appears to increase

anxious reactivity in healthy individuals (MacLeod, Rutherford, Campbell, Ebsworthy & Holker,

2002), and 'reversing' attentional biases in individuals with anxiety disorders has been found to

provide lasting symptom relief (Schmidt, Richey, Buckner, & Timpano, 2009) and improve

behavioral functioning (Najmi & Amir, 2010). Several Pavlovian fear conditioning studies (Kelly

& Forsyth, 2009; Lee, Lim, Lee, Kim, & Choi, 2009; Pischek-Simpson, Boschek, Neumann, &

Waters, 2009; Van Damme, Crombez, Hermans, Koster, & Eccleston, 2006) have documented an

attentional bias for the CS+ that accompanies acquisition of other CRs (e.g., increased skin

conductance; Pischek-Simpson et al., 2009), suggesting that an attentional bias is one mechanism

through which aversive learning could contribute to anxiety disorders.

Whereas fear conditioning has been found to lead to an attentional bias towards the CS+, disgust conditioning may be associated with an attentional bias away from the CS+, as the UR to disgust-evoking stimuli may involve visual avoidance (Armstrong, Sarawgi, & Olatunji, 2012; Tolin, Lohr, Lee, & Sawchuk, 1999), due to the offensive sensory properties of disgust-evoking stimuli (Royzman & Sabini, 2001). Indeed, 'attentional avoidance' of threat appears to be most prominent in specific phobias, such as BII phobia (Mogg, Bradley, Miles, & Dixon, 2004) and spider phobia (Rinck & Becker, 2006), which may be due to the disgusting quality of stimuli in these disorders (Armstrong & Olatunji, 2012). Attentional avoidance is believed to play a functional role similar to behavioral avoidance, in that it prevents extinction and reappraisal, thereby maintaining harm associations (Cisler & Koster, 2010; Mogg, Mathews, & Weinman, 1987).

In the first study to investigate the effects of Pavlovian disgust conditioning on attentional bias, Mason and Richardson (2010) found that disgust images elicited attentional avoidance, and that a facial stimulus came to elicit attentional avoidance after being paired with disgust images, as revealed by eye tracking. Interestingly, attentional avoidance of the CS+ was not affected by an extinction procedure, consistent with past research suggesting that disgust associations can be resistant to extinction (Olatunji, Forsyth, & Cherian, 2007). Mason and Richardson also found that disgust sensitivity was associated with the retention of attentional avoidance of the CS+ after extinction, but not with the initial acquisition of attentional avoidance of the CS+. However, it is not clear if these findings are specific to disgust learning. Attentional avoidance may be related to more general attributes of aversive learning, and thus may be observed for CSs associated with any unpleasant stimulus.

To determine if attentional avoidance is specific to disgust learning, the present study contrasted the effects of disgust learning on attention with the effects of more general aversive

learning, by including a condition with a US that evoked predominantly fear. Prior research along these lines has assessed attention with a very small number of trials, constraining the reliability of the attentional biases that may be observed. Accordingly, the present study assessed CS–related attentional bias over a larger number of trials, at three time points (post-habituation, post-acquisition, post-extinction). It was predicted that attentional avoidance of the US and the CS+ would only characterize disgust learning. Second, mediational analysis was utilized to provide further insight into the relations between attentional bias, disgust learning, and disgust sensitivity. It was predicted that disgust sensitivity would lead to increased attentional avoidance of the disgust US through its effect on the amount of disgust experienced in response to this stimulus. Further, it was predicted that disgust sensitivity would lead to increased attentional avoidance of the disgust CS+ through its effect on attentional avoidance of the disgust US.

Methods

Participants

One-hundred and twenty participants at a Vanderbilt University participated in the experiment in exchange for course credit. Participants completed either a condition with a disgust-specific US ($n = 55$; 76.9% female; age $M = 19.36$, $SD = 1.28$) or a condition with a generally aversive US that predominantly elicited fear ($n = 65$; 76.4% female; age $M = 19.49$, $SD = 1.11$).

Measures

The *Disgust Scale—Revised* (DS-R; Haidt et al., 1994; Modified by Olatunji et al., 2007) is a 25-item questionnaire assessing sensitivity to a range of disgust elicitors, including core (e.g., rotting food), animal-reminder (e.g., mutilation), and contamination-based (e.g., contact with germs) disgust domains. The DS-R had good internal consistency ($\alpha = .89$) in the present study.

Materials and Apparatus

The videos used as USs were selected from publically available online sources. Four videos of individuals vomiting were used as disgust USs; four videos of individuals being harmed in sudden motor vehicle accidents were used as fear USs, and four videos of different streams and rivers were used as control video stimuli. Videos were in color, did not contain audio, and were re-sized to subtend a visual angle of 14.62º x 11.71º. Two male faces and two female faces were selected from the NimStim Face Stimulus Set (Tottenham et al., 2009). One male-female pair was used for the CS+ (paired with US) and CS– (paired with control videos), with gender-CS pairing counterbalanced (Lee et al., 2009). The other male-female pair was not presented during phases of the conditioning task, but was instead included as "filler" (e.g., Kellough, Beevers, Ellis, & Wells, 2008) in the assessment of attentional biases, in order to delay habituation to the CSs. Face stimuli were converted to greyscale, matched for luminance and contrast, and resized to subtend a visual angle of 5.71º x 7.14º. Stimuli were presented using E-Prime version 2.0 software on a 17-in. widescreen monitor (1280 x 1024 resolution, 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 .5º-1º. Participants' heads were stabilized with a chinrest at a viewing distance of 60.5 cm.

Procedure

Participants provided informed consent to a protocol approved by the Institutional Review Board, and then completed the measures as well as a basic demographic survey. Participants then completed the following tasks on the computer:

Conditioning procedure

Habituation. This stage consisted of 4 non-reinforced presentations (15 s) of each CS in random order. Participants were instructed to look directly at the CS. CSs were preceded by a

fixation cross (1.5 s) and followed by an inter-trial interval (ITI; blank screen) that varied

randomly between 12 s and 18 s. The CSs were centered in the lower third of the screen.

Acquisition. During this stage, the CSs were presented for 20 s in the lower third of the

screen. After 5 s of presentation, a video began playing in the center of the screen for the

remaining 15 s of the CS presentation. Participants were instructed to look directly at the CS until

the video began, and then to watch the video. CSs were preceded by a fixation cross (1.5 s) and

followed by an ITI that varied randomly between 12 s and 18 s. The CS+ cued the US video; the

CS– cued the control video. There were two blocks of trials, each consisting of 4 presentations of

CS+ trials, and 4 presentations of CS– trials, presented in a random order. Eye movements were

recorded during acquisition trials to assess gaze tendencies in response to the US.

Reacquisition. The acquisition procedure was repeated, but with only one block (4 trials of

the CS+ and 4 trials of the CS–) in order to reactivate the associations prior to extinction (Kelly et

al., 2007). Eye movements were again recorded.

Extinction. The acquisition procedure was repeated without US presentation (8 trials of

CS+ and 8 trials of CS–).

Self-report CR assessment. Participants rated how disgusted and how afraid the CS's

made them feel using the unidimensional version of the Empirical Valence Scale (EVS; Lishner,

Cooter, & Zald, 2008). This visual analog scale has verbal descriptors placed at empirically

determined locations—not at all (0), barely (7), slightly (12), mildly (24), moderately (38),

strongly (70), extremely (85), and most imaginable (100)—and is designed to reduce floor effects

for subtle responses (such as those expected for the CSs) and to limit ceiling effects for intense

responses (such as those expected for the USs). Ratings can be made at any point along the scale

using a mouse cursor. CS ratings were collected after habituation, midway through and after

acquisition, and after extinction. In addition, participants completed the same ratings procedure for

the US videos once they completed the conditioning procedure. Ratings were collected after a 5 s sample of each video.

Eye movement CR assessment. After the habituation, conditioning, and extinction stages of the conditioning procedure, an eye tracking procedure was conducted to assess attention allocation to the CSs. The CS+ and CS− were presented side by side, for 3 s, with centers separated by 10° of visual angle. Participants were told to view the faces as they please, and were asked to respond to a central fixation point (X or O) that preceded the CSs by clicking or not clicking the mouse, in order to obscure the nature of the task (e.g., Armstrong et al., 2010). The fixation point was presented for 700 ms or until participants responded. Following the CSs, the ITI consisted of a blank screen for 1.5 s, 2 s, or 2.5 s, varied randomly. The task consisted of 16 trials of the CS+ and CS−, as well as 16 "filler" trials of the male and female face not presented during conditioning phases. Location (right or left) was balanced for both face pairs.

Eye movement data reduction

Eye movement events (saccades, fixations, blinks) were defined using BeGaze 2.0 software from SMI, and a fixation was classified as 100 ms or more in which gaze was stable within 1.5° of visual angle. For acquisition and reacquisition phases, the rectangle containing the US video was the area of interest (AOI). Total fixation duration (dwell time), averaged across trials, was computed for the US video and the control video for each participant. These values were used in Analysis of Variance (ANOVA). For correlational and mediational analyses, dwell time on the control video was subtracted from dwell time on the US video, in order to control for individual differences in fixation time on the videos that were unrelated to stimulus content (e.g., differences related to quality of eye tracking signal). Thus, negative values reflect visual avoidance of the US video relative to the control video. This variable was initially computed for the first half of acquisition (prior to midpoint CS ratings), for the second half of acquisition, and

for reacquisition. These three indices had excellent internal consistency ($\alpha = .92$) and were combined to create a composite variable that would be more reliable, stable, and resistant to error (Campbell & Fiske, 1959). For the eye movement CR assessment, the rectangles containing the CSs were the area of interest (AOI). We computed the average dwell time on the CS+ and the CS– for each assessment (i.e., after habituation, after acquisition, and after extinction). These values were used in ANOVAs. For correlational and mediational analyses, dwell time on the CS– was subtracted from dwell time on the CS+, in order to control for individual differences in fixation time overall. Thus, negative values on the resulting variable reflected attentional avoidance of the CS+ relative to the CS–.[1]

Data analytic plan

For US validation, A 2 (condition: disgust, negative) X 2 (video: US, control) X 2 (emotion: disgust, fear) mixed-effects ANOVA was conducted on self-reported emotion to the videos, and a 2 (condition: disgust, negative) X 2 (video: US, control) mixed-effects ANOVA was conducted on fixation duration on the videos. In line with other Pavlovian conditioning studies (e.g., Kelly & Forsyth, 2007; Lissek et al., 2008; Mason & Richardson, 2010), CR analyses were conducted separately for each stage of the conditioning procedure (habituation, acquisition, extinction). For the self-reported emotion CR, a 2 (condition: disgust, negative) X 2 (CS: CS+, CS–) X 2 (emotion: fear, disgust) mixed-effects ANOVA was conducted. Self-report data from the midpoint and end of acquisition were collapsed together for all analyses. Analyzing only the endpoint acquisition ratings yielded the same pattern of results. For the eye movement CR, a 2 (condition: disgust, negative) X 2 (CS: CS+, CS–) mixed-effects ANOVA was conducted. In

---

[1] Orienting bias was also examined by considering the proportion of initial fixations captured by each CS. This variable may be more relevant to fear conditioning, as it shows convergent validity with reaction time variables (Armstrong & Olatunji, 2012) used in studies of fear conditioning (Pischek-Simpson et al., 2009). No effects were found on this variable in either condition.

addition, planned interaction contrasts were used to explore differences in CR discrimination

between phases of the conditioning procedure (Kelly & Forsyth, 2007). Lastly, for correlational

and mediational analyses, variables reflecting discriminant responding to the CSs (CS+ − CS–)

and the USs (US − control) were used (e.g., Indovina et al., 2011; Lissek et al., 2008; Mason &

Richardson, 2010). Mediation was tested using Preacher and Hayes's (2008) boot-strapping

procedure, which does not impose distributional assumptions often violated in smaller samples.

Results

Group characteristics

Participants in the disgust and fear condition did not significantly differ in gender, χ^2 (1, N

= 110) = .005; age, t (118) = .59; or disgust sensitivity, t (118) = -1.15, all ps > .05.

US validation

Self-report UR assessment. There was a significant main effect of video, F (1, 118) =

338.45, $p < .001$, such that regardless of condition, the US elicited more negative emotion than the

control video, as intended. The main effect of condition was not significant, F (1, 118) = .45, $p >$

.05, nor was the condition by video interaction, F (1, 118) = .23, $p > .05$. Thus, the conditions did

not differ in terms of the overall negative emotion elicited by the US videos. Importantly, the

predicted condition by video by emotion interaction was significant, F (1, 118) = 272.84, $p < .001$,

indicating that the conditions differed in terms of the specific negative emotions elicited by the US

videos. To interpret this effect, the video by emotion type interaction was examined in each

condition separately. For the disgust condition, significant main effects of video, F (1, 54) =

217.08, $p < .001$, and emotion, F (1, 54) = 219.66, $p < .001$, were qualified by a significant video

by emotion interaction, F (1, 54) = 261.97, $p < .001$, indicating that while the disgust videos

elicited more fear and disgust than the neutral videos, disgust was the predominant negative

emotional reaction to the disgust videos compared to the neutral videos. Likewise, for the fear

21

condition, there were significant main effects of video, $F(1, 64) = 145.36$, $p < .001$, and emotion, $F(1, 64) = 13.03$, $p < .001$, qualified by a significant video by emotion interaction, $F(1, 64) = 24.65$, $p < .001$, indicating that while the fear videos elicited more fear and disgust than the neutral videos, fear was the predominant emotional response to the fear videos compared to the neutral videos. Table I provides Ms and SDs for US ratings.

Table I. Means (SDs) for self-reported emotional responses to the US

| Rating | Video | Condition | |
		Disgust	Fear
Disgust	US	60.91 (26.50)	30.47 (24.04)
	Control	2.74 (5.55)	2.82 (5.32)
Fear	US	12.65 (14.88)	39.73 (23.97)
	Control	1.47 (3.89)	1.58 (3.30)

Note. US = unconditioned stimulus.

Eye movement UR assessment. Significant main effects of condition, $F(1, 118) = 30.56$, $p < .001$, and video, $F(1, 118) = 33.39$, $p < .001$ were qualified by a condition by video interaction, $F(1, 118) = 32.45$, $p < .001$. To interpret this interaction, planned contrasts were conducted in each condition comparing fixation duration on the US video versus the control video. In the disgust condition, the US was viewed less ($M = 7.24$ s, $SD = 4.27$) than the control video ($M = 9.53$ s, $SD = 2.47$), $t(54) = -6.44$, $p < .001$, whereas in the fear condition, viewing times for the US ($M = 11.16$ s, $SD = 2.79$) and control video ($M = 11.18$ s, $SD = 2.00$) did not differ, $t(54) = -.08$, $p > .05$. Thus, the disgust US was uniquely characterized by a UR of attentional avoidance.

Habituation

Self-report CR assessment. The main effect of CS, the condition by CS interaction, and the condition by CS by emotion interaction were all non-significant, Fs $(1, 118) < 1$, ps $> .05$. Thus, there were no differences in emotional responding to the CSs prior to acquisition in either group. Table II provides Ms and SD for all CS ratings, and Figure II depicts these ratings.

Table II. Means (*SDs*) for self-reported emotional responses to the CSs

Disgust condition

Rating	CS	Phase of conditioning		
		Habituation	Acquisition	Extinction
Disgust	CS+	11.89 (13.33)	23.01 (23.04)	13.09 (17.73)
	CS−	10.33 (12.68)	7.78 (9.15)	5.95 (12.29)
Fear	CS+	15.82 (15.90)	15.62 (15.99)	9.6 (12.80)
	CS−	19.13 (18.22)	9.93 (11.69)	7.4 (10.09)

Fear condition

Rating	CS	Phase of conditioning		
		Habituation	Acquisition	Extinction
Disgust	CS+	8.49 (11.87)	15.75 (15.09)	13.48 (18.06)
	CS−	8.89 (12.63)	6.70 (10.09)	7.95 (14.62)
Fear	CS+	14.05 (15.27)	18.53 (15.37)	13.14 (15.77)
	CS−	16.03 (17.75)	8.61 (13.02)	5.80 (12.80)

Note. CS = conditioned stimulus (face); CS+ = face paired with unconditioned stimulus video; CS− = face paired with control video.
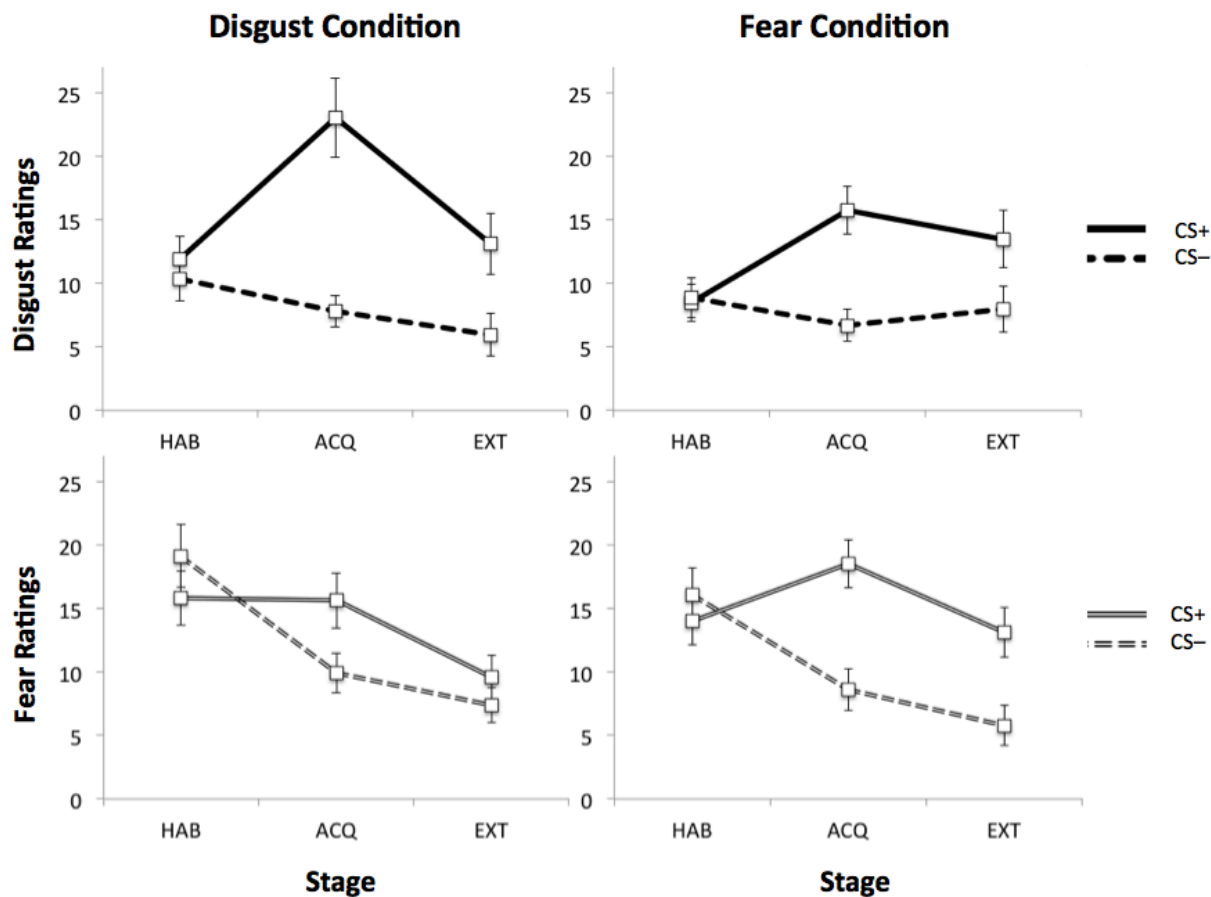
Figure II. Self-reported emotion in response to the conditioned stimuli (i.e., faces). CS+ = face paired with unconditioned stimulus video; CS− = face paired with control video; HAB = post-habituation; ACQ = post-acquisition, EXT = post-extinction. Error bars represent *SE*.

Eye movement CR assessment. The main effect of CS and the condition by CS interaction were both non-significant, *F*s (1, 118) < 1, *p*s > .05, as there were no differences in attentional responses to the CSs prior to acquisition in either the disgust condition (CS+: *M* = 1038 ms, *SD* = 180, CS−: *M* = 1036 ms, *SD* =201, *t* (54) = .05, *p* > .05) or the fear condition (CS+: *M* = 1026 ms, *SD* = 199, CS−: *M* = 1042 ms, *SD* =211, *t* (64) = -.37, *p* > .05).

Acquisition

Self-report CR assessment. There was a significant main effect of CS, $F(1, 118) = 45.67$, $p < .001$, reflecting acquisition of negative emotion to the CS+ vs. CS– in both conditions. The condition by CS interaction was not significant, $F(1, 118) = .11$, $p > .05$, indicating that the overall negative emotion acquired in both conditions was similar. However, a significant condition by CS by emotion interaction revealed that the conditions differed in terms of the specific negative emotional responses that were acquired, $F(1, 118) = 13.14$, $p < .001$. To interpret this interaction, the main effect of CS and the CS by emotion interaction term were examined in both conditions separately. The main effect of CS was significant in both conditions, $ps < .001$. In the disgust condition, the CS by emotion interaction was significant, $F(1, 54) = 18.77$, $p < .001$, such that more disgust than fear was acquired for the CS+ relative to the CS–. However, in the fear condition, this interaction was not significant, $F(1, 64) = .22$, $p > .05$, such that similar levels of disgust and fear were acquired for the CS+ relative to the CS–.

Eye movement CR assessment. The main effect of CS and the condition by CS interaction were not significant, $Fs(1, 118) < 1$, $ps > .05$, as dwell time on the CSs did not significantly differ after acquisition in the disgust condition (CS+: $M = 986$ ms, $SD = 233$; CS–: $M = 1020$ ms, $SD = 244$, $t(54) = -.63$, $p > .05$) or in the fear condition (CS+: $M = 988$ ms, $SD = 245$; CS–: $M = 987$ ms, $SD = 262$, $t(64) = .02$, $p > .05$).

Extinction

Self-report CR assessment. There was a main effect of CS, $F(1, 118) = 18.60$, $p < .001$, indicating that discriminant negative emotional responding to the CS+ persisted after extinction. The main effect of CS was not qualified by a condition by CS interaction, $F(1, 118) = .47$, $p > .05$, such that overall residual negative emotion to the CS+ versus CS– did not differ between conditions. However, a significant condition by CS by emotion interaction, $F(1, 118) = 4.47$, $p <$

.04 indicated that the conditions differed in terms of the specific negative emotion to the CS+ remaining after extinction. To interpret this interaction, the main effect of CS and the CS by emotion interaction term were examined in both conditions separately. The main effect of CS was significant in both conditions, ps < .001. In the disgust condition, the CS by emotion interaction was significant, $F (1, 54) = 4.65$, $p < .04$, such that more disgust than fear remained for the CS+ relative to the CS–. However, in the fear condition, this interaction was not significant, $F (1, 64) = .67$, $p > .05$, such that similar levels of disgust and fear remained for the CS+ relative to the CS–.

This pattern of findings, which was highly consistent with the pattern of findings at acquisition, indicated that complete extinction was not achieved in either condition. To determine if partial extinction was achieved, an exploratory analysis was conducted to test if self-reported negative emotion to the CS+ declined between acquisition and extinction. Conditioning phase was added to the ANOVA model, and limited to the levels of acquisition and extinction. The analysis revealed a CS by phase interaction, $F (1, 118) = 7.33$, $p < .01$, suggesting that negative emotion to the CS+ did decline as a function of extinction in both conditions. This interaction was not qualified by any further interactions (ps > .05), indicating that extinction effects did not differ as a function of condition, emotion rating, or their interaction. To determine if negative emotion in response to the CS+ vs. CS– after extinction was greater than baseline levels, a similar analysis was conducted comparing habituation and extinction. Again, there was a significant CS by phase interaction, $F (1, 118) = 15.85$, $p < .001$, confirming that residual negative emotion was greater than baseline levels. The CS by phase interaction was not qualified by further interactions (ps > .05).

Eye movement CR assessment. A significant main effect of CS, $F (1, 118) = 16.40$, $p < .001$, was qualified by a condition by CS interaction, $F (1, 118) = 4.76$, $p < .04$. To interpret this interaction, paired samples t-tests were conducted in each condition. In the disgust condition,

individuals viewed the CS+ less compared to the CS− (CS+: $M = 877$ ms, $SD = 211$; CS−: $M = 1097$ ms, $SD = 261$, t (54) = -4.06, $p < .001$. In the fear condition, viewings times did not differ between CSs, (CS+: $M = 976$ ms, $SD = 225$; CS−: $M = 1042$ ms, $SD = 223$, t (64) = -1.43, $p > .05$. An exploratory analysis compared dwell time on the CSs between habituation and extinction, in order to control for any baseline differences in dwell time on the faces. There was a CS by phase interaction, F (1, 118) = 11.37, $p = .001$, which was further qualified by a condition by CS by phase interaction, F (1, 118) = 4.55, $p < .05$. In order to interpret this interaction, we examined the CS by phase interaction within each condition. In the disgust condition, the CS by phase interaction was significant, F (1, 54) = 13.43, $p = .001$, whereas in the fear condition, the CS by phase interaction was not significant, F (1, 64) = .87, $p > .05$. Thus, an attentional bias away from the CS+ after extinction only differed from baseline attentional bias in the disgust condition. Figure III depicts changes in attentional bias across phases in both conditions.
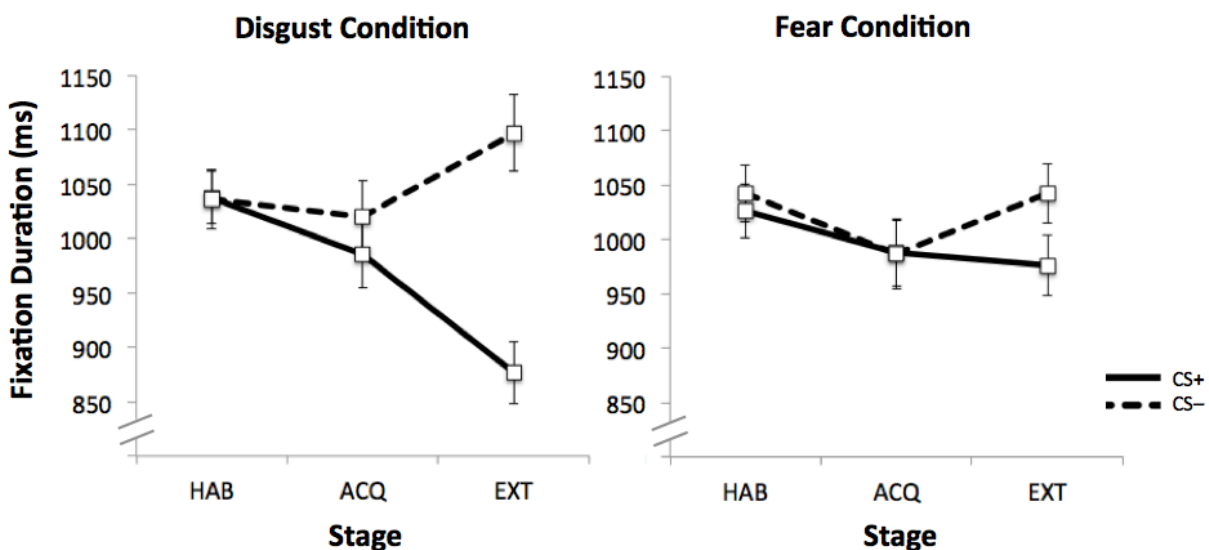
Figure III. Fixation duration on the conditioned stimuli. CS+ = face paired with unconditioned stimulus video; CS− = face paired with control video; HAB = post-habituation; ACQ = post-acquisition, EXT = post-extinction. Error bars represent SE.

Do differential attentional biases for disgust and fear USs account for differential attentional biases for disgust and fear CSs?

A mediational model was tested in which differences in attentional CRs between conditions were a function of differences in attentional URs between conditions, consistent with theoretical accounts of associative learning and Pavlovian conditioning (e.g., Mackintosh, 1983). The indirect path from condition (disgust vs. fear) to attentional avoidance of the CS+ through attentional avoidance of the US was significant ($p < .05$) as indicated by the 95% confidence intervals not containing 0 (lower limit = -206.92, upper limit = -19.34; B = -103.073, *SE* = 47.53). Thus, mediation was demonstrated (Figure IV). Whereas this analysis required the full sample, the remaining analyses focus on participants in the disgust condition.
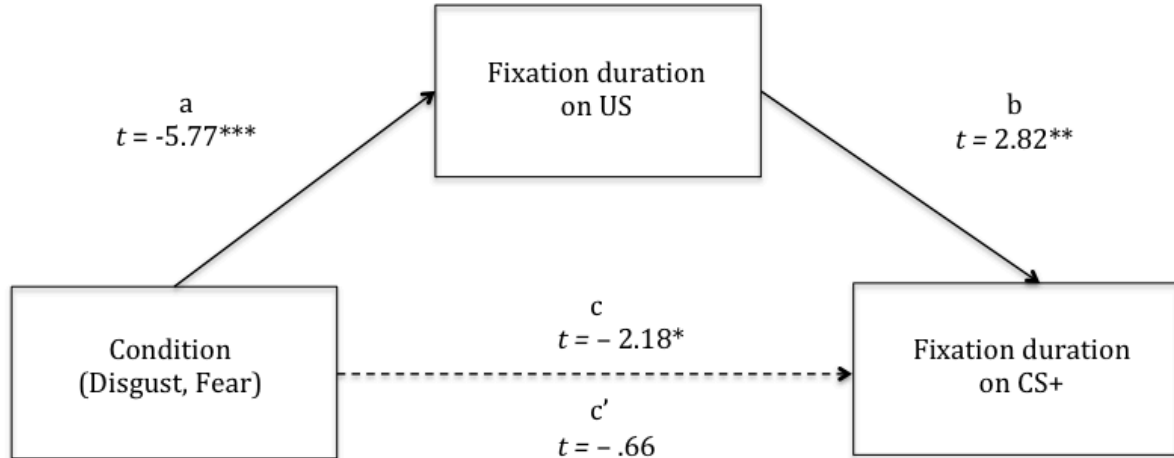
Figure IV. Fixation duration on the conditioned stimuli. CS+ = face paired with unconditioned stimulus video; CS– = face paired with control video; HAB = post-habituation; ACQ = post-acquisition, EXT = post-extinction. Error bars represent *SE*.

What are the relations between disgust sensitivity, disgust URs, and disgust CRs?

Disgust sensitivity and URs. Disgust sensitivity was strongly correlated with disgust responding to the US video ($r = .59$, $p < .001$) and dwell time on the US video ($r = -.47$, $p < .001$), such that individuals who were more disgust sensitive reported being more disgusted by the vomit videos and viewed them less. Also, disgust responding to the US video was strongly correlated with dwell time on the US video ($r = -.57$, $p < .001$), such that individuals who reported more disgust in response to the videos viewed them less. A mediational analysis was conducted to test the hypothesis that disgust sensitivity increased the experience of disgust in response to the vomit videos, which in turn increased the use of visual avoidance to down-regulate disgust. The indirect path from disgust sensitivity to visual avoidance through self-reported disgust was significant ($p < .01$) as indicated by the 99% confidence intervals not containing 0 (lower limit = -131.01, upper limit = -20.18; B = -61.93, $SE = 20.04$). Thus, mediation was demonstrated (Figure V).
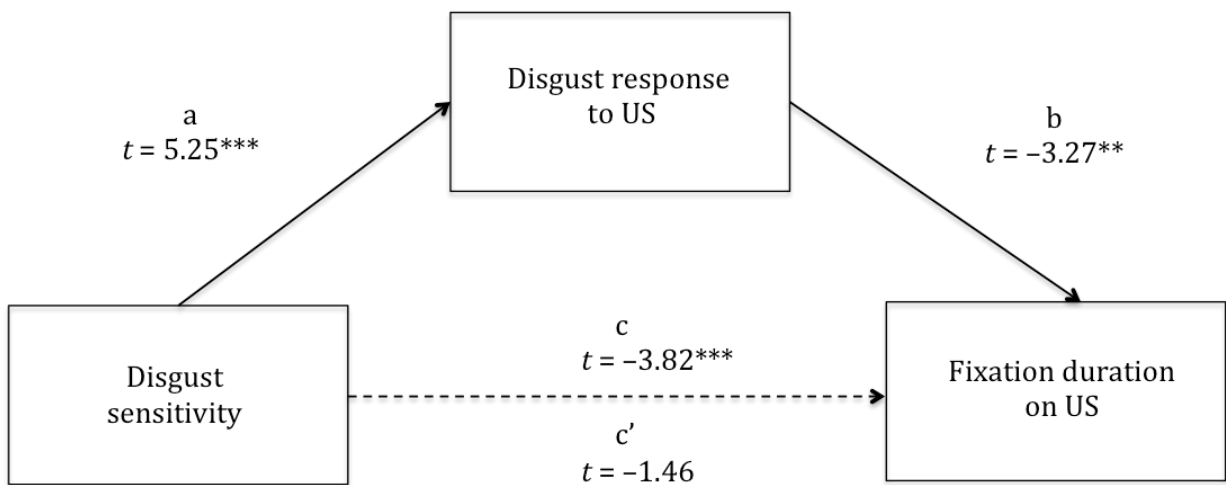
Figure V. Mediational model of the relations between disgust sensitivity, self-reported disgust in response to the US, and fixation duration on the US in the disgust condition. Fixation duration on the US is relative to the control video, disgust in response to the US is relative to the control video, and *t*-values are for path coefficients. US = unconditioned stimulus; CS = conditioned stimulus (faces); CS+ = face paired with unconditioned stimulus video; CS– = face paired with control video; ** $p < .01$; *** $p < .001$.

Disgust sensitivity, URs and CRs. Disgust sensitivity was not correlated with discriminant self-reported disgust in response to the CSs after acquisition or after extinction ($rs <$ .20, ps > .05) in the disgust condition. However, disgust sensitivity was correlated with discriminant dwell time on the CSs after extinction ($r = -.28$, $p < .05$), such that individuals with higher disgust sensitivity avoided looking at the CS+ relative to the CS– in the disgust condition. Interestingly, discriminant dwell time on the CSs after extinction was associated with discriminant disgust in response to the CSs after acquisition ($r = -.29$, $p = .03$), but not after extinction ($r = -.15$, $p > .05$), such that attentional avoidance of the CS+ post-extinction was linked to the amount of disgust initially acquired, but not to the amount of disgust remaining after extinction (on self-report measures). In addition, discriminant dwell time on the CSs after extinction was associated with dwell time on the disgust US, such that a tendency to avoid looking at the vomit videos predicted a tendency to avoid looking at the CS+ after extinction.

Does attentional avoidance of the disgust US mediate the relationship between disgust sensitivity and attentional avoidance of the disgust CS?

A mediational analysis was conducted to test the hypothesis that disgust sensitivity confers a tendency to avoid looking at unconditioned disgust stimuli, which in turn leads to increased visual avoidance of conditioned disgust stimuli post-extinction. The indirect path was significant ($p < .05$) as indicated by the 95% confidence intervals not containing 0 (lower limit = -8.22, upper limit = -.04; B = -3.26, SE = 2.07). Thus, mediation was demonstrated (Figure VI).
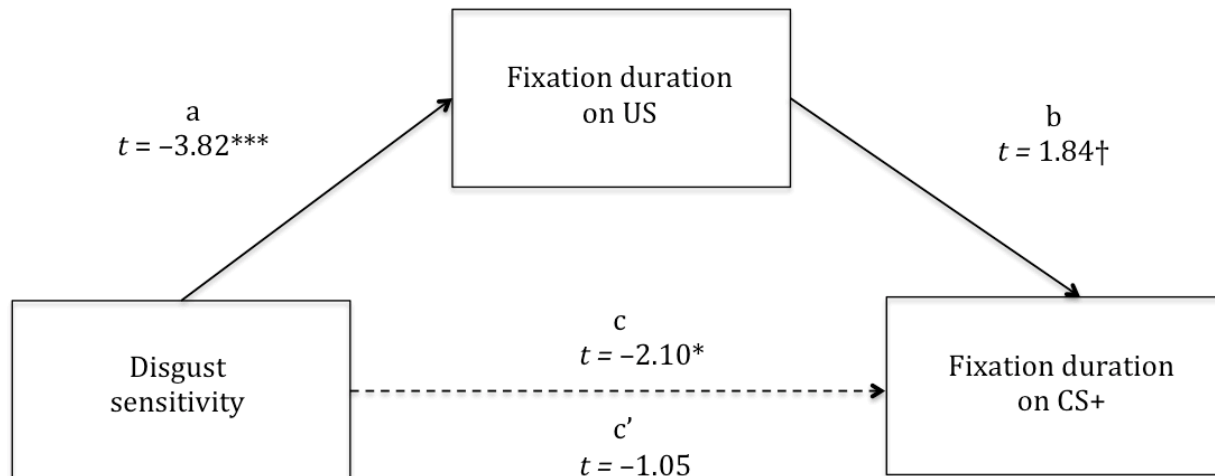
Figure VI. Mediational model of the relations between disgust sensitivity, fixation duration on the US, and fixation duration on the CS+ in the disgust condition. Fixation duration on the CS+ is relative to the CS−, fixation duration on the US is relative to the control video, and t-values are for path coefficients. US = unconditioned stimulus; CS = conditioned stimulus (faces); CS+ = face paired with unconditioned stimulus video; CS− = face paired with control video; † = $p = .07$; * = $p < .05$; *** $p < .001$.

Discussion

The present study is the first, to our knowledge, to contrast the effects of disgust learning and more general aversive learning on attention using comparable USs. Individuals in the disgust condition showed robust attentional avoidance of the CS+ relative to the CS−, a pattern not observed in the fear condition. However, this effect did not reach significance immediately after acquisition, and instead became pronounced following subsequent reacquisition and extinction. Although this pattern of results was unexpected, attentional avoidance of the disgust CS+ post-extinction nonetheless appeared to be a *learned* bias that resulted from the pairing of the CS+ with the US during acquisition and reacquisition. Importantly, attentional avoidance of the CS+ post-extinction was significantly greater than baseline levels (i.e., post-habituation), was correlated with the initial acquisition of self-reported disgust to the CS+, and was correlated with disgust

31

URs (both self-reported disgust and attentional avoidance). Further, two mediational models, one contrasting the disgust and fear conditions, and one focusing within the disgust condition, both suggested that attentional avoidance of the disgust CS+ was a function of attentional avoidance of the disgust US, providing additional evidence that attentional bias post-extinction was related to a transfer of affective properties from the disgust US to the CS+.

Attentional avoidance of the disgust CS+ observed in the present study was correlated with the initial acquisition of self-reported disgust, yet emerged later in the conditioning procedure. Robust attentional avoidance of the CS+ may have developed after extinction, rather than after acquisition, because this more distal CR relies on greater consolidation of the disgust memory. Increased consolidation may have been achieved through the additional reinforced trials in the reacquisition phase, or by the passage of time between acquisition and extinction. This pattern of dissociation between self-reported disgust ratings and attentional avoidance may suggest that these CRs reflect distinct underlying learning processes. Disgust ratings closely tracked the contingency between the CS+ and the disgust US, increasing at acquisition and attenuating at extinction. This may suggest that disgust ratings reflect expectancy learning, as self-reported fear ratings of the CS+ in fear conditioning studies have been found to mostly track this type of learning (e.g., Hermans et al., 2002). In contrast, attentional avoidance may reflect evaluative or affective learning, the process by which the affective properties of the US "transfer" to the CS. Evaluative learning has been found to be less sensitive to extinction compared to expectancy learning (e.g., Olatunji et al., 2007), which may explain why attentional avoidance of the CS+ post-extinction was decoupled from self-reported disgust post-extinction, yet was linked to self-reported disgust post-acquisition. In addition, evaluative learning is often observed on *implicit* measures that are outside of a participant's awareness or control (e.g., affective priming, Hermans et al., 2002; startle blink potentiation, Sevenster, Beckers, & Kind, 2012). Eye tracking may be conceptualized

as an implicit measure that is sensitive to evaluative learning because the effect of the CS–US

association on eye movements occurs without the participant's awareness or effort (De Houwer,

Teige-Mocigemba, Spruyt, & Moors, 2009).

The present findings may have important implications for understanding the association

between disgust sensitivity and symptoms of certain anxiety disorders (Olatunji et al., 2010), as

multiple points of evidence suggest that disgust sensitivity increases attentional avoidance, which

is a potential mechanism in the etiology or maintenance of anxiety (Cisler & Koster, 2010). First,

disgust sensitivity was found to increase attentional avoidance of disgust USs. This effect was

mediated by self-reported disgust elicited by the USs, which suggests that attentional avoidance is

a coping strategy used to down-regulate the experience of disgust in individuals who are highly

sensitive to this emotion. Second, by increasing attentional avoidance of disgust USs, disgust

sensitivity was found to indirectly increase attentional avoidance of disgust CSs after extinction.

These effects may have clinical significance, because attentional avoidance appears to deprive

anxious individuals of beneficial exposure to disorder-related USs and CSs. For example, in the

case of BII phobia, a disorder involving elevated disgust sensitivity as well as enhanced disgust

conditioning (Olatunji et al., 2009), merely viewing images (Öst, Fellenius, & Sterner, 1991) or

videos (Hellström, Fellenius, & Öst, 1996) related to BII threat has been found to provide

considerable symptom relief in up to 50% of patients (Öst et al., 1991). Specifically, visual

exposure to USs (e.g., venipuncture in BII phobia) may cause habituation of URs and subsequent

US re-evaluation (i.e., reappraisal as less threatening). In addition, visual exposure to CSs (e.g.,

syringe in BII phobia) may promote extinction of CRs. Indeed, training attention away from threat

signals has been found to impair extinction, compared to training attention towards threat signals

(Van Bockstaele,Verschuere, De Houwer & Crombez, 2010). In light of this evidence, attentional

avoidance is one potential mechanism through which disgust sensitivity and related disgust learning tendencies could contribute to anxiety disorders.

The present findings also suggest that attentional avoidance may be relatively specific to disgust learning, as generally negative learning did not lead to attentional avoidance of the CS+ after acquisition or extinction. Mediational analyses revealed that differential attentional bias acquisition between conditions was a function of the differential effect of the USs on attention, as disgusting stimuli appear to have a unique ability to repel attention. Disgusting content may motivate attentional avoidance more than other negative content because it is intrinsically unpleasant to perceive (Armstrong & Olatunji, 2012). Indeed, Royzman and Sabini (2001) argue that compared to other negative emotions, disgust is more easily elicited by a stimulus's concrete sensory and perceptual qualities. Interestingly, disgust has also been contrasted with other negative emotions in terms of its cognitive impenetrability. For example, Rozin and Nemeroff (1990) showed that individuals could not overcome an aversion to eating chocolate fudge shaped to look like dog poop, or an aversion to drinking water into which a sterilized cockroach was dipped, despite knowing that their disgust responses were irrational. The insensitivity to extinction found to characterize attentional avoidance of disgust CS+s (Mason & Richardson, 2010) may be conceptualized as a form of cognitive impenetrability; once acquired, attentional avoidance may be encapsulated from higher cognitive processes, such that it is unaffected by knowledge that the CS no longer predicts the US (Barrett & Kurzban, 2006). In addition, disgust may be resistant to extinction because disgust USs are highly salient in episodic memory (Chapman, Johannes, Poppenk, Moscovitch, & Anderson, 2013), which may allow the disgust US to resist inhibition from the extinction memory when activated by the CS+ post-extinction.

The attentional bias *away* from disgust CS+s observed in the present study contrasts with the bias that has been observed for fear CS+s. The handful of studies examining attentional bias

for fear CSs (Kelly & Forsyth, 2009; Lee et al., 2009; Pischek-Simpson et al., 2009; Van Damme et al., 2006) suggests that fear learning is related to increased rather than decreased attention to the CS+, and that this bias may track expectancy learning rather than evaluative learning. For example, Kelly and Forsyth (2009), employing a video-based conditioning procedure, found that attentional bias for the fear CS+ was highly sensitive to an extinction procedure, as did Van Damme et al. (2006) in a more classical fear conditioning procedure that utilized electrocutaneous shocks as the US. One possibility is that hypervigilance in anxiety disorders is driven by threat signaling related to expectancy learning, whereas subsequent attentional avoidance is driven by intrinsic aversiveness related to evaluative learning. Accordingly, the hypervigilant-avoidant pattern of attention to threat observed in some anxiety disorders, particularly specific phobias, may reflect a combination of fear and disgust learning (Armstrong & Olatunji, 2012).

Although these findings provide new insight into a complex pattern of relations between disgust, evaluative learning, and attention that may inform etiological models of some anxiety disorders, the findings should be interpreted with several limitations in mind. First, the failure to observe attentional avoidance of the disgust CS+ immediately after acquisition limits the conclusions that can be made regarding extinction, because it is unclear if the bias developed in time to be effected by the extinction trials. However, the present findings are consistent with prior research showing that attentional avoidance acquired through disgust conditioning is insensitive to extinction (Mason & Richardson, 2010). In addition, the present study did not collect US expectancy ratings or measure skin conductance responses (SCR) to the CSs. These measures of expectancy learning (Sevenster et al., 2010) could have helped parse expectancy and evaluative learning, and would have allowed more thorough comparison with aversive learning examined in other paradigms (e.g., Hermans et al., 2002). Also, the effects of conditioning on self-reported emotion, although statistically significant, were quite modest. This may be due to the use of brief

video clips as USs, as viewing unpleasant videos is less intense than receiving a shock (Hermans et al., 2002) or a hearing a 103 dB scream (Indovina et al., 2011). Lastly, the fear US may not have been ideally matched to the disgust US, because it did not strongly elicit a specific negative emotion; instead, it moderately elicited a blend of negative emotions (fear and disgust). If the negative US had been more specific to fear, it would have allowed stronger conclusions about the specificity of the findings in relation to other basic emotions. Future research that reconciles some of these limitations and employs a longitudinal approach would allow more inferences to be made regarding how disgust learning confers risk for the development of certain anxiety disorders through its effects on attention.

CHAPTER III

EXPERIMENT 2: DISGUST CONDITIONING AND ATTENTION

IN CONTAMINATION-BASED OCD

Experiment 1 sought to contrast the effects of disgust and fear learning on attention, and to relate these effects to known vulnerability factors for anxiety disorders. Having established that disgust learning, but not fear learning, leads to attentional avoidance, and that this effect is conditional on disgust sensitivity, I sought to examine relations between disgust learning, attention, and disgust sensitivity in the context of contamination-based OCD.

Contamination obsessions paired with washing compulsions are reported by over 50% of patients with OCD, making this the most common symptom theme in the disorder (Rasmussen & Eisen, 1992). Contamination involves the perceived transfer of an undesirable property (e.g., dirty, infected, polluted, impure) through physical or symbolic contact (Rozin & Fallon, 1987). Contamination concerns in OCD have been traditionally conceptualized in terms of fear and anxiety; however, research in the general population suggests that disgust is the predominant emotional response to contamination (Rozin & Fallon, 1987), and there is growing evidence that disgust plays an important role in contamination-based OCD (Olatunji et al., 2010). For example, several studies have observed that individual differences in disgust sensitivity predict symptoms of contamination-based OCD on both self-report and behavioral measures, even when controlling for negative affect (see Olatunji et al., 2010).

However, specific disease mechanisms explaining the relationship between disgust sensitivity and symptoms of contamination-based OCD have not been delineated. One possibility is that disgust sensitivity is associated with impairments in disgust learning that underlie excessive contamination concerns in OCD. Disgust sensitivity may cause disgust associations to form more

37

easily, leading to more frequent perceptions of contamination, or to persist longer, leading to more enduring perception of contamination (e.g., enduring despite the passage of time or ordinary hygiene procedures). Experiment 1 and Mason and Richardson (2010) both observed a specific link between disgust sensitivity and conditioned disgust responding *after* extinction. These preliminary findings suggests that disgust sensitivity may contribute to contamination-based OCD through causing more enduring, rather than more frequent, perceptions of contamination. The literature on fear learning in anxiety disorders also suggests that individual differences at extinction rather than acquisition may be more relevant to etiological mechanisms. For example, prospective research relating fear learning tendencies to the development of anxiety disorders has found that increased fear responding at extinction, but not at acquisition, uniquely predicts subsequent onset of PTSD (Lommen et al., 2013). In the case of both disgust and fear learning, the initial acquisition of conditioned responding may be generally adaptive (Lissek, Pine, & Grillon, 2006). Dysfunction might occur later in the failure to unlearn conditioned responding when it is no longer beneficial.

If disgust sensitivity contributes to contamination-based OCD by causing more frequent or more enduring disgust associations, how might these disgust associations lead to impairment? In other words, what are the specific conditioned disgust responses that might contribute to contamination-based OCD? Previous research has established that behavioral avoidance (e.g., not touching something) is a conditioned disgust response, in that it characterizes responding to contaminated objects (Rozin & Fallon, 1987). Experiment 1 suggests that attentional avoidance is another conditioned disgust response that could play a role in OCD. However, given that contamination is perceived as highly threatening in OCD, and that threatening stimuli capture attention (Bar-Haim et al., 2007), it is possible that individuals with contamination-based OCD are vigilant, rather than avoidant, of conditioned disgust stimuli. Indeed, Armstrong et al. (2012)

found that individuals high in contamination concerns showed vigilance, rather than attentional avoidance, for contamination threat. Another possibility is that conditioned disgust stimuli elicit a 'hypervigilant-avoidant' pattern of attention to threat in contamination-based OCD, reflecting automatic, fear-driven vigilance followed by strategic, disgust-driven avoidance (Rinck & Becker, 2006).

The aims of Experiment 2 were to determine if contamination-based OCD is characterized by disgust learning abnormalities, particularly impairments in extinction learning; to determine if disgust learning abnormalities in contamination-based OCD manifest in an attentional bias; and to determine if disgust learning abnormalities and related attentional biases in contamination-based OCD are related to individual differences in disgust sensitivity. Another aim of Experiment 2 was to address limitations in the design of Experiment 1. First, the effects of conditioning on self-reported disgust in Experiment 1 were statistically significant yet small in magnitude. To enhance the disgust conditioning procedure, disgusting images were used as USs and were presented immediately after the CS+. Olatunji et al. (2013) found larger and more reliable self-reported conditioned disgust responses using this procedure, compared to the procedure used in Experiment 1. A conditioning procedure with image USs similar to Olatunji et al. (2013) was used by Mason and Richardson (2010), which could explain their ability to observe an attentional bias for disgust CSs earlier in the conditioning procedure, at acquisition. Second, Experiment 1 paired the CS– with neutral videos that were rated as slightly positive and may have caused positive evaluative conditioning of the CS–. To eliminate this potential confound and to adhere more closely to the design of fear conditioning studies of anxiety disorders (Lissek et al., 2005), the CS– in Experiment 2 was not paired with a neutral stimulus, and was instead followed by the ITI (i.e., non-occurrence of the US). Finally, to ensure that reduced dwell time on the CS+ was driven by the unpleasantness of the CS+ rather than pleasantness of the CS–, two additional categories of

trials were added to the eye movement assessment of conditioned responding. In addition to trials in which the CS+ was paired with the CS−, there were trials in which the CS+ and CS− were presented independently, paired with a control stimulus not presented during conditioning. These new conditions parsed the effects of the CS+ and the CS− on attention.

Methods

Participants

Three large undergraduate classes ($n = 311$) at Vanderbilt University were screened using the Padua Inventory contamination fear subscale (PI; Burns, Keortge, Formea, & Sternberger, 1996), in order to identify students high and low in contamination concerns. Using criteria informed by the PI means of OCD patients and healthy controls (Burns et al., 1996), individuals were recruited to form a high (PI total score > 13) contamination fear group (HCF; $n = 32$), and low (PI total score < 6) contamination fear group (LCF; $n = 30$). Similar methods for identifying analogue contamination fear groups have been employed in prior studies (e.g., Olatunji, Lohr, Sawchuk, & Tolin, 2007), and there is compelling evidence that studies of analogue OCD samples are relevant to understanding OCD in clinical populations (see Gibbs, 1996 for a review). For example, Burns, Formea, Keortge, and Sternberger (1995) found that non treatment-seeking individuals who scored highly on self-report measures of OC symptoms often met diagnostic criteria for OCD, evidenced stability of symptoms over time, and exhibited similar associated symptom features as patients diagnosed with OCD. Indeed, the levels of contamination fear reported on the PI in the current study's analogue OCD group ($M = 20.41$, $SD = 4.89$) were above levels reported by individuals meeting diagnostic criteria for OCD ($M = 13.87$, $SD = 7.96$; Burns et al., 1996). Such findings are inline with a growing consensus that OCD symptoms occur on a continuum of severity and have their origin in largely normal human processes, such as associative

learning and negative reinforcement. Under this dimensional model, OCD-related phenomena can be observed and studied among analogue samples.

Measures

The *Attentional Control Scale* (ACS; Derryberry & Reed, 2002) is a 20-item self-report questionnaire which assesses the ability to voluntarily maintain attention on a given task and to strategically reallocate attention. It is important to note that the ACS does not contain questions related to emotionally-valenced situations, and as such attempts to capture a general information processing trait uncontaminated by reactions to emotional stimuli or cognitions. The ACS had good internal consistency ($\alpha = .84$) in the present sample.

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 excellent internal consistency ($\alpha = .90$) in the present sample.

Obsessive Compulsive Inventory – Revised (OCI-R; Foa et al., 2002). The OCI-R is an 18-item questionnaire of OCD symptoms experienced in the past month. The OCI-R has six dimensional subscales, of which only the Washing subscale was relevant to the present study. The Washing subscale of the OCI-R had adequate internal consistency ($\alpha = .80$) in the present sample.

The *Padua Inventory* (PI; Burns et al., 1996) contamination fear subscale is a 10-item measure of contamination obsessions and washing compulsions. The PI had excellent internal consistency ($\alpha = .96$) in the present sample.

Materials and apparatus

The CS's consisted of neutral male faces from the Karolinska Directed Emotional Faces set (Lundqvist, Flykt, & Öhman, 1998) converted to greyscale and matched for luminance and contrast. The CS+ and CS- were discriminated by the actor expressing the face, with actor-CS

pairing counterbalanced across subjects. In addition, control stimuli (neutral male faces not presented in the conditioning context) were also selected for the attentional CR assessment. The US consisted of 8 different disgusting images selected from the International Affective Picture System (IAPS; Lang, Cuthbert, & Bradley, 2008) and online public sources. Stimuli were presented on a 17" widescreen monitor (1280 x 1024 resolution; 60 Hz) using E-prime 2.0 software. Gaze was recorded continuously using the iViewX RED system from SensoMotoric Industries (SMI), a 60 Hz video-based eye tracker with a dark pupil tracking method.

Procedure

Participants provided informed consent to a protocol approved by the Vanderbilt University Institutional Review Board, and then completed the measures as well as a basic demographic survey (age, gender, ethnicity/race). Participants then completed the conditioning task, consisting of the following stages: *Habituation.* Participants viewed 8 non-reinforced presentations (6 s) of each CS. CSs were preceded by a fixation cross (1.5 s) and followed by an ITI, varied randomly between 12 s and 18 s. The CSs appeared in the center of the screen. *Acquisition.* During this stage, the CSs were presented for 6 s in the center of the screen. Immediately after CS+ offset, the US was presented for 3 s (see Figure VII).
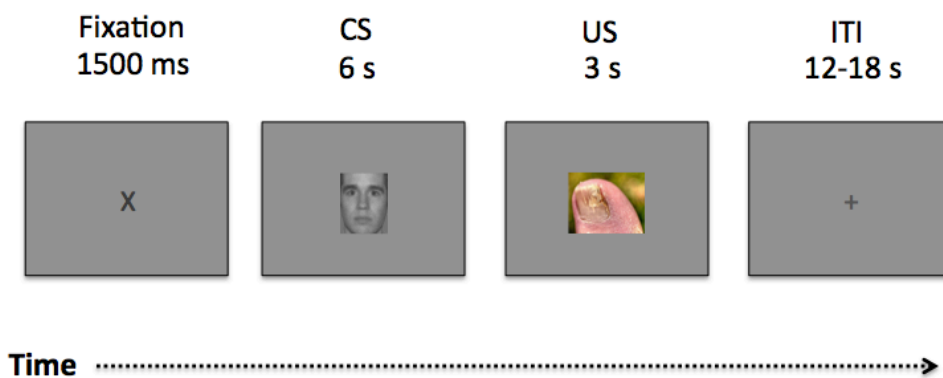
Figure VII. An overview of the acquisition stage of conditioning in Experiment 2.
CS = conditioned stimulus, US = unconditioned stimulus, ITI=inter-trial interval.

After CS- offset, the trial proceeded to the ITI. CSs were preceded by a fixation cross (1.5 s) and followed by an ITI, varied randomly between 12 s and 18 s. There were 8 presentations of CS+ trials, and 8 presentations of CS– trials, presented in pseudorandom order. *Reacquisition.* The conditioning procedure was repeated, but with half the trials of each CS. *Extinction.* The conditioning procedure was repeated, but without US presentation.

Attentional CR assessment. This task consisted of 3 types of trials: CS+ paired with control stimulus of the opposite gender (16 trials); CS– paired with control stimulus of the opposite gender (16 trials); and CS+ paired with CS– (16 trials). The remaining parameters and procedural placement of the passive viewing task replicated those of Experiment 1.

Self-report CR assessment. At the end of each conditioning stage, participants retrospectively rated how disgusted the CSs made them feel and how much they expected the US to follow the CS on modified EVS scales, as described in Experiment 1.

Self-report US assessment. At the end of the study, participants rated how disgusted the USs made them feel on a modified Empirical Valence Scale.

Eye movement data reduction

Methods for identifying eye movement events and forming variables replicated Experiment 1. However, each eye movement variable was also computed for the CS+/control and CS-/control trials (in addition to the CS+/CS– trials).

Data analytic plan

In line with other Pavlovian conditioning studies (e.g., Kelly & Forsyth, 2007; Lissek et al., 2008; Mason & Richardson, 2010), CR analyses were conducted separately for each stage of the conditioning procedure (habituation, acquisition, extinction). For the self-report and eye movement CRs, 2 (CS: CS+, CS–) X 2 (group: HCF, LCF) mixed-effects ANOVAs were conducted. For the eye movement CRs, separate ANOVAs were conducted for the separate trial

types (CS+/CS–, CS+/control, CS–/control). In addition, planned interaction contrasts were used

to explore differences in CR discrimination between acquisition and extinction (Kelly & Forsyth,

2007). Lastly, for correlational and mediational analyses, variables reflecting discriminant

responding to the CSs (CS+ − CS–) were used (e.g., Indovina et al., 2011; Lissek et al., 2008;

Mason & Richardson, 2010). Mediation was tested using Preacher and Hayes's (2008) boot-

strapping procedure, which does not impose distributional assumptions often violated in smaller

samples.

Results

Group characteristics

As revealed in Table III, the HCF and LCF groups were adequately matched in terms of

demographic variables.

Table III. Group Characteristics for Experiment 2

	HCF (n = 32)	LCF (n = 30)	
Age	20.16 (1.27)	20.40 (.97)	$t(60) = .84$ ns
Gender			$\chi^2 = .008$ ns
%Female	66.7	65.6	
Ethnicity			$\chi^2 = 6.15$ ns
% White	53.1	76.7	
% Black	25.0	10.0	
% Hispanic	3.1	3.3	
% Asian	9.4	10.0	
% Other	9.4	0	
PI	20.41 (4.89)	2.93 (1.33)	$t(60) = -18.92$***
DS-R	56.88 (16.93)	41.27 (15.67)	$t(60) = -3.76$***
OCI-R Wash	4.53 (2.96)	.57 (.63)	$t(60) = -7.18$***
ACS	52.44 (8.21)	55.17 (8.65)	$t(60) = 1.28$ ns
US disgust rating	59.17 (25.12)	42.31 (21.76)	$t(60) = -2.82$**

Note: HCF = high contamination fear; LCF = low contamination fear; PI = Padua Inventory, Contamination Subscale; DS-R = Disgust Scale–Revised; OCI-R Wash = Obsessive-Compulsive Inventory–Revised, Washing Subscale; ACS = Atttention Control Scale; US = unconditioned stimulus; ns = non-significant; * $p < .05$, ** $p < .01$, *** $p < .001$

There were no significant differences between groups in terms of age, gender, or ethnicity. The HCF group had significantly higher levels of OCD-related washing symptoms, disgust sensitivity, and trait anxiety compared to the LCF group, but did not have significantly diminished attentional control (Table III). The HCF group also rated the US stimuli as more disgusting compared to the LCF group (Table III).

Habituation

Self report CR: expectancy ratings. The main effect of CS, the main effect of group, and the CS X group interaction were all non-significant, Fs $(1, 60) < 2.57$, $ps > .05$. Thus, prior to acquisition, the CSs did not differ in terms of their ability to elicit anticipation of the US, nor did the groups differ in terms of their anticipation of the US. Table IV provides Ms and SDs for all CS ratings, and Figure VIII (next page) depicts these ratings.

Table IV. Means (*SDs*) for self-reported responses to the CSs on 100-point scale.

HCF group

Rating	CS	Habituation	Acquisition	Extinction
		Phase of conditioning		
Disgust	CS+	20.62 (24.42)	45.38 (30.06)	34.34 (32.33)
	CS-	12.69 (16.50)	9.22 (12.70)	4.16 (5.93)
US expectancy	CS+	37.88 (26.44)	81.44 (19.90)	51.84 (33.90)
	CS-	32.72 (18.74)	7.37 (15.53)	3.97 (6.53)

LCF group

Rating	CS	Habituation	Acquisition	Extinction
		Phase of conditioning		
Disgust	CS+	10.93 (14.88)	31.80 (24.97)	15.93 (15.34)
	CS-	10.67 (13.89)	4.53 (6.22)	4.20 (9.68)
US expectancy	CS+	32.80 (23.77)	85.50 (24.49)	37.77 (29.66)
	CS-	29.27 (20.27)	2.83 (5.81)	1.60 (4.45)

Note. HCF = high contamination fear; LCF = low contamination fear; CS = conditioned stimulus (face); CS+ = face followed by unconditioned stimulus; CS- = face not followed by unconditioned stimulus.

Self-report CR: disgust ratings. The main effect of CS, the main effect of group, and the CS X

group interaction were all non-significant, Fs $(1, 60) < 2.98$, ps $> .05$. Thus, prior to acquisition,

the CSs did not differ in terms of their ability to elicit disgust, nor did the groups differ in terms of

disgust elicited by the CSs.
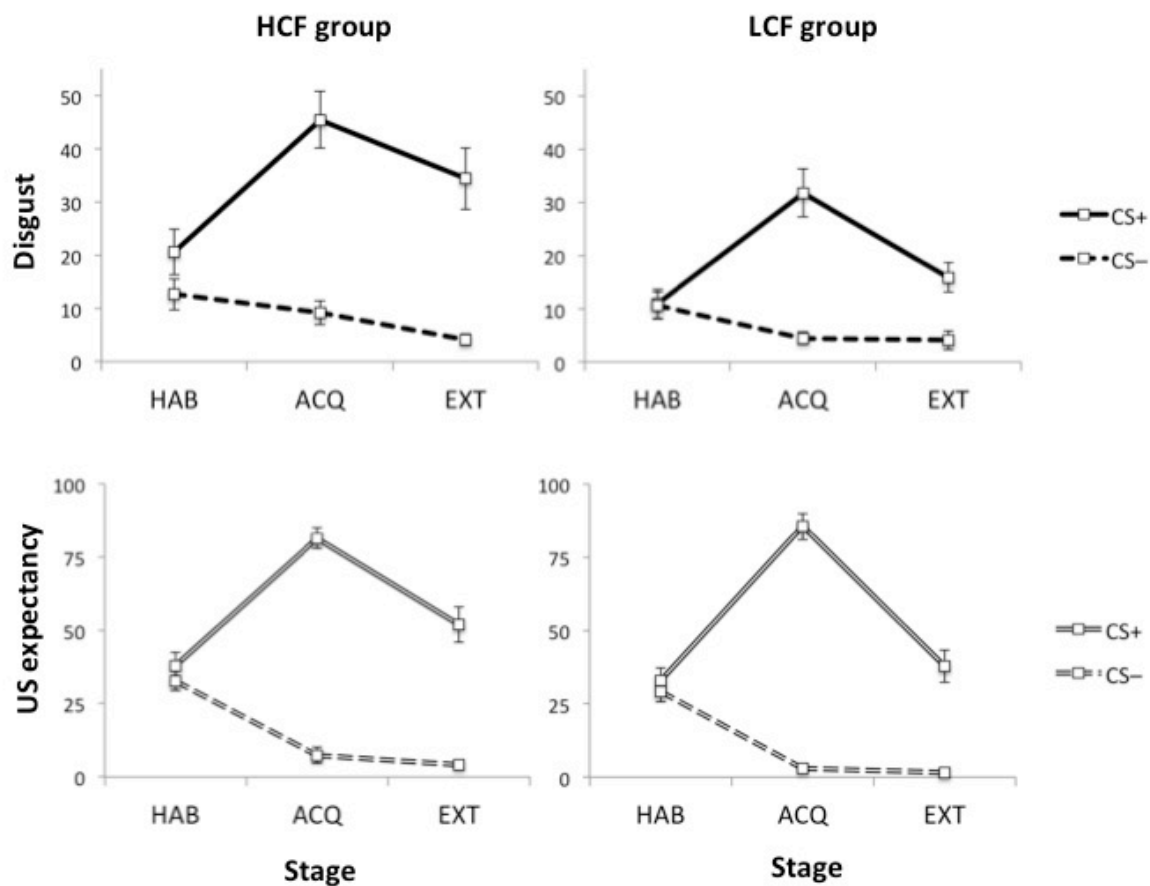
Figure VIII. Self-report ratings of the CSs in Experiment 2. HCF = high contamination fear; LCF = low contamination fear; CS = conditioned stimulus (face); CS+ = face followed by unconditioned stimulus; CS− = face not followed by unconditioned stimulus; US = unconditioned stimulus; HAB = habituation; ACQ = acquisition; EXT = extinction.

Eye movement CR: orienting bias. For trials with the CS+ and CS-, the main effect of CS, the main effect of group, and the CS X group interaction were all non-significant, Fs (1, 60) < .98, ps > .05. Similarly, for trials with the CS+ paired with the control stimulus, the main effect of CS, the main effect of group, and the CS X group interaction were all non-significant, Fs (1, 60) < 2.07, ps > .05. For trials with the CS– paired with the control stimulus, there was a significant main effect of CS, F (1, 60) = 8.45, p < .01, such that the CS– captured initial fixations more often than the accompanying control stimulus. The main effect of group and the CS X group interaction were non-significant, Fs (1, 60) < 2.60, ps > .05. Table V provides Ms and SDs for CS orienting bias data at each stage of conditioning.

Table V. Means (*SDs*) for proportion of initial fixations on CSs (i.e., orienting bias) in Experiment 2.

HCF group

Trial type	Stimulus	Phase of conditioning		
		Habituation	Acquisition	Extinction
CS+/CS–	CS+	.54 (.17)	.50 (.14)	.50 (.15)
	CS-	.46 (.17)	.50 (.14)	.50 (.15)
CS+/control	CS+	.53 (.15)	.56 (.19)	.50 (.11)
	control	.47 (.15)	.44 (.19)	.50 (.11)
CS–/control	CS–	.57 (.14)	.52 (.11)	.57 (.14)
	control	.43 (.14)	.48 (.11)	.43 (.14)

LCF group

Trial type	CS	Phase of conditioning		
		Habituation	Acquisition	Extinction
CS+/CS–	CS+	.48 (.09)	.50 (.14)	.47 (.11)
	CS-	.52 (.09)	.50 (.14)	.53 (.11)
CS+/control	CS+	.51 (.10)	.54 (.10)	.54 (.13)
	control	.49 (.10)	.46 (.10)	.46 (.13)
CS–/control	CS–	.52 (.10)	.55 (.14)	.57 (.10)
	control	.48 (.10)	.45 (.14)	.43 (.10)

Note. HCF = high contamination fear; LCF = low contamination fear; CS = conditioned stimulus (face); CS+ = face followed by unconditioned stimulus; CS– = face not followed by unconditioned stimulus.

Eye movement CR: dwell time. For trials with the CS+ and CS-, the main effect of CS, the main effect of group, and the CS X group interaction were all non-significant, Fs (1, 60) < 2.57, ps > .05. Similarly, for trials with the CS- paired with the control stimulus, the main effect of CS, the main effect of group, and the CS X group interaction were all non-significant, Fs (1, 60) < 2.31, ps > .05. For trials with the CS+ paired with the control stimulus, the main effects of CS and group were not significant, Fs (1, 60) = 2.35, ps > .05, however, there was an unpredicted significant group by CS interaction, F (1, 60) = 5.18, p < .05. Independent-samples t-tests revealed that whereas the two groups did not differ in terms of dwell time on the CS+, t (60) = .76, p > .05, the HCF group dwelled longer on the control stimulus paired with the CS+, compared to the LCF group, t (60) = 2.83, p < .01. In summary, the CSs did not differ in terms of their ability to modulate gaze, nor did the groups differ in terms of modulation of gaze by the CSs, with the exception of trials pairing the CS+ with the control stimulus, in which HCF individuals unexpectedly dwelled longer on the control stimulus. Table VI (next page) provides Ms and SDs for CS dwell time data at each stage of conditioning.

Table VI. Means (*SDs*) for fixation duration (ms) on CSs in Experiment 2.

HCF group

Trial type	Stimulus	Habituation	Acquisition	Extinction
		Phase of conditioning		
CS+/CS−	CS+	1003 (395)	890 (476)	964 (378)
	CS−	1030 (361)	924 (487)	973 (372)
CS+/control	CS+	1069 (400)	916 (488)	1039 (418)
	control	929 (335)	886 (499)	899 (368)
CS−/control	CS−	1030 (311)	972 (363)	1055 (353)
	control	969 (352)	828 (365)	872 (293)

LCF group

Trial type	CS	Habituation	Acquisition	Extinction
		Phase of conditioning		
CS+/CS−	CS+	1056 (225)	987 (347)	1025 (320)
	CS−	1110 (229)	1034 (339)	1026 (314)
CS+/control	CS+	1044 (298)	990 (248)	1057 (302)
	control	1151 (276)	1015 (300)	962 (257)
CS−/control	CS−	1110 (266)	1010 (319)	1043 (311)
	control	1086 (247)	1001 (332)	1031 (290)

Note. HCF = high contamination fear; LCF = low contamination fear; CS = conditioned stimulus (face); CS+ = face followed by unconditioned stimulus; CS− = face not followed by unconditioned stimulus.

Acquisition

Self report CR: expectancy ratings. The main effect of CS was significant, $F(1, 60) = 566.37$, $p < .001$. As hypothesized, participants anticipated the US more during the CS+ compared to the CS-, indicating that participants learned the CS-US contingency during the acquisition procedure. The main effect of group, and the CS by group interaction were both non-significant, $Fs(1, 60) < 1.71$, $ps > .05$. Thus, the groups did not differ in terms of their overall or differential anticipation of the US during the acquisition phase.

Self report CR: disgust ratings. The main effect of CS was significant, $F(1, 60) = 72.30$, $p < .001$. As hypothesized, participants reported more disgust in response to the CS+ compared to the CS-. There was also a significant main effect of group, $F(1, 60) = 5.87$, $p < .02$, but these

main effects were not qualified by a significant CS by group interaction, F (1, 60) = 1.42, p > .05. Thus, the HCF group reported experiencing more disgust to the CSs in general during the acquisition phase.

Eye movement CR: orienting bias. For trials with the CS+ and CS-, the main effect of CS, the main effect of group, and the CS by group interaction were non-significant, Fs (1, 60) < .98, ps > .05. For trials with the CS+ paired with the control stimulus, there was a main effect of CS, F (1, 60) = 6.28, p < .02, such that the CS+ captured more initial fixations compared to the accompanying control stimulus. The main effect of group and the CS X group interaction were non-significant, Fs (1, 60) < .49, ps > .05. Similarly, for trials with the CS– paired with the control stimulus, there was a main effect of CS, F (1, 60) = 4.99, p < .03, such that the CS– captured more initial fixations compared to the accompanying control stimulus. The main effect of group and the CS X group interaction were non-significant, Fs (1, 60) < .35, ps > .05.

Eye movement CR: dwell time. For all trial types, the main effect of CS, the main effect of group, and the CS by group interaction were non-significant, Fs (1, 60) < 2.24, ps > .05. Thus, contrary to hypotheses for the acquisition stage, the CSs did not differ in terms of their ability to modulate gaze, nor did the groups differ in terms of modulation of gaze by the CSs.

Extinction

Self report CR: expectancy ratings. The main effect of CS was significant, F (1, 60) = 106.21, p < .001, indicating that participants continued to anticipate the US more during the CS+ compared to the CS- during the extinction phase. There was also a significant main effect of group, F (1, 60) = 4.04, p < .05, which was not qualified by a significant CS by group interaction, F (1, 60) = 2.06, p > .05. Thus, compared to the LCF group, the HCF group reported greater anticipation of the US during CS presentation, regardless of which CS. To determine if partial extinction of US anticipation occurred, an exploratory analysis was conducted to test if US

expectancy for the CS+ declined between acquisition and extinction. Conditioning phase was added to the ANOVA model, and limited to the levels of acquisition and extinction. Of most relevance to the present hypotheses, there was a CS by conditioning phase interaction, $F(1, 60) = 83.89$, $p < .001$. Paired samples t-tests revealed that US anticipation during the CS+ significantly decreased from acquisition to extinction, $t(60) = 9.52$, $p < .001$, whereas US anticipation during the CS- did not significantly change, $t(60) = 1.76$, $p > .05$. Thus, partial extinction of US anticipation during the CS+ was achieved. The CS by conditioning phase interaction was further qualified by a CS by conditioning phase by group interaction, $F(1, 60) = 6.56$, $p < .02$. To clarify this interaction, the groups were compared in terms of changes in US expectancy from acquisition to extinction for each CS. Compared to the LCF group, the HCF group reported a smaller decrease in US expectancy for the CS+ from acquisition to extinction, $t(60) = 2.33$, $p < .03$. An analogous effect was not observed for the CS-, $t(60) = -.81$, $p > .05$. Thus, the HCF group exhibited reduced extinction of US expectancy for the CS+, specifically.

Self report CR: disgust ratings. The main effect of CS was significant, $F(1, 60) = 39.67$, $p < .001$. Participants reported experiencing more disgust in response to the CS+ compared to the CS- during the extinction phase. There was also a significant main effect of group, $F(1, 60) = 6.98$, $p < .02$, and these main effects were qualified by a significant CS by group interaction, $F(1, 60) = 7.69$, $p < .01$. Independent samples t-tests revealed that compared to the LCF group, the HCF group reported more disgust in response to the CS+, $t(60) = -2.83$, $p < .01$, but not the CS-, $t(60) = .02$, $p > .05$. To determine if partial extinction was achieved, an exploratory analysis was conducted to test if self-reported disgust for the CS+ declined between acquisition and extinction. Conditioning phase was added to the ANOVA model, and limited to the levels of acquisition and extinction. Of most relevance to the present hypotheses, there was a CS by conditioning phase interaction, $F(1, 60) = 14.54$, $p < .001$. Paired samples t-tests revealed that disgust in response to

51

the CS+ significantly decreased from acquisition to extinction, $t(60) = 5.16$, $p < .001$, whereas

disgust in response to the CS- did not significantly change, $t(60) = 1.95$, $p > .05$. Thus, partial

extinction of disgust to the CS+ occurred. The CS by conditioning phase interaction was not

qualified by a significant CS by conditioning phase by group interaction, $F(1, 60) = 2.88$, $p > .05$.

Eye movement CR: orienting bias. For trials with the CS+ and CS-, as well as trials with

the CS+ paired with the control stimulus, the main effect of CS, the main effect of group, and the

CS by group interaction were non-significant, Fs $(1, 60) < 1.70$, ps $> .05$. For trials with the CS–

paired with the control stimulus, there was a main effect of CS, $F(1, 60) = 19.18$, $p < .001$, such

that the CS– captured more initial fixations compared to the accompanying control stimulus. The

main effect of group and the CS X group interaction were non-significant, Fs $(1, 60) < .06$, ps $>$

.05.

The finding of an orienting bias towards the CS– versus the control stimulus at each stage

of conditioning, as well as the finding of an orienting bias for the CS+ versus the control stimulus

at acquisition, were not predicted. An examination of the pattern of means (Table V) suggested

that in the entire sample, there was a general tendency to orient to CS stimuli (CS+ or CS–) when

paired with control stimuli, perhaps due to increased exposure to the CS stimuli relative to the

control stimuli (the control stimuli were not presented during the conditioning procedures).

Although novel stimuli capture attention in some contexts, some studies have found that familiar

stimuli capture attention under certain conditions (e.g., Nelson & Palmer, 2007), which could

explain why increased exposure to the CSs led to an orienting bias towards these stimuli.

Alternatively, certain physical features of the CSs may have been more attention grabbing than

those of the control stimuli. To determine if there was a general orienting bias towards CSs paired

with control stimuli, and to determine if it was independent of the CS-US contingency, an

exploratory analysis was conducted in which conditioning phase was added to the ANOVA

model, with all three levels of conditioning (habituation, acquisition, extinction). For trials with the CS+ paired with the control stimulus, there was a main effects of CS, $F(1, 60) = 13.59$, $p = .001$, which was not qualified by a CS by conditioning phase interaction, $F(1, 60) = 1.35$, $p > .05$. All effects involving the group factor were also nonsignificant, $Fs(1, 60) < .5$, $ps > .05$. Likewise, for trials with the CS– paired with the control stimulus, there was a main effect of CS, $F(1, 60) = 29.37$, $p = .001$, which was not qualified by a CS by conditioning phase interaction, $F(1, 60) = 1.10$, $p > .05$. All effects involving the group factor were also non-significant, $Fs(1, 60) < 1.75$, $ps > .05$. These findings indicate that the CSs ability to capture more initial fixations than accompanying control stimuli did not depend on the conditioning stage, and thus did not depend on the CS-US contingency.

Eye movement CR: dwell time. For all trial types, the main effect of CS, the main effect of group, and the CS by group interaction were non-significant, $Fs(1, 60) < 3.95$, $ps > .05$. Thus, contrary to hypotheses for the extinction stage, the CSs did not differ in terms of their ability to modulate gaze, nor did the groups differ in terms of modulation of gaze by the CSs.

Relations between conditioned disgust responding at extinction, symptom measures, and unconditioned disgust responding.

In the HCF group, disgust sensitivity ($r = .65$, $p < .001$), OCD washing symptoms ($r = .50$, $p < .01$), and US self-reported disgust ratings ($r = .53$, $p < .01$) were all significantly correlated with discriminant self-reported disgust in response to the CSs (i.e., CS+ vs. CS-) at extinction, such that higher levels of disgust sensitivity, higher levels of OCD washing symptoms, and high self-reported disgust to the US predicted greater conditioned disgust responding. Of these three variables, disgust sensitivity predicted the most unique variance in conditioned disgust responding at extinction in the HCF group. When conditioned disgust responding at extinction was regressed on both disgust sensitivity and OCD washing symptoms, $R^2 = .46$, $F(2, 29) = 12.57$, $p < .001$,

disgust sensitivity remained a significant predictor ($\beta = .53$, $p < .01$), whereas OCD washing symptoms were no longer a significant predictor ($\beta = .25$, $p > .05$). Likewise, when conditioned disgust responding at extinction was regressed on both disgust sensitivity and US disgust ratings, $R^2 = . 42$, $F (2, 29) = 10.67$, $p < .001$, disgust sensitivity remained a significant predictor ($\beta = .55$, $p < .02$), whereas US disgust ratings were no longer a significant predictor ($\beta = .13$, $p > .05$). Trait anxiety ($r = -.10$, $p > .05$) and attention control ($r = .04$, $p > .05$) were not significantly correlated with discriminant self-reported disgust in response to the CSs at extinction in the HCF group. In the LCF group, conditioned disgust responding at extinction was not significantly correlated with any of theses measures (rs $< .25$, ps $> .05$).

Does disgust sensitivity mediate group differences in conditioned disgust responding at extinction?

Given prior findings that individual differences in disgust sensitivity predict impaired disgust extinction learning (Armstrong et al., 2014; Mason & Richardson, 2010), a mediational model was tested in which group differences in conditioned disgust responding at extinction were mediated by group differences in disgust sensitivity. The indirect path from group (HCF vs. LCF) to conditioned disgust responding at extinction through disgust sensitivity was significant ($p < .01$) as indicated by the 99% confidence intervals not containing 0 (lower limit = 3.78, upper limit = 25.79; B = -103.073, SE = 47.53). Thus, mediation was demonstrated (Figure IX, next page).
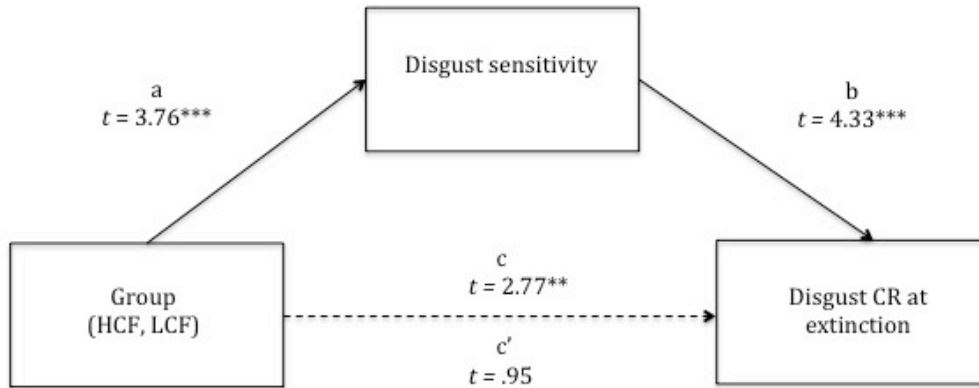
Figure IX. A mediational model demonstrating that group differences in disgust at extinction are mediated by group differences in disgust sensitivity. *Note.* HCF = high contamination fear; LCF = low contamination fear; CR = conditioned response.

Do group differences in the effect of extinction on US expectancy account for differences in the persistence of disgust responding?

A mediational model was tested in which group differences in disgust responding at extinction were accounted for by group differences in the effect of extinction on US expectancy (change in US expectancy from acquisition to extinction). The indirect path from group (HCF vs. LCF) to conditioned disgust responding at extinction through change in US expectancy was non-significant (p > .05) as indicated by the 99% confidence intervals containing 0 (lower limit = -1.95, upper limit = 12.92; B = 3.25, SE = 2.60), and the direct path from group to conditioned disgust responding at extinction remained significant when accounting for this indirect path (B=15.20, SE = 6.94, t = 2.19, p < .04) Thus, mediation was not demonstrated (Figure X, next page), and group differences in the persistence of disgust responding were found to be relatively independent of group differences in the change in US expectancy due to extinction.
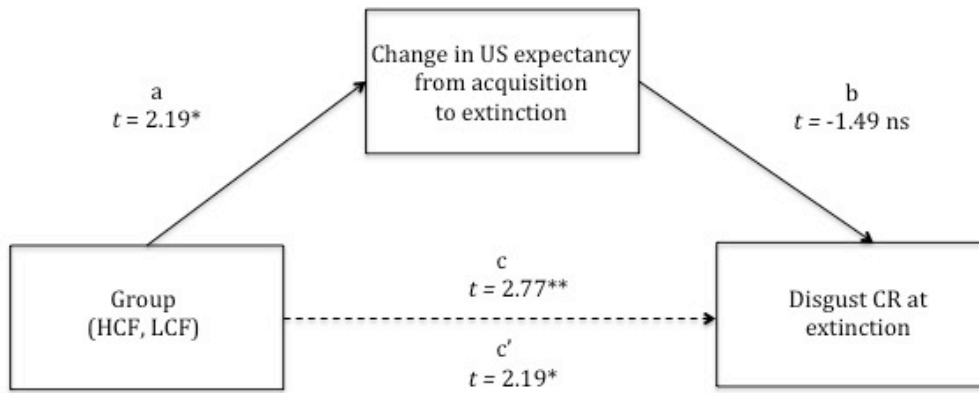
Figure X. A mediational model demonstrating that group differences in disgust at extinction are independent of group differences in the effects of extinction on US expectancy. *Note.* HCF = high contamination fear; LCF = low contamination fear; US = unconditioned stimulus; CR = conditioned response.

Discussion

The present study failed to observe the basic effect of disgust conditioning on overt attention that was found in Experiment 1 and in two additional studies (Mason & Richardson, 2010; Mason & Richardson, unpublished data). In addition, the present study failed to observe the hypothesized difference between the HCF and LCF group in terms of this basic effect of disgust conditioning on overt attention. However, the present study did observe important differences in disgust learning between the HCF and LCF groups. The HCF group's US expectancy during the CS+ was more resistant to extinction, compared to the LCF group, and the HCF group reported greater levels of self-reported disgust to the CS+ during extinction compared to the LCF group. Disgust sensitivity was strongly correlated with conditioned disgust responding at extinction in the HCF group, and group differences in conditioned disgust responding at extinction were mediated by disgust sensitivity. Thus, the present findings were consistent with Experiment 1 and Mason and Richardson (2010), in that disgust sensitivity was robustly linked to conditioned disgust responding at extinction, albeit on a self-report rather than an eye movement measure.

There are several factors that may explain the present study's failure to observe the basic effect of disgust conditioning on overt attention that was found in Experiment 1. Given that conditioned responding should be proportional to the strength of the US (Bouton, 2007), one possibility is that the US in the present study was not sufficiently potent to elicit more distal forms of conditioned disgust responding, such as attentional avoidance. The mean disgust rating for the US in the present sample was 51.01 (SD = 24.86), whereas the mean disgust rating for the US in Experiment 1 was 60.91 (SD = 26.50) on the same 100-point scale. In addition, the US images in the present study represented a broader range of disgust elicitors than those in Experiment 1. Whereas Experiment 1 presented 4 videos of individuals vomiting as USs and repeated each US once during acquisition, the current study presented 12 images as USs, without repetition, and included images of vomit, rotting food, feces, and poor hygiene. According to Hermans et al.'s (2002) "referential" theory, evaluative conditioning does not involve an actual transfer of affective properties from the US to the CS, but instead involves the activation of US imagery by the CS. One possibility is that the use of additional US stimuli with varying content in the present study led to a less coherent representation of the US in memory, and hence, less aversion to the imagery activated by the CS. Indeed, Mason and Richardson (2010) also presented fewer unique US stimuli than in the present study, which may have allowed the CS to activate clearer US imagery, and thereby elicit attentional avoidance.

Another feature of the present study that could explain the failure to observe attentional avoidance as a conditioned disgust response is the lack of a neutral unconditioned stimulus (US-) paired with the CS–. Whereas Experiment 1 paired the CS– with videos of streams and waterfalls, and Mason and Richardson (2010) paired the CS– with images of household objects, the present study did not include a US– of this nature. The present design instead adhered to the design of prior fear conditioning experiments on anxiety disorders (e.g., Lissek et al., 2008), in which the

57

CS– simply predicts the non-occurrence of the aversive US. One possibility is that the disgust CS–
in Experiment 1 and Mason and Richardson (2010) was able to hold attention (and thus sustain
attentional avoidance of the disgust CS+) because it was previously paired with the occurrence of
a neutral stimulus, and could thereby activate this neutral imagery to counteract the disgusting
imagery activated by the CS–.

An additional factor that could explain the discrepant results between Experiment 1 and the
present study is the use of overlapping CS-US presentations in Experiment 1. Although the CS
was presented alone for 5 s prior to the US in Experiment 1, it remained on the screen throughout
the 15 s US presentation. In the current study, the CS and the US did not overlap in their
presentation. One of the unique features of evaluative conditioning is that purely simultaneous CS-
US presentation produces robust conditioned responding (Hoffman et al., 2010). In contrast,
Pavlovian fear conditioning is attenuated by simultaneous CS-US presentation, and is strongest
under "forward conditioning" procedures in which the CS onset precedes the US onset, often
without any CS-US overlap (e.g., "trace" conditioning; Bouton, 2007). According to the "holistic
account" of evaluative conditioning, CS-US pairings lead to a single, joint representation of the
CS that is later activated by the CS. One possible implication of this account is that simultaneous
CS-US presentation enhances the holistic representation of the CS-US (Hofmann et al., 2010).
Indeed, some evaluative conditioning effects are observed *only* with simultaneous CS-US
presentations (e.g., conditioning responding in the absence of contingency awareness; Hütter &
Sweldens, 2013). Accordingly, the prolonged co-occurrence of the CS and US in Experiment 1
may have caused stronger evaluative conditioning, allowing the observation of conditioned
responding in overt attention. However, Mason and Richardson (2010) employed a sequential,
non-overlapping CS-US presentation and were able to observe effects of disgust conditioning on
overt attention, which suggests that other factors may explain the present null findings.

Although the present study did not reveal an attentional bias related to disgust learning, it did reveal robust differences in disgust learning between HCF and LCF individuals. The present study found robust evidence of impaired disgust extinction learning in HCF individuals. This impairment appeared to involve independent cognitive and affective processes. In terms of cognitive processes, the HCF group reported less change in their expectation that the CS+ would predict the US during extinction. Although there is a paucity of research on this aspect of disgust learning, a recent study found that fear extinction learning impairments revealed by self-reported US expectancy predicted the development of PTSD in Dutch soldiers deploying to Afghanistan (Lommen et al., 2013). In terms of affective processes, the HCF reported a greater disgust response to the CS+ at extinction, which was not accounted for by the HCF group's failure to modify their representation of the CS-US contingency during extinction (i.e., US expectancy). This suggests that persistent disgust responding to the CS+ in the HCF group was related to an affective learning process that is relatively independent from anticipatory learning (Sevenster et al., 2012), consistent with the prevailing view that evaluative conditioning features prominently in disgust learning (Olatunji et al., 2007).

The impairments in disgust extinction learning observed in the HCF group could provide insight into the etiology and maintenance of contamination-based OCD. Indeed, many of the symptoms of contamination-based OCD can be viewed as a failure to extinguish disgust responding acquired through associative learning. For example, the common symptom of excessive hand washing may reflect difficulty attenuating a disgust response to one's hands after touching a perceived contaminant. Interestingly, the present study did not find any difference between the HCF and LCF groups in terms of the initial acquisition of conditioned disgust responding. This finding may reflect the fact that concerns about hygiene and the spread of contamination are normative (Rozin & Fallon, 1987. For example, most individuals would feel

59

disgusted by their hands and experience the urge to wash after touching a disgusting stimulus. The pathology of contamination-based OCD may lie not in how easily conditioned disgust responding is acquired, but in how resistant it is to extinction and other forms of corrective learning.

The present study also sheds light into the role of disgust sensitivity in contamination-based OCD. Numerous studies have observed that individual differences in disgust sensitivity predict symptoms of contamination-based OCD; however, a specific mechanism explaining the role of disgust sensitivity in contamination-based OCD has been elusive. Consistent with Experiment 1 and Mason and Richardson (2010), the present study suggests that disgust sensitivity may contribute to contamination-based OCD by causing conditioned disgust responses to persist longer and resist extinction. In addition to causing avoidance, as found in Experiment 1, the persistence of conditioned disgust could contribute to safety behaviors, such as washing or cleaning behaviors often observed in OCD. Elevated disgust sensitivity could also interfere with treatment by causing disgust responses to be less amenable to extinction learning in the context of exposure therapy.

The present study may also have implications for the treatment of contamination-based OCD. The finding that HCF individuals are characterized by impaired extinction learning raises the possibility that contamination-based OCD, and potentially other disgust-relevant disorders, require augmented exposure therapy that addresses extinction learning deficits. Several methods for augmenting extinction learning during exposure therapy have been proposed (see Craske et al., 2008). These procedures focus on preventing the return of conditioned responding, which can occur through processes such as re-instatement, context renewal, and spontaneous recovery (Bouton, 2002). However, these techniques are informed by basic research on fear learning, which may not generalize to disgust learning. Disgust learning appears to primarily involve evaluative learning (Experiment 1; Mason & Richardson, 2010; Olatunji et al., 2007), which is highly

resistant to extinction and likely based in taste aversion learning, a form of associative learning that is qualitatively distinct from fear learning (Bouton, 2007). Accordingly, treatment for contamination-based OCD and other disgust-related disorders may need to harness learning pathways that target the affective value acquired by the CS, rather than its perceived ability to predict the US. Indeed, recent studies suggest that counter-conditioning procedures, which pair the disgust CS+ with a positive US, may be particularly effective at attenuating conditioned disgust responding (Engelhard, Leer, Lange, & Olatunji, in press; see Jones, Vilensky, Vasey, & Fazio, 2013 for a related training procedure).

Although the present findings provide novel insights into the role of disgust in contamination-based OCD, they should be interpreted with several limitations in mind. First, the present study utilized an analogue sample rather than a patient sample that met full criteria for contamination-based OCD. Although there is compelling evidence that research on subclinical contamination fear generalizes to clinical samples (Burns et al., 1996), these findings would be strengthened by replication in a community sample of patients. Another limitation to the present study is that the lack of group differences in disgust learning at acquisition may have been the result of a ceiling effect, or alternatively, a "strong situation" (Lissek, Pine, & Grillon, 2006). Lissek et al. (2006) argue that the acquisition of conditioned fear responding represents adaptive functioning, and thus should be present in controls as well as patients. These authors suggest using weaker conditioning procedures in order to reveal learning abnormalities in patients. It may be possible to observe increased acquisition of conditioned disgust responding in HCF individuals under more ambiguous conditions, such as partial reinforcement of the CS+. Future research along these lines would help clarify the nature of disgust learning abnormalities in contamination-based OCD.

CHAPTER IV

EXPERIMENT 3: FEAR CONDITIONING AND ATTENTION IN PTSD

Whereas Experiment 2 sought to examine relations between disgust learning and attention in contamination-based OCD, Experiment 3 sought to examine relations between fear learning and attention in PTSD. PTSD is an ideal disorder for studying fear learning processes because it is the only anxiety-related disorder with a "specific etiology" (Rosen & Lilienfeld, 2008). In addition to requiring a pattern of symptoms, the diagnosis of PTSD requires that a specific type of event has caused these symptoms. This event, in which a person experiences or witnesses a life-threatening trauma, can be conceptualized as a learning experience involving an unconditioned stimulus (e.g., an explosion during a military patrol; Brewin & Holmes, 2003; Keane, Zimmering, & Caddell, 1985; Orr et al., 2000). Until recent revisions to the DSM (DSM-5; APA, 2013), the diagnostic criteria for PTSD also specified an unconditioned response to trauma that involved fear, helplessness, or horror (DSM-IV-TR; APA, 2000), and many of the subsequent criteria describe reactions (e.g., distress, avoidance) to trauma-reminders that are suggestive of conditioned fear responses. Thus, fear learning mechanisms appear to play a central role in the etiology of PTSD (Lissek & Grillon, 2012).

Given their increased exposure to life-threatening trauma, combat veterans are a population with elevated risk for PTSD (Dohrenwend et al., 2006). Indeed, PTSD received formal recognition as a psychiatric condition in response to symptom presentations in combat veterans following the Vietnam War (Baldwin, Williams, & Houts, 2004). Although the prevalence of PTSD in veterans has been a topic of ongoing debate (see Armstrong & Olatunji, 2009), recent estimates from the wars in Afghanistan and Iraq suggest that 8% of US soldiers exposed to combat will develop PTSD (Smith et al., 2008). Veterans with PTSD from these military conflicts often report

symptoms that are suggestive of conditioned responding (Tuerk, Grubaugh, Hammer, & Foa, 2009). For example, several veterans in the present study reported debilitating fear while driving that was related to experiencing or witnessing explosions during their combat experience. This fear was triggered by stimuli such as road kill or trash on the side of the road (conditioned stimuli), which had previously been associated with improvised explosive devices (unconditioned stimulus) during their tours in Iraq or Afghanistan.

Although there is wide agreement that the development of PTSD involves abnormalities in fear learning, the precise nature of these abnormalities has been difficult to delineate (Lissek et al., 2005). For example, it is unclear to what extent PTSD involves abnormal fear learning in relation to stimuli that predict danger (CS+) versus stimuli that predict safety (CS–). Orr and colleague's (2000) argue that PTSD is characterized by increased "conditionability." These authors have found that PTSD is characterized by greater excitatory fear learning to the CS+, such that the CS+ elicits more fear than the CS– at acquisition and extinction. In contrast, Davis and colleagues (2000) suggest that PTSD involves the failure to discriminate between the CS+ and CS–, as seen in a tendency to develop fear responding to both the CS+ and the CS–. Rather than involving enhanced *excitatory* fear learning to the CS+, Davis and colleagues (2000) argue that PTSD is characterized by impaired *inhibitory* fear learning to the CS–, such that patients with PTSD have difficulty suppressing fear to stimuli that are present in the conditioning context, yet do not predict the US (or actually predict its absence).

In a meta-analysis of fear conditioning research, Lissek et al. (2005) found that patients with anxiety disorders (predominantly PTSD) compared to controls showed increased conditioned fear responding at acquisition and extinction. However, this effect was strongest when only considering the CS+. When considering responding to the CS+ versus the CS–, patients showed only a modest increase in fear relative to controls, suggesting that patients are characterized by

63

excitatory fear learning to both the CS+ and the CS−, which can be interpreted in part as failure to inhibit fear learning to the CS−. Although these findings contradict the "conditionability" theory of Orr and colleagues (2000), Lissek et al. (2005) did find a small effect of discriminant fear conditioning in patients versus controls at extinction (d = .28), whereas virtually no effect (d = .08) was found at acquisition. Further, a recent prospective study (Lommen et al., 2013) found that increased discriminant fear conditioning at extinction predicts subsequent development of PTSD in soldiers. Thus, the extent literature suggests that PTSD may be characterized by increased excitatory and decreased inhibitory fear learning at acquisition and extinction, as well as possibly increased discriminant conditioning at extinction.

Another process that has been highly studied in PTSD is attentional bias for threat (Buckley et al., 2000). Like fear learning, attentional bias for threat is reflected in the diagnostic criteria for the disorder, which include *hypervigilance*, a phenomenon in which patients constantly monitor their environment for the presence of threat (APA, 2013). Several studies have found increased attention to threatening or trauma-relevant stimuli in PTSD (Buckley et al., 2000; Cisler et al., 2011). This bias has been documented using a variety of paradigms, including reaction time measures, such as the emotional Stroop (Cisler et al., 2011), modified dot probe (e.g., Fani et al., 2012), and visual search task (Pineles, Shipherd, Welch, & Yovel, 2007; Pineles, Shipherd, Mistoufi, Abramovitz, & Yovel, 2009), as well as more sophisticated measures that delineate the time course and components of attention, such as the emotional attentional blink task (Olatunji, Armstrong, McHugo, & Zald, 2012) and eye tracking (Armstrong, Bilsky, Zhao, & Olatunji, 2013). Increased attention to threat in PTSD has been observed for both trauma-specific (e.g., combat scenes; Olatunji, Armstrong, McHugo, & Zald, 2013) and generally threatening stimuli (e.g., fearful faces; Armstrong, Bilsky, Zhao, & Olatunji, 2013), and a review of eye tracking studies (Armstrong & Olatunji, 2012) suggests that PTSD may be distinguished from other

anxiety disorders by the sustained nature of this bias. Whereas other anxiety disorders, particularly specific phobia, are characterized by a tendency to avoid threatening stimuli later in exposure when strategic control of attention becomes possible, patients with PTSD have been found to continue monitoring threat, consistent with the phenomenon of hypervigilance (Armstrong & Olatunji, 2012). In addition to being a symptom of PTSD, an attentional bias for threat may play a role in the maintenance of PTSD. For example, a tendency to search for and dwell on trauma reminders could contribute to hyperarousal and distress, two core features of PTSD (APA, 2013).

Although there has been a considerable amount of research on both fear learning and attentional bias in PTSD, virtually no studies have attempted to synthesize these perspectives. For example, there are no published studies examining attentional biases as a conditioned response in PTSD. However, there are several studies showing that an attentional bias is a normative conditioned fear response, such that individuals develop a tendency to allocate more attention to the CS+ compared to the CS− (e.g., Pischek-Simpson et al., 2009). This bias has also been shown to exhibit extinction and re-instatement effects parallel to other conditioned responses (e.g., increased autonomic arousal as revealed by skin conductance; SCR; Van Damme et al., 2006). There are several conceivable ways in which attentional biases acquired through fear learning could contribute to PTSD. One possibility is that attentional biases are a proximal mechanism through which excessive fear associations contribute to PTSD symptomatology. On this account, one might expect fear learning abnormalities in PTSD to manifest the same across attentional and autonomic measures. Another possibility is that fear learning abnormalities in PTSD manifest differently on attentional measures compared to autonomic measures. Beckers et al. (2013) argue that individual differences in fear conditioning that are relevant to psychopathology may not be observed at the level of immediate fear responding, but instead may manifest in more distal forms of conditioned responding, such as behavioral avoidance or attentional bias. Accordingly,

traumatized individuals with and without PTSD may develop the same degree of conditioned fear responding to the CS+ at the level of autonomic arousal; however, individuals with PTSD may develop a stronger attentional bias for the CS+ compared to those without PTSD.

In considering the roles of fear conditioning and attentional bias in PTSD, it is important to take into account how these phenomena relate to known vulnerability factors for the disorder. One factor that may confer risk for PTSD in traumatized individuals is anxiety sensitivity, a trait that encompasses individual differences in the fear of bodily sensations related to anxiety (Reiss & McNally, 1985). Anxiety sensitivity was initially examined as a risk factor for panic disorder; however, subsequent research has shown that anxiety sensitivity is strongly related to PTSD symptoms (Naragon-Gainey, 2010; Olatunji & Wolitzky-Taylor, 2008). Further, several prospective studies have found that anxiety sensitivity predicts the development of PTSD in response to traumatic stress (Feldner et al., 2006; Keough, Ayers, & Francis, 2002; Kilic, Kilic, & Yilmaz, 2008; Marshall, Miles, & Stewart, 2010). Although the nature of the relationship between anxiety sensitivity, trauma, and PTSD is still unclear, one hypothesis is that anxiety sensitivity increases fear reactivity during trauma exposure, leading to greater fear conditioning, and in turn, more symptoms in response to trauma reminders (e.g., Feldner et al., 2006). In addition, PTSD symptoms have been shown to have a reciprocal relationship with anxiety sensitivity, such that PTSD symptoms that develop after traumatic experiences lead to increases in anxiety sensitivity, which may complicate the course of treatment and worsen stress reactions to subsequent traumas (Marshall et al., 2010). Thus, in addition to moderating the effects of trauma, anxiety sensitivity may mediate the effects of current PTSD symptoms on processes such as fear conditioning or attentional bias.

To explore these possibilities, the present study examined attentional bias as a conditioned response during fear learning in trauma-exposed veterans with and without PTSD. The procedure

66

adhered to the general design of Experiment 2, with attentional biases assessed after habituation, acquisition, and extinction. To assess fear learning, a loud scream was used as the US (Indovina, Robbins, Núñez-Elizalde, Dunn, & Bishop, 2011). Also, in order to replicate prior studies demonstrating effects of fear learning on attention (e.g., Van Damme et al., 2006), a pink and a green rectangle were used as CSs. Whereas many of the prior studies demonstrating effects of fear learning on attention have used a key press spatial cueing task, the present study utilized a saccadic eye movement spatial cueing task (Bannerman et al., 2010), in order to avoid confounds related to emotion-induced generic response slowing (Mogg et al., 2008). In addition to examining conditioned responding in terms of attention, the present study used pupil diameter to measure condition responding in terms of autonomic arousal. Pupil diameter has been shown to converge with skin conductance as a measure of autonomic arousal in response to emotion-laden stimuli and appears to have a better signal-to-noise ration compared to electrode-based psychophysiological measures (Bradley et al., 2008). In addition, pupil diameter has been found to reflect both simple and more complex forms of differential fear conditioning (Reinhard, Lachnist, & König, 2006). Finally, self-report measures of US expectancy and anxiety in response to the CS were also collected to provide additional insight into conditioned responding (Boddez et al., 2013).

Methods

Participants

Two groups of participants were recruited: veterans exposed to combat-related trauma that met full diagnostic criteria for PTSD (PTSD+; $n = 20$) and veterans exposed to combat-related trauma without a diagnosis of PTSD (PTSD–; $n = 31$). Exposure to combat-related trauma was defined as meeting criterion A1 of the DSM–IV (APA, 2000) diagnosis for PTSD (the person has been exposed to a traumatic event in which the person experienced, witnessed, or was confronted with an event or events that involved actual or threatened death or serious injury, or a threat to the

67

physical integrity of self or others). Recruitment involved community advertisement and referrals from various veteran services, and diagnoses were determined using the *Mini International Neuropsychiatric Interview* (MINI; Sheehan et al., 1998), which was administered by clinicians supervised by a clinical psychologist. Exclusionary criteria included a diagnosis or history of bipolar disorder, intellectual disability, psychosis, ADHD, developmental disorders, neurological disease or traumatic brain injury. These criteria were applied during a phone screening and again following the MINI. Consistent with known patterns of PTSD comorbidity, 30% of veterans in the PTSD group also met diagnostic for major depressive disorder, 15% met diagnostic criteria for dysthymia, and 20% met diagnostic criteria for alcohol abuse.

Measures

The *Post-Traumatic Stress Disorder Checklist* (PCL; Weathers, Litz, Herman, Huska, & Keane, 1993) is a 17-item measure of PTSD symptom severity over the past month. Items are rated on a five-point scale ranging from 1 (not at all) to 5 (extremely). The PCL has been shown to have excellent internal consistency in Vietnam and Persian Gulf veterans, victims of motor vehicle accidents, and sexual assault survivors and has shown excellent test-retest reliability in Vietnam veterans (Orsillo, 2001). The PCL had excellent internal consistency in the present study (α = .92).

The *Combat Exposure Scale* (CES; Keane et al., 1989) is a 7-item scale that assesses various dimensions of combat-related stress. The CES uses a 5-point Likert scale (1 -5) and assesses the duration and intensity of exposure to a variety of warzone stressors and traumatic events. The CES had acceptable internal consistency in the present study (a = .63).

The *State Trait Anxiety Inventory--Trait Version, Form Y* (STAI-T; Spielberger et al., 1983) is a 20-item scale that measures the enduring or chronic experience of anxiety. Trait anxiety was assessed because it may moderate the effects of fear conditioning on attention (e.g., Lee et al., 2009). The STAI-T had excellent internal consistency in the present study (α = .92).

68

The *Anxiety Sensitivity Index-3* (Taylor et al., 2007) is an 18-item scale that assesses the tendency to view arousal-related sensations as harmful or threatening. This tendency is parsed in terms of social (e.g., "When I begin to sweat in a social situation, I fear people will think negatively of me"), cognitive (e.g., "When my thoughts seem to speed up, I worry that I might be going crazy") and physical concerns (e.g., "When I feel pain in my chest, I worry that I'm going to have a heart attack"). Anxiety sensitivity was examined because multiple studies suggest that it could be a risk factor for PTSD (e.g., Marshall, Miles, & Stewart, 2012). Also, whereas trait anxiety assessed by the STAI-T largely reflects negative affect, a broad vulnerability factor related to both anxiety and depression (Clark & Watson, 1991), anxiety sensitivity, as assessed by the ASI-3, may capture a specific vulnerability for anxiety disorders with a prominent arousal component, such as PTSD and panic disorder (Olatunji & Wolitzky-Taylor, 2009). The ASI-3 had excellent internal consistency in the present study ($\alpha = .93$).

The *Attentional Control Scale* (ACS; Derryberry & Reed, 2002) is a 20-item self-report questionnaire which assesses the ability to voluntarily maintain attention on a given task and to strategically reallocate attention. It is important to note that the ACS does not contain questions related to emotionally-valenced situations, and as such attempts to capture a general information processing trait uncontaminated by reactions to emotional stimuli or cognitions. The ACS was included because attentional control could potentially moderate effects of fear conditioning on attention. The ACS had good internal consistency ($\alpha = .86$) in the present sample.

Materials and apparatus

Pink and green rectangles that subtended 2.5 x 2 degrees of visual angle were presented as conditioned stimuli (Van Damme et al., 2006). The sound of a woman screaming (750 ms duration; 50 ms rise/fall; 90 dB) was played over earbud headphones as the unconditioned stimulus. Ratings of the CSs and US were made on the same modified empirical valence scales

used in the previous experiments. The stimuli were presented on a 17" monitor (75 Hz; 1280 x 1024 resolution) at a viewing distance of 82 cm. Stimuli were presented using MATLAB's Psychophysics toolbox (Brainard, 1997). Eye movements and pupil diameter were recorded monocularly at 1000 Hz using an EyeLink 1000 system from SR Research, and communication with the stimulus presentation machine was achieved using MATLAB's EyeLink toolbox (Cornelissen, Peters, & Palmer, 2002).

Procedure

Participants provided informed consent to a protocol approved by the Vanderbilt University Institutional Review Board, and then completed the MINI interview. Subsequently, participants completed the measures as well as a basic demographic survey (age, gender, ethnicity/race, income, education) on a computer. Participants then completed the conditioning task, consisting of the following stages: *Habituation.* Participants viewed 5 non-reinforced presentations (6 s) of each CS. During all stages, CS's were presented at the center of the screen in a pseudorandom order that prevented more than 2 consecutive presentations of the same CS (Lissek et al., 2009) and were preceded by a fixation cross (1.5 s) and followed by an ITI, varied randomly between 12 s and 18 s. *Acquisition.* During this stage, the CS+ was reinforced. On CS+ trials, the US was played during the last 750 ms of CS+ presentation, such that the CS+ and US co-terminated; on CS- trials, the US was not played. The acquisition phase was divided into two blocks, both with 5 presentations of CS+ trials, and 5 presentations of CS- trials. Between blocks, US expectancy was rated for each CS. *Reacquisition.* The acquisition procedure was repeated, but with only one block of trials. *Extinction.* The acquisition procedure was repeated, but without US presentation (i.e., CS+ reinforcement).

Attentional CR assessment. A modified spatial cueing task was used to assess changes in attention towards the CS's. Trials consisted of a central fixation point (700 ms), followed by a 200

70

ms "gap" (blank screen) to facilitate disengagement of attention (Bannerman et al., 2010). The CS was then presented for 30 ms at 9.2° eccentricity to the left or right of fixation, followed by a black asterisk ("probe"; 2° x 2°; 1000 ms) appearing either at the same location (valid trials) or at the opposite location (invalid trials) of the CS (see Figure XI).
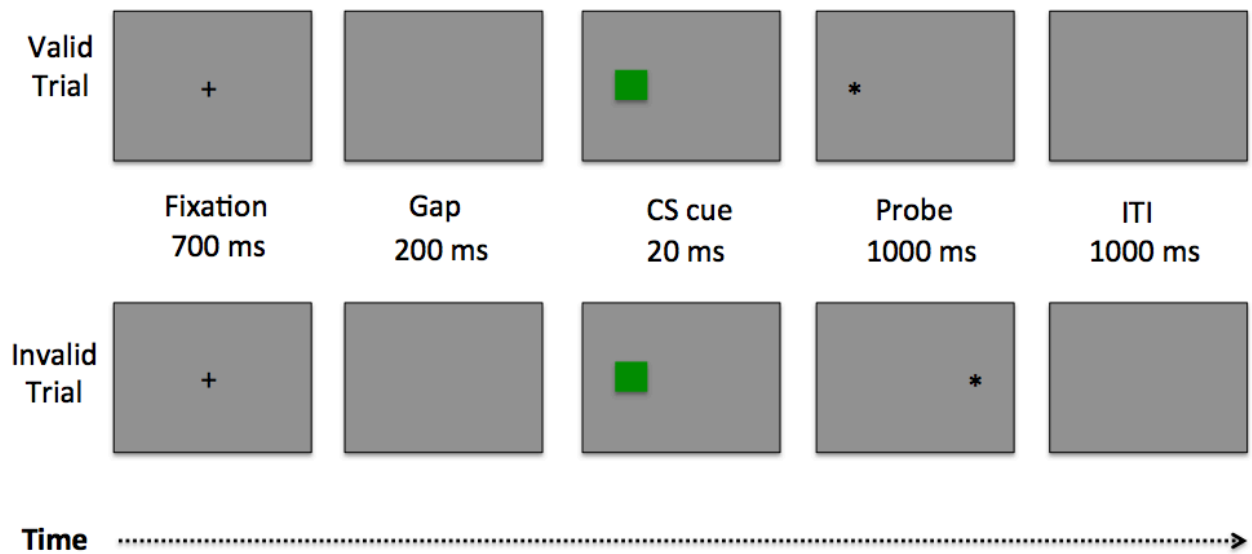
Figure XI. An overview of the spatial cueing task in Experiment 3. CS = conditioned stimulus, ITI=inter-trial interval, ms = milliseconds.

The ITI was 1000 ms. There were 128 trials (32 valid CS+ cue; 32 invalid CS+ cue; 32 valid CS- cue; 32 invalid CS- cue). Participants' task was to make a saccade to the probe as quickly and accurately as possible. Speeded responding to valid trials reflects facilitated orienting of covert attention to the CS, whereas delayed responding on invalid trials reflects difficulty disengaging covert attention from the CS. Bannerman et al. (2010) found that 20 ms and 40 ms, but not 100 ms cue presentations, revealed both of these effects for threatening faces. Attentional CR assessment occurred after habituation, after conditioning, and after extinction.

Psychophysiological CR assessment. Pupil diameter was used to measure autonomic arousal in response to the CSs at habituation, conditioning, reacquisition, and extinction. Pupil diameter was recorded throughout these procedures. In line with Bradley et al. (2008), the last 1 s of the ITI prior to the CS presentation was used as a baseline, and the first 2 s of CS presentation, which contain the initial light reflex, were excluded from analyses. This decision was made a priori; however, post hoc examination of the pupillary response to the CSs confirmed that the initial light reflex was contained within this 2 s window (see Figure XII).
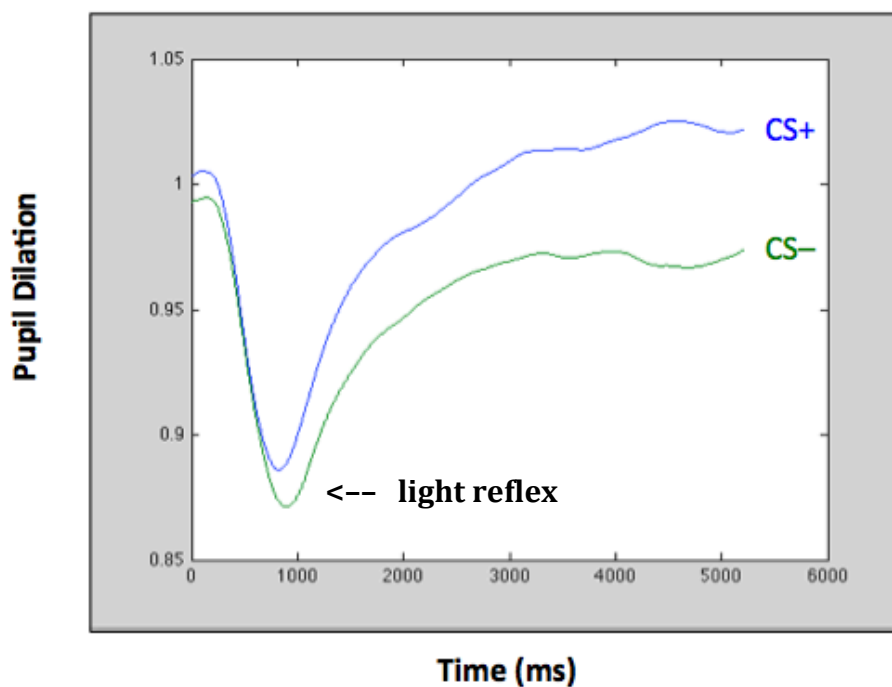
Figure XII. Pupil dilation to the CSs at acquisition in the full sample (post-smoothing). Pupil dilation units are a proportion of baseline pupil area. CS+ = rectangle followed by unconditioned stimulus; CS– = rectangle not followed by unconditioned stimulus.

To exclude responding to the US and to match the period of measurement for the CS+ and CS–, data after 5.2 s were omitted. Thus, pupil diameter in response to the CSs was measured from 2 s to 5.2 s (3.2 s window).

Self-report CR assessment. At the end of each stage, participants retrospectively rated how anxious the CSs made them feel and how much they expected the scream on a modified EVS. At the end of the experiment, participants were presented the scream one additional time, and then rated how afraid the scream made them feel on modified EVSs. The term *anxious* was used with the CSs, and *afraid* with the US, because anxiety involves anticipating a threat (e.g., waiting for a possible scream), whereas fear involves encountering a threat (e.g., hearing a scream; Lang, Davis, & Öhman, 2000).

Pupil diameter and eye movement data reduction

For each trial, pupil diameter for the CS was computed as a proportion of the baseline pupil diameter prior to the CS. The EyeLink system does not provide an absolute measurement of pupil diameter, and instead uses arbitrary units that depend on factors that vary between subjects. Accordingly, the manufacturer recommends computing a proportion of the baseline, rather than subtracting the baseline (Bradley et al., 2008), in order to allow the comparison of data between subjects. Missing pupil diameter data caused by blinks were replaced using linear interpolation, a procedure that minimally alters the data (Beatty & Lucero-Wagoner, 2000). To remove noise in the recording, data were smoothed using a 300-point filter, which approximated the 5-point filter often reported with 60 Hz recording (e.g., Siegle, Granholm, Ingram, & Matt, 2001).

Saccades were detected using the standard velocity and acceleration thresholds of the EyeLink system. Saccade latency, defined as the time elapsed between probe onset and saccade initiation, was the variable of interest in the spatial cueing task. Trials with errors (saccades to the wrong location) were excluded (7.87%), as were trials with saccade latencies that were 3 SD greater than the participant's average latency for the stage of assessment (.001%). Also, trials with saccade latencies shorter than 80 ms (anticipatory saccades) were excluded (7.37%). Finally, saccades were excluded if the participant's gaze was not within 2 degrees of the central fixation

cross at probe onset (6.31%). These methods for handling saccade latency data were based on Bannerman et al. (2010).

Data Analytic Plan

Analyses were conducted largely in line with the plan used in Experiment 2. For the spatial cueing task, 2 (Cue: valid, invalid) X 2 (CS: CS+, CS–) X 2 (group: HCF, LCF) mixed-effects ANOVAs were conducted at each stage. Also, for correlational analyses, analyses included the entire sample, in line with previous studies comparing trauma-exposed individuals with and without PTSD (Milad et al. 2009; Orr et al., 2000). In Experiment 2, recruitment for high and low symptom groups focused on the tails of the distribution of OCD symptoms, and excluded participants with OCD symptom levels in the center of the distribution. This "extreme groups" recruitment necessitates separate correlational analyses, because including only the tails of the distribution for a variable artificially inflates its correlations with other variables (Preacher, Rucker, MacCallum, & Nicewander, 2005). In contrast, the present study did not exclude veterans with mid-range symptoms of PTSD. During the majority of participant enrollment, the study was open to trauma-exposed veterans regardless of PTSD status. During the final months of enrollment, veterans with PTSD were oversampled to ensure adequate power for comparisons between diagnostic groups; however, the resulting distribution of PTSD symptoms, as measured by the PCL-M, approximated a normal distribution: a Kolmogorov-Smirnov test failed to reject the assumption that the distribution of PCL-M scores was normal, and skewness (.41) and kurtosis (-.57) values for the PCL-M were acceptable.

Results

Group characteristics

The two veteran groups did not differ in terms of age, gender, ethnicity, or income ($ps >$ .05). In addition, the two groups did not differ in terms of the time elapsed since their last tour or their exposure to combat stress ($ps > .05$). In line with their diagnoses, the veterans with PTSD had significantly greater levels of PTSD symptoms, anxiety sensitivity, trait anxiety, and diminished attentional control, compared to the veterans without PTSD ($ps < .001$). Finally, the veterans with PTSD reported more fear in response to the US stimulus ($p < .05$). Table VII reports Ms and SDs for these variables.

Table VII. Group Characteristics for Experiment 3

	Veterans PTSD+ ($n = 20$)	Veterans PTSD– ($n = 31$)	
Age	31.09 (7.65)	31.90 (7.60)	t (49) = .39 ns
Gender			$\chi^2 = 3.15$ ns
% Male	82.6	96.8	
Ethnicity			$\chi^2 = 7.87$ ns
% White	60.9	83.9	
% Black	21.7	6.5	
% Hispanic	13.0	3.2	
% Asian	0	3.2	
% Multiracial	0	3.2	
% Other	4.3	0	
Annual income	$54,173 (30,503)	$51,484(38,465)	t (49) = -.28 ns
Time since end of last tour	36 months (31)	47 months (31)	t (49) = 1.30 ns
CES	25.24 (5.70)	24.50 (7.04)	t (47) = -.39 ns
PCL-M	20.41 (4.89)	2.93 (1.33)	t (49) = -18.92***
ACS	46.95 (6.96)	56.00 (6.88)	t (49) = 4.70***
ASI-3	34.45 (14.16)	12.42 (9.49)	t (49) = -6.79***
STAI-T	58.55 (8.57)	46.87 (8.67)	t (49) = -4.85***
US afraid rating	53.78 (16.05)	42.00 (18.79)	t (49) = -2.31*

Note: PTSD+ = diagnosis of post-traumatic stress disorder; PTSD– = no diagnosis of post-traumatic stress disorder; CES = Combat Exposure Scale; PCL-M = PTSD Checklist – Military Version; ASI-3 = Anxiety Sensitivity Index – Third Edition; STAI-T = State-Trait Anxiety Inventory – Trait Version; US = unconditioned stimulus; ns = non-significant; * p < .05, ** p < .01, *** p < .001

Habituation

Self report CR: US expectancy ratings. The main effect of CS, the main effect of group, and the CS X group interaction were all non-significant, Fs (1, 49) < 1.92, ps > .05. Thus, prior to acquisition, the CSs did not differ in terms of their ability to elicit anticipation of the US, nor did the groups differ in terms of their anticipation of the US. Table VIII provides Ms and SDs for all CS ratings, and Figure XIII (next page) depicts these ratings.

Table VIII. Means (*SDs*) for self-reported responses to the CSs on 100-point scale.

PTSD+

Rating	CS	Phase of conditioning		
		Habituation	Acquisition	Extinction
US expectancy	CS+	11.68 (15.90)	90.59 (16.48)	54.12 (26.61)
	CS-	14.35 (22.91)	11.93 (18.33)	15.06 (19.05)
Anxiety	CS+	14.93 (18.52)	68.65 (26.92)	46.27 (27.57)
	CS-	18.31 (22.56)	16.33 (20.46)	12.05 (17.91)

PTSD−

Rating	CS	Phase of conditioning		
		Habituation	Acquisition	Extinction
US expectancy	CS+	5.82 (11.18)	84.06 (20.03)	32.71 (26.29)
	CS-	8.48 (16.45)	12.03 (16.98)	14.28 (17.54)
Anxiety	CS+	7.43 (12.64)	47.61 (28.84)	31.04 (22.51)
	CS-	9.13 (15.95)	17.11 (16.81)	15.03 (16.2)

Note. PTSD+ = veterans with PTSD; PTSD− = veterans without PTSD;
CS = conditioned stimulus (rectangle); CS+ = rectangle followed by unconditioned stimulus;
CS- = rectangle not followed by unconditioned stimulus.

Self-report CR: anxiety ratings. The main effect of CS was non-significant, $F(1, 49) < 1, p > .05$. There was a significant main effect of group, $F(1, 49) = 4.74, p < .04$, which was not qualified by a group X CS interaction, $F(1, 49) < 1, p > .05$. Veterans with PTSD reported higher levels of anxiety in response to both CSs, possibly reflecting higher levels of state anxiety.

Figure XIII. Self-report ratings of the CSs in Experiment 3. PTSD+ = diagnosis of post-traumatic stress disorder; PTSD– = no diagnosis of post-traumatic stress disorder; CS+ = rectangle followed by unconditioned stimulus; CS– = rectangle not followed by unconditioned stimulus. HAB = habituation; ACQ = acquisition; EXT = extinction.

Psychophysiological CR: pupil diameter. The main effect of CS, the main effect of group, and the CS X group interaction were all non-significant, $F(1, 49) < 1$, $p < .001$. Thus, prior to acquisition, the CSs did not differ in terms of their effects on pupil dilation, nor did the groups differ in terms of their pupil dilation. Table IX provides Ms and SDs for pupil dilation in response to the CSs at all stages, and Figure XIV depicts these data.

Table IX. Means (SDs) for pupil dilation to the CSs as a proportion of baseline pupil area.

PTSD+

		Phase of conditioning		
Group	CS	Habituation	Acquisition	Extinction
PTSD+	CS+	.93 (.06)	1.01 (.09)	1.03 (.11)
	CS-	.93 (.07)	.97 (.08)	1.01 (.11)
PTSD–	CS+	.93 (.05)	1.00 (.08)	.98 (.07)
	CS-	.94 (.08)	.97 (.07)	.96 (.05)

Note. PTSD+ = veterans with PTSD; PTSD– = veterans without PTSD; CS = conditioned stimulus (rectangle); CS+ = rectangle followed by unconditioned stimulus; CS- = rectangle not followed by unconditioned stimulus.
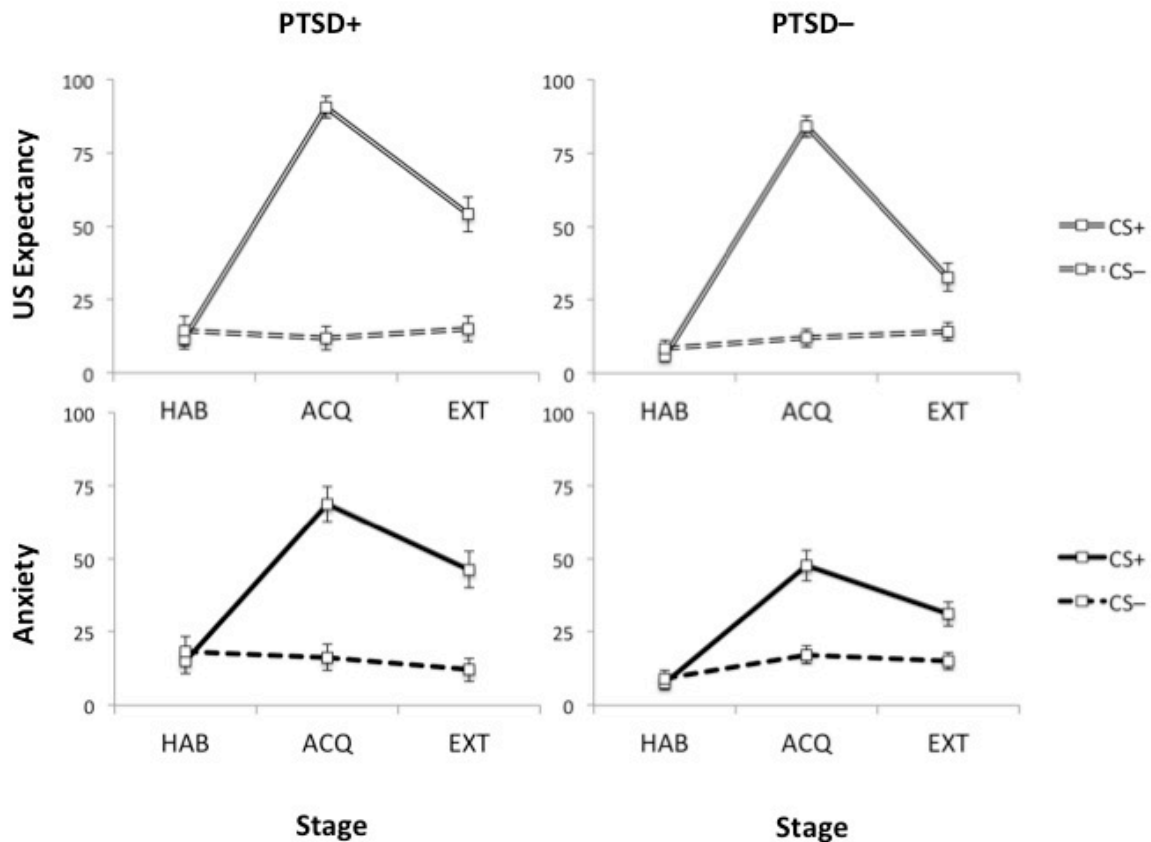

Figure XIII. Pupil dilation to the CSs in Experiment 3. PTSD+ = diagnosis of post-traumatic stress disorder; PTSD– = no diagnosis of post-traumatic stress disorder; CS+ = rectangle followed by unconditioned stimulus; CS– = rectangle not followed by unconditioned stimulus. HAB = habituation; ACQ = acquisition; EXT = extinction.

Eye movement CR: saccade latencies. The main effect of cue was significant, $F (1, 49) = 174.31$, $p < .001$, such that participants responded faster to probes preceded by valid cues (i.e., cues that appeared in the probe location) compared to invalid cues (i.e., cues that appeared opposite the probe location). No other effects were significant, Fs $(1, 49) < 1$, ps $> .05$. Thus, prior to acquisition, the CSs did not differ in terms of their effects on attention, nor did the groups differ in terms of these effects on attention. Table X provides Ms and SDs for saccade latencies to the CSs at all stages.

Table X. Means (*SDs*) for saccade latencies (ms) in spatial cueing task.

PTSD+

		Phase of conditioning		
Trial type	CS	Habituation	Acquisition	Extinction
Valid	CS+	160.89 (58.01)	150.99 (41.31)	142.13 (32.65)
	CS–	162.59 (48.98)	154.45 (41.93)	139.35 (29.75)
Invalid	CS+	199.26 (47.70)	185.76 (37.90)	185.25 (37.42)
	CS–	200.66 (41.15)	190.77 (38.25)	184.97 (35.51)

PTSD–

		Phase of conditioning		
Trial type	CS	Habituation	Acquisition	Extinction
Valid	CS+	165.75 (41.85)	155.47 (40.52)	150.22 (37.88)
	CS–	167.44 (37.75)	155.62 (37.18)	149.21 (32.84)
Invalid	CS+	206.95 (39.44)	199.08 (52.97)	194.09 (36.24)
	CS–	200.78 (39.74)	192.79 (35.68)	192.94 (34.36)

Note. PTSD+ = veterans with PTSD; PTSD– = veterans without PTSD;
CS = conditioned stimulus (rectangle); CS+ = rectangle followed by unconditioned stimulus;
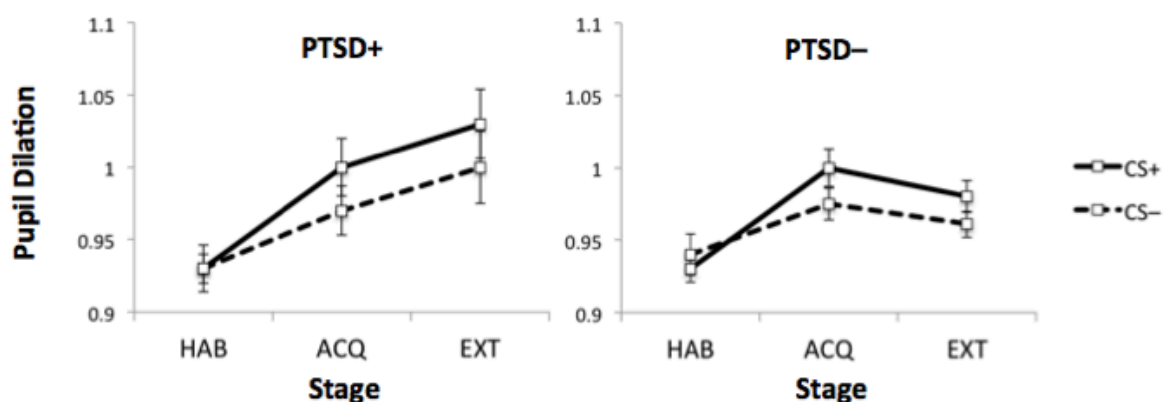CS– = rectangle not followed by unconditioned stimulus.

Acquisition

Self report CR: US expectancy ratings. The main effect of CS was significant, F (1, 49) = 245.74, p < .001. Participants had greater expectations of the US following the CS+ versus CS–, reflecting successful discriminant conditioning in the entire sample. The main effect of group and the CS by group interaction were not significant, Fs (1, 49) < 2.62, ps > .05.

Self report CR: anxiety ratings. The main effect of CS, F (1, 49) = 72.61, p < .001, and the main effect of group were significant, F (1, 49) = 4.53, p < .05, and these main effects were qualified by a CS by group interaction, F (1, 49) = 5.04, p < .05. Independent-samples t-tests revealed that compared to the veterans without PTSD, veterans with PTSD reported greater anxiety during the CS+, t (49) = -2.61, p < .02, but not during the CS–, t (49) = .15, p > .05.

Psychophysiological CR: pupil diameter. The main effect of CS was significant, F (1, 49) = 12.08, p = .001, such that pupil dilation was greater in response to the CS+ versus the CS– in the full sample. The main effect of group and the group by CS interaction were not significant, Fs (1, 49) < 1, ps > .05.

Eye movement CR: saccade latencies. The main effect of cue was significant, F (1, 49) = 82.52, p < .001, replicating the basic cueing effect found after habituation. No other effects were significant, Fs (1, 49) < 2.26, ps > .05. Thus, following acquisition, the CSs did not differ in terms of their effects on attention, nor did the groups differ in terms of these effects on attention, contrary to hypotheses.

Extinction

Self report CR: US expectancy ratings. There were significant main effects of CS, F (1, 49) = 50.27, p < .001, and group, F (1, 49) = 6.47, p < .04, which were qualified by a CS by group interaction, F (1, 49) = 6.47 p < .02. Independent-samples t-tests revealed that compared to the veterans without PTSD, veterans with PTSD reported greater expectation of the US during the

CS+, t (49) = -2.83, p < .01, but not during the CS–, t (49) = -.15, p > .05. To determine if partial extinction was achieved, an exploratory analysis was conducted to test if self-reported US expectancy declined between acquisition and extinction. Conditioning phase was added to the ANOVA model, and limited to the levels of acquisition and extinction. Of most relevance to the present hypotheses, there was a CS by phase interaction, F (1, 49) = 72.74 p < .001, reflecting successful extinction learning in the entire sample. This interaction was not further qualified by a CS by phase by group interaction, F (1, 49) = 1.71 p > .05, such that groups did not differ in terms of decline of US expectancy from acquisition to extinction.

Self report CR: anxiety ratings. There were significant main effects of CS, F (1, 49) = 48.45, p < .001. The main effect of group was not significant, F (1, 49) = 1.45, p > .05; however, the main effect of CS was qualified by a CS by group interaction, F (1, 49) = 6.37, p < .02. Independent-samples t-tests revealed that compared to the veterans without PTSD, veterans with PTSD reported greater expectation of the US during the CS+, t (49) = -2.16, p < .04, but not during the CS–, t (49) = .62, p > .05. To determine if partial extinction was achieved, an exploratory analysis was conducted to test if self-reported anxiety in response to the CSs declined between acquisition and extinction. Of most relevance to the present hypotheses, there was a CS by phase interaction, F (1, 49) = 13.06, p = .001, reflecting successful extinction learning in the entire sample. This interaction was not further qualified by a CS by phase by group interaction, F (1, 49) < 1 p > .05, such that groups did not differ in terms of decline of anxiety from acquisition to extinction.

Psychophysiological CR: pupil diameter. The main effect of CS was marginally significant, F (1, 49) = 3.21, p < .08, and the main effect of group was significant, F (1, 49) = 5.28, p < .03; however, these main effects were not qualified by a group by CS interaction, F (1, 49) < 1, p > .05. Thus, there was a trend of discriminant conditioning in pupil dilation that

81

persisted during extinction, and while the veteran groups did not differ in terms of this trend, veterans with PTSD showed greater pupil dilation in response to the CSs *in general* during extinction. An exploratory analysis of pupil dilation at acquisition versus extinction revealed a main effect of CS, $F (1, 49) = 11.44$, $p = .001$, which was not qualified by a CS by phase interaction, suggesting that significant extinction of conditioned responding was not achieved in terms of autonomic arousal revealed by pupil dilation. Of relevance to the present hypotheses, there was not a significant CS by phase by group interaction, $F (1, 49) < 1$, $p > .05$; however, there was a significant phase by group interaction, $F (1, 49) = 4.50$, $p < .04$. Follow-up ANOVAs conducted separately in each veteran group revealed that there was not a significant main effect of stage in either group, $Fs (1, 49) < 2.2$, $p > .05$; however, as noted above, there as a significant main effect of group at the extinction phase, but not the acquisition phase. From acquisition to extinction, pupil dilation to CSs generally declined in the veterans without PTSD, whereas it increased in the veterans with PTSD, leading to the emergence of this significant group difference.

Eye movement CR: saccade latencies. The main effect of cue was again significant, $F (1, 49) = 222.0$, $p < .001$. No other effects were significant, $Fs (1, 49) < 2.26$, $ps > .05$. Thus, following extinction, the CSs did not differ in terms of their effects on attention, nor did the groups differ in terms of these effects on attention, contrary to hypotheses.

Correlations between symptom measures, unconditioned responding, and conditioned responding

Table XI (next page) reports correlations between symptom measures and measures of unconditioned and conditioned responding for the full sample of veterans.

82

Table XI. Correlations between symptom measures and conditioning variables

Measure	1	2	3	4	5	6	7	8	9	10
1. PCL-M	--	.76***	.22	.19	.39**	.37**	.39**	.05	.15	.12
2. ASI-3		--	.49***	.24	.51***	.41**	.38**	.12	.07	.39**
3. UR fear			--	.24	.56***	.26	.37**	.30*	-.23	.20
4. ACQ expectancy				--	.63***	.29*	.31*	.16	.03	.20
5. ACQ anxiety					--	.41**	.52***	.17	-.09	.15
6. EXT expectancy						--	.80***	.32*	.22	-.01
7. EXT anxiety							--	.37**	.25	-.08
8. ACQ pupil								--	.07	.05
9. EXT pupil									--	.20
10. EXT pupil (both CSs)										--

Note: PCL-M = PTSD Checklist – Military Version; ASI-3 = Anxiety Sensitivity Index – Third Edition; UR = unconditioned fear response (self-report); ACQ = acquisition; EXT = extinction; CS = conditioned stimulus. Unless otherwise noted, conditioned response variables reflect discriminant conditioning (CS+ – CS–).

Relations with symptom measures. Correlational analyses focused on the symptom measures that were most relevant to PTSD and PTSD vulnerability, the PCL-M and the ASI-3, respectively, and on the CR variables for which evidence of conditioning or group differences were observed, and thus excluded saccade latency data. To summarize the main findings of interest, symptoms of PTSD were correlated with self-reported discriminant conditioning at both acquisition and extinction. At acquisition, this correlation was limited to anxiety ratings ($p < .01$), and not observed for US expectancy ($p > .05$); at extinction, this correlation was observed for both anxiety ($p < .01$) and US expectancy ($p < .01$). PTSD symptoms were not correlated with discriminant conditioning as revealed by pupil diameter ($ps > .05$), or with overall pupil dilation to

CSs at extinction ($p > .05$; a variable on which veterans with PTSD showed increased responding compared to veterans without PTSD). Also, PTSD symptoms were not correlated with self-reported fear responding to the US ($p > .05$). Anxiety sensitivity showed the same pattern of relations with self-report measures of discriminant conditioned responding as PTSD symptoms (ps $< .01$), and was also not related to discriminant conditioned responding as revealed by pupil dilation ($p > .05$). However, anxiety sensitivity was correlated with both overall pupil dilation in response to CSs at extinction ($p < .01$), and with self-reported fear responding to the US ($p < .001$).

Relations between conditioned and unconditioned responses. The self-report and psychophysiological CRs were generally not correlated (ps $> .05$); however, discriminant pupillary responding to the CSs at acquisition predicted both self-reported US expectancy ($p < .03$) and anxiety ($p < .01$) at extinction (but not at acquisition). Self-reported fear responding to the US predicted self-reported conditioned anxiety at both acquisition ($p < .001$) and extinction ($p < .01$), but only marginally predicted US expectancy at both phases ($p < .09$). Also, self-reported fear responding to the US predicted discriminant conditioning as revealed by pupil dilation at acquisition ($p < .04$), but not at extinction ($p > .05$).

Modeling relations between PTSD, anxiety sensitivity, unconditioned fear reactivity, and conditioned anxiety.

The pattern of correlations reported in Table XI may provide some insight into relations between anxiety sensitivity, fear learning, and PTSD. According to theoretical models of fear conditioning, the magnitude of a conditioned response, such as anxiety in the presence of threat cues, is determined in part by the magnitude of the unconditioned fear response to the threat itself (see Bouton, 2007). Thus, the relation between PTSD and conditioned fear responding could be mediated by the relation between PTSD and unconditioned fear responding. However, PTSD

84

symptoms were not significantly correlated with unconditioned fear responding, as revealed by self-reported fear in response to the scream. On the other hand, there was a highly significant correlation between anxiety sensitivity and unconditioned fear responding, and the present study found a strong correlation between anxiety sensitivity and PTSD symptoms, in line with prior research (Olatunji & Wolitzky-Taylor, 2008). One possibility is that anxiety sensitivity mediates the relationship between PTSD symptoms and unconditioned fear responding, which in turn mediates the relationship between anxiety sensitivity and conditioned fear responding. This pattern of effects would represent sequential multiple mediation, with an indirect effect leading from PTSD symptoms (PCL-M) to anxiety sensitivity (ASI-3) to unconditioned fear to conditioned anxiety (PROCESS Model 6; Hayes, 2013).

This model was applied to self-reported anxiety (to CS+ versus CS−) at both the acquisition and extinction phases (Figures XV and XVI, next page). At both phases, the hypothesized indirect effect was significant ($p < .05$), as reflected by the 95% confidence intervals (CIs) not containing zero (acquisition: $d = .25$, SE = .13, lower CI = .06, upper CI = .61; extinction: $d = .17$, SE = .13, lower CI = .01, upper CI = .54). In addition, alternative indirect effects that required one fewer step of mediation (PCL-M to ASI-3 to conditioned anxiety; PCL-M to unconditioned fear to conditioned anxiety) were not significant (ps > .05) when accounting for the hypothesized indirect effect (PCL-M to ASI-3 to unconditioned fear to conditioned anxiety), at both stages.

Figure 1 (top diagram):

ASI-3 — b_3 $t = 3.41^{***}$ → UR

a_1 $t = 9.29^{***}$ a_2 $t = -1.47$ ns b_1 $t = 1.13$ ns b_2 $t = 3.10^{**}$

PCL-M c $t = 2.88^{**}$ CR-ACQ
c′ $t = .36$ ns

Figure XV. A sequential multiple mediation model demonstrating that PTSD symptoms are related to conditioned anxiety at acquisition through the effects of anxiety sensitivity on unconditioned fear. *Note:* PCL-M = PTSD Checklist – Military Version; ASI-3 = Anxiety Sensitivity Index – Third Edition; UR = unconditioned response (self-reported fear); CR-ACQ = conditioned response (self-reported anxiety) at acquisition.

Figure 2 (bottom diagram):

ASI-3 — b_3 $t = 3.41^{***}$ → UR

a_1 $t = 9.29^{***}$ a_2 $t = -1.47$ ns b_1 $t = -.18$ ns b_2 $t = 1.96$ †

PCL-M c $t = 2.91^{**}$ CR-EXT
c′ $t = -.56$ ns

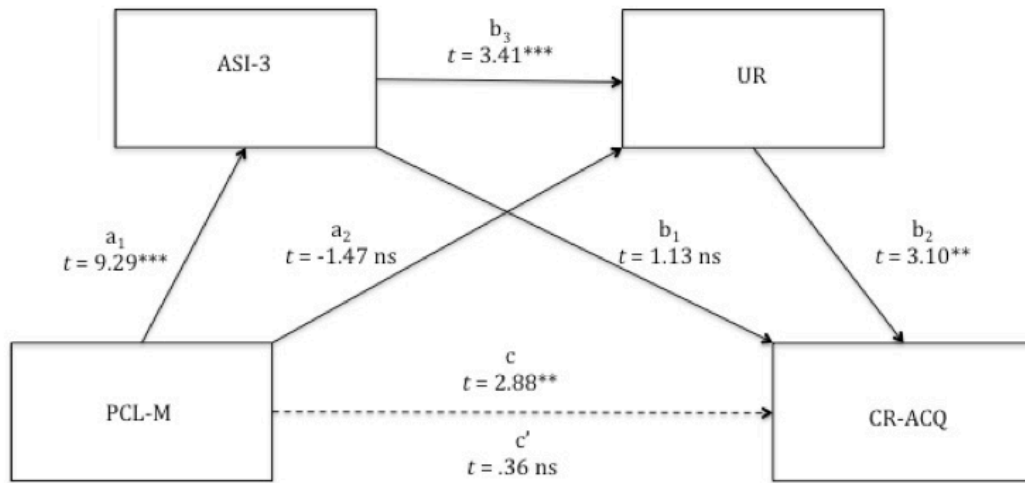**Figure XVI.** A sequential multiple mediation model demonstrating that PTSD symptoms are related to conditioned anxiety at extinction through the effects of anxiety sensitivity on unconditioned fear. *Note:* PCL-M = PTSD Checklist – Military Version; ASI-3 = Anxiety Sensitivity Index – Third Edition; UR = unconditioned response (self-reported fear); CR-ACQ = conditioned response (self-reported anxiety) at extinction.
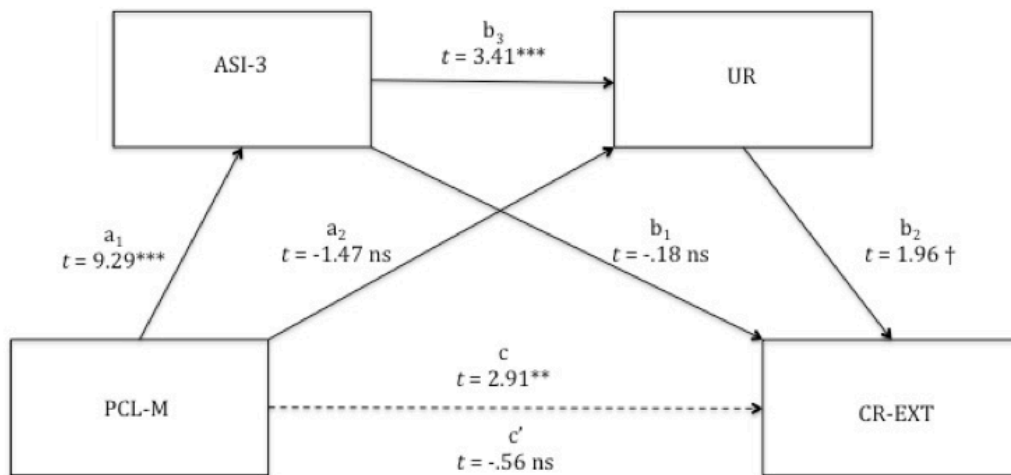
Discussion

The present study is the first to examine attentional bias as a conditioned response in PTSD. Contrary to hypotheses, fear conditioning did not have any basic effects on spatial attention, and veterans with and without PTSD did not differ in terms of the effects of fear conditioning on attention. This null result cannot be attributed to a failure of the fear conditioning paradigm, as robust acquisition effects were observed on both self-report and psychophysiological measures. Participants reported greater US expectancy, anxiety, and displayed greater pupil dilation in response to the CS+ versus the CS–. In addition, the fear conditioning paradigm appeared to have diagnostic validity (Boddez et al., 2013), as veterans with and without PTSD were distinguished by their patterns of conditioned responding. Veterans with PTSD reported greater anxiety to the CS+ at acquisition and extinction, and reported greater US expectation during the CS+ at extinction, compared to veterans without PTSD. Although these group differences in discriminant responding were not observed on pupil dilation, veterans with PTSD did show greater pupil dilation to both CSs at extinction. Finally, veterans with PTSD reported greater unconditioned fear responding, and mediational modeling revealed that levels of PTSD symptoms were related to increased conditioned anxiety through the effects of anxiety sensitivity on unconditioned fear responding.

The failure to observe effects of fear conditioning on spatial attention may be attributed to several factors. First, the present study established CS-US contingencies and assessed attention in separate procedures, with the spatial cueing task occurring *after* each conditioning phase. In contrast, other studies (e.g., Van Damme et al., 2006) have established CS-US contingencies within the spatial cueing task, for example, by reinforcing 50% of the CS+ cues with a shock. One limitation of assessing attention to the CSs in a separate task is that the parameters of the CSs change. For example, the CSs were presented centrally for 6 s in the conditioning phases, but were

87

presented peripherally for 30 ms in the spatial cueing assessment of attention. These changes in parameters may weaken (or even eliminate) the ability of the CSs to activate the US representation and thus elicit conditioned responding. Another limitation to assessing attentional bias for the CSs in a separate task is the potential for extinction. Each time the CS+ was presented without reinforcement in the spatial cueing task, its ability to activate the US representation was likely weakened through the process of extinction. However, other studies have been able to observe effects of fear conditioning on attention through tasks occurring after the conditioning procedure, in spite of these limitations (e.g., Lee & Lee, 2009; Mulckhuyse et al., 2013; Pischek-Simpson et al., 2008).

Another possibility is that the measure of attention used in the present study was not adequate for measuring effects of fear conditioning. Whereas prior studies observing effects of fear conditioning on attention in the spatial cueing task have used 100 ms cue presentations, the present study used a 30 ms cue presentation, as Bannerman and colleagues (2009a; 2009b; 2010a; 2010b) have demonstrated in multiple studies that saccade latencies reflect emotional modulation of attention earlier than manual response latencies, with the strongest effect for 20 or 40 ms cues. However, these studies have used fearful faces or postures, rather than conditioned fear stimuli. It is possible that conditioned fear stimuli do not exert effects on saccade latencies at such brief presentations.

Although conditioned responding was not revealed in the spatial cueing task, it was found for self-report and psychophysiological measures, which showed varying degrees of diagnostic validity. Compared to veterans without PTSD, Veterans with PTSD reported increased anxiety to the CS+ at both acquisition and extinction. Although veterans with PTSD responded with greater anxiety to the CS+ at extinction, this finding appeared to reflect a larger initial acquisition of anxiety, rather than an extinction learning deficit, as veterans with and without PTSD showed

88

similar declines in their conditioned anxiety from acquisition to extinction. These findings are in line with the "conditionability" theory of Orr and colleagues (2000), because they suggest that PTSD is characterized by excessive excitatory fear learning, rather than impaired inhibitory fear learning, as suggested by Davis and colleagues (2000). In addition to not observing PTSD-related deficits in inhibitory learning to the CS+ at extinction, the present study also did not observe PTSD-related deficits in inhibitory learning to the CS– at acquisition, a finding that is also inconsistent with the theory of Davis and colleagues (2000). However, it is possible that deficits in inhibitory learning related to PTSD can only be observed in procedures that probe more complex forms of inhibitory learning (e.g., safety transfer in conditional discrimination; see Jovanovic & Ressler, 2010).

In line with prior research (Lommen et al., 2013), PTSD was also linked to increased US expectancy during CS presentation. Compared to veterans without PTSD, veterans with PTSD reported greater US expectation for the CS+ at extinction, but not at acquisition. Although PTSD-related differences in US expectancy may be specific to extinction, it is possible that group differences in US expectancy were not observed at acquisition because of a ceiling effect, as both veterans with and without PTSD rated their expectation of the US near the maximum value of the scale. Another way of looking at these findings is in terms of a "strong situation," a social psychological concept describing a situation that elicits such a reliable response that it conceals individual differences (see Lissek et al., 2006). Reinforcing 100% of the trials during acquisition appeared to produce such a reliable contingency awareness that both groups formed near-maximum US expectations during the CS+. In contrast, the extinction phase presented greater ambiguity with regards to the CS-US contingency: the CS+ was no longer reinforced, but given the preceding reinforced presentations during acquisition and re-acquisition, it was unclear whether one should stop expecting the US. Under these more ambiguous circumstances, the

veterans with PTSD exhibited a stronger tendency to continue expecting the US, perhaps because they discounted the non-reinforced trials in judging the likelihood of the US. Lommen et al. (2013) found that increased US expectancy during extinction trials predicted the development of PTSD in Dutch soldiers, which suggests that the present finding could reflect a vulnerability factor in veterans with PTSD that pre-exists trauma exposure.

In addition to revealing fear learning tendencies that characterize PTSD, the present study sheds light on relations between anxiety sensitivity and fear learning in PTSD. Anxiety sensitivity is more strongly related to PTSD than to other anxiety-related disorders (Naragon-Gainey, 2010; Olatunji & Wolitzky-Taylor, 2008), and prospective studies have identified anxiety sensitivity as a risk factor for developing PTSD in response to trauma (Feldner et al., 2006; Keough, Ayers, & Francis, 2002; Kilic, Kilic, & Yilmaz, 2008). Some have suggested that anxiety sensitivity may confer vulnerability to PTSD by increasing reactivity to a traumatic stressor, as reflected in the severity of peritraumatic distress (Olatunji & Wolitzky-Taylor, 2008). The present study found that anxiety sensitivity accounted for the relationship between symptoms of PTSD and unconditioned fear responding (reactivity to the US), which may be analogous to the relations between anxiety sensitivity, PTSD, and trauma reactivity observed in naturalistic, descriptive research (e.g., Kilic et al., 2008). Consistent with basic models of fear conditioning (Bouton, 2007), the present study also demonstrated that increased fear in response to the US led to increased anxiety in response to the CS+, and that this effect provides a mechanism through which anxiety sensitivity increases conditioned anxiety in PTSD. These findings suggest that anxiety sensitivity not only increases peritraumatic distress, but in doing so, may potentiate fear conditioning to innocuous peritraumatic stimuli, thereby creating additional risk for PTSD.

Although the present study found robust PTSD-related differences in self-reported conditioned responding, these differences were not observed in autonomic conditioned

90

responding, as reflected in pupil dilation. Although there was evidence of discriminant

conditioning in pupil dilation in the entire sample at acquisition and to a lesser extent at extinction,

there were no group differences in this discriminant responding. However, veterans with PTSD

did show increased pupil dilation to both CSs at extinction, and this effect was related to anxiety

sensitivity. One possibility is that veterans with PTSD became more aroused by both stimuli

during extinction because of the uncertainty created by the change in reinforcement contingency.

Prior research on contextual fear has found that when a shock cued by a CS becomes

unpredictable, individuals show a generalized increase in autonomic arousal that is related to a

chronic expectation of the US (Vansteenwegen, Iberico, Vervliet, Marescau, & Hermans, 2008).

One possibility is that during extinction, veterans with PTSD implicitly expected the US to return

unpredictably, and as a result, were more aroused during the presentation of both CSs.

Although the present findings offer new insight into the relations between fear

conditioning, anxiety sensitivity, and PTSD, they should be interpreted with multiple limitations in

mind. First, it is unclear if the PTSD-related fear learning tendencies observed in the present study

were present prior to trauma exposure and the emergence of PTSD symptomatology. While the

present findings are consistent with prospective studies establishing fear learning abnormalities

(Lommen et al., 2013) and anxiety sensitivity (e.g., Keough et al., 2002) as premorbid

vulnerability factors for PTSD, it is possible that the fear learning tendencies observed in the

present study, as well as their relation to anxiety sensitivity, develop as a consequence of PTSD

symptomatology. However, under this scenario the present findings would still have implications

for the course of PTSD, as individuals with PTSD are often exposed to repeated traumas (Orcutt et

al., 2002). Indeed, PTSD symptoms uniquely predict subsequent exposure to trauma, such that

individuals who are experiencing PTSD are more likely to experience additional traumas as a

consequence of their symptoms (e.g., due to problematic coping strategies; Cougle, Resnick, &

Kilpatrick, 2009; Orcutt et al., 2002). Thus, even if the phenomena linked to PTSD in the present study were not risk factors for patients' current episode of PTSD, they could serve as risk factors for adverse reactions to future stressors. However, prospective research examining both fear learning and anxiety sensitivity in a population at risk for PTSD is needed to clarify the nature of the present findings. An additional limitation to the present study is that self-reported fear learning tendencies linked to PTSD were not corroborated by the pupil dilation data. Thus, it is possible that the present findings reflect verbal response tendencies in PTSD that do not generalize to underlying physiological processes implicated in fear learning (e.g., Grillon, 2002). The present findings would be strengthened by replication on a more objective indicator of conditioning fear responding, such as fear potentiated startle (Lissek et al., 2009) or amygdala activity (e.g., LeDoux et al., 1990). In addition, US expectancy ratings were not collected online during CS presentation (Lommen et al., 2013), but were instead collected retrospectively, at the end of each conditioning phase. Collecting US ratings online during each trial could have provided greater insight into the cognitive processes involved in fear conditioning (Boddez et al., 2013). Despite these limitations, the present study may offer new insights into the role of fear conditioning and anxiety sensitivity in PTSD.

CHAPTER V

GENERAL DISCUSSION

This program of research had two overarching goals. The first goal was to contrast disgust and fear learning in terms of basic processes, with a focus on how disgust and fear learning differ in terms of their effects on attention. The second goal was to examine disgust and fear learning in the context of anxiety-related disorders in which each may be particularly relevant (contamination-based OCD and PTSD, respectively), with a focus on how disgust and fear learning might shape attentional biases for threat in these disorders. In pursuing both of these goals, an additional interest was exploring relations between emotional learning processes and traits that have been established as vulnerability factors for anxiety-related disorders.

Experiment 1 demonstrated that disgust and fear learning indeed have distinct effects on attention. Using a video-based conditioning paradigm (Kelly & Forsyth, 2007) with comparable disgust and fear USs, this study found that only disgust conditioning produced sustained attentional avoidance of the CS+. Consistent with Mason and Richardson (2010), this attentional CR was present after an extinction procedure and correlated with disgust sensitivity, a known vulnerability factor for disgust-related anxiety-disorders. Mediational modeling revealed that *conditioned* disgust and fear stimuli elicit different attentional CRs because *unconditioned* disgust and fear stimuli elicit different attentional URs: disgust USs uniquely repel gaze, which in turn allows disgust CSs to repel gaze. Additional mediational modeling suggested that individuals high in disgust sensitivity avoid looking at disgust USs because they experience more disgust in response to these stimuli, and that individuals high in disgust sensitivity show a greater tendency to avoid looking at conditioned disgust stimuli because of their greater tendency to avoid looking at unconditioned disgust stimuli. Together, these findings shed light on specific pathways by

93

which disgust sensitivity may contribute to certain anxiety disorders, and thus provide an important contribution to the literature on disgust and psychopathology.

Experiment 2 sought to extend the findings of Experiment 1 by examining the effects of disgust on attention in contamination-based OCD. However, the disgust conditioning procedure used in Experiment 2 did not produce any observable effects on attention. Despite this limitation, the disgust conditioning procedure in Experiment 2 did reveal learning tendencies that may characterize contamination-based OCD. HCF individuals' self-reported US expectancy during the CS+ was resistant to extinction, compared to LCF individuals, and HCF individuals reported a greater disgust response to the CS+ at extinction, compared to LCF individuals. Interestingly, these effects appeared to be independent, perhaps representing dissociable anticipatory and affective learning processes (Sevenster et al., 2012). Further, Experiment 2 found that disgust sensitivity was strongly correlated with conditioned disgust responding at extinction, and accounted for group differences in conditioned disgust responding. These findings were consistent with Experiment 1, providing additional evidence that disgust sensitivity contributes to certain anxiety disorders by causing newly acquired disgust responses to persist longer.

Experiment 3 sought to explore the effects of fear conditioning on attention in PTSD. In a manner similar to Experiment 2, the fear conditioning procedure did not have observable effects on attention, but it was able to reveal fear learning tendencies that distinguished veterans with PTSD from veterans without PTSD. Veterans with PTSD reported greater anxiety to the CS+ at both acquisition and extinction, as well as greater US expectancy at extinction. Also, PTSD symptom severity was related to greater conditioned anxiety through its relation to greater unconditioned fear responding. This research also showed that the relation between PTSD and greater unconditioned fear was mediated by anxiety sensitivity, an established vulnerability factor for PTSD.

94

Learning and attention in anxiety-related disorders

The null results in Experiments 2 and 3 may suggest that aversive learning does not have highly robust effects on attention and thus may not contribute significantly to attentional bias in anxiety-related disorders. Rather than arising out of learning experiences, attentional biases may be intrinsic to the diatheses for anxiety disorders. Indeed, there are several studies linking attentional bias for threat to temperamental risk factors (see Fox & Pine, 2012), as well as potential genetic vulnerabilities for affective disorders (see Pergamin-Hight, Bakermans-Kranenburg, van IJzendoorn, & Barh-Haim, 2012). In addition, pre-existing, threat-related attentional biases have been found to confer risk for PTSD (Beevers et al., 2011; Wald et al., 2011; Wald et al., 2013).

If attentional biases that characterize anxiety disorders do not arise through learning experiences, this does not necessarily imply that they are irrelevant to learning theories of anxiety. One possibility is that attentional biases influence the process of fear learning. Rather than being a consequence of pathological fear learning, attentional biases may instead play a role in causing pathological fear learning in disorders such as PTSD. The plausibility of this hypothesis is supported by basic fear conditioning research, which has shown that attention to the CS and the US is both a requisite for fear conditioning, as well as a moderator of the extent of fear conditioning, presumably because attention to these stimuli enhances learning of the CS-US contingency (Bouton, 2007).

Although there is a paucity of research on peri-traumatic attentional bias, the few studies examining attentional biases during exposure to chronic, potentially traumatic stress have yielded a consistent pattern of results. In both soldiers deployed to combat zones (Wald et a., 2013), as well as civilians living in war torn regions (Wald et al., 2011), the tendency to *avoid* attending to threat has been found to confer risk for subsequent PTSD. As a whole, this small body of research

95

suggests that while an attentional bias toward threat characterizes individuals at risk for PTSD prior to the stress of combat or impending deployment (Wald et al., 2013), during exposure to combat stress, an attentional bias toward threat is a normative response and perhaps a resilience factor. For example, Wald et al. (2013) found that attentional bias for threat moderated the interaction of serotonin transporter genotype and combat stress, such that individuals with low 5-HTT functionality exposed to high combat stress had fewer future PTSD symptoms if they exhibited an attentional bias towards threat during combat stress. Together, these findings may suggest that attending to threat during traumatic events leads to adaptive fear learning, whereas avoiding attending to threat during traumatic events leads to maladaptive fear learning. One possibility is that actively monitoring for danger, as reflected in an attentional bias for threat, leads individuals to notice which stimuli were meaningful precursors to a traumatic event, and which were not, leading to more discriminant conditioning. In contrast, individuals who are engaging in distraction during a traumatic event may fail to discriminate which stimuli were meaningful predictors of the event, leading to overgeneralized fear conditioning (Lissek, 2012). Accordingly, learning theories of anxiety-related disorders may benefit from examining how attentional tendencies shape contingency learning in different contexts.

Although greater learning of attentional bias in anxious individuals in Experiments 2 and 3 was not observed, it may be premature to conclude from these data that emotional learning processes do not play a role in the etiology of attentional bias. One reason this conclusion cannot be drawn is that neither experiment was able to demonstrate the basic effects of disgust or fear learning on attention, despite multiple reported replications of both phenomena (see Armstrong et al., 2013). Accordingly, it is unclear if these null findings reflect the procedural limitations of these experiments, or if they reflect a true absence of group differences in the learning of attentional biases for threat. In addition, Experiment 1 provided evidence that an attentional bias

for conditioned disgust sensitivity is learned more readily in individuals with elevated disgust

sensitivity, a potential vulnerability factor for several anxiety disorders (Olatunji et al., 2010), and

other research has found that an attentional bias for conditioned fear stimuli is learned more

readily in individuals with elevated trait anxiety (e.g., Lee et al., 2009; Notebaert et al., 2012; c.f.

Notebaert et al., 2011). Thus, more research is needed to determine the conditions under which

fear and disgust learning lead to attentional biases, as well as the conditions under which these

effects are moderated by vulnerability factors such as disgust sensitivity and trait anxiety. This

research would lay the foundation for longitudinal studies that could allow stronger inferences

about the acquisition and retention of attentional biases in anxiety-related disorders.

Pavlovian conditioning and stress-diathesis models of anxiety

A broader issue addressed by this dissertation research is the utility of Pavlovian aversive

conditioning as a paradigm for studying anxiety-related disorders. Stress-diathesis models of

anxiety-related disorders (e.g., Mineka & Zinbarg, 2006) often invoke Pavlovian conditioning;

however, traits that confer risk for anxiety disorders do not appear to be reliably linked to

excessive fear learning as revealed by classical conditioning paradigms (Davidson et al., 1964;

Fredrikson & Georgiades, 1992; Otto et al., 2007; Pineles et al., 2009; Torrents-Rodas et al.,

2013). Several authors (e.g., Beckers et al., 2012; Lissek & Grillon, 2006) have argued that, given

the adaptive nature of fear learning, relations between anxiety-related traits and excessive fear

learning may only emerge under alternative conditioning procedures in which the contingency

between a CS and the US is more ambiguous. However, this dissertation research suggests

another possible explanation for these null findings. Whereas Beckers and colleagues (2012), as

well as Lissek and Grillon (2006), have focused on shortcomings of fear conditioning procedures

used in clinical research, it may be the broad assessment of trait vulnerability that is responsible

for failures to observe relations with conditioned responding. Nearly all of the studies failing to

observe this relationship have focused on neuroticism (Pineles et al., 2009; Davidson et al., 1964; Fredrikson & Georgiades, 1992) or trait anxiety (Torrents-Rodas et al., 2013), which both reflect one's propensity to experience negative affect, a general vulnerability factor for mood and anxiety disorders. In contrast, Experiments 2 and 3 assessed more specific risk factors, that is, factors that confer risk for particular disorders above and beyond negative affect (e.g., Clark, Watson, & Mineka, 1994). In Experiment 2, *disgust sensitivity* was found to predict increased conditioned disgust responding in contamination-based OCD, and in Experiment 3, *anxiety sensitivity* was found to predict increased conditioned fear responding in PTSD. Both of these traits have been established as specific risk factors for the disorders in question: numerous studies have shown that disgust sensitivity predicts vulnerability to contamination-based OCD when covarying for negative affect (see Olatunji et al., 2010), and likewise, that anxiety sensitivity predicts vulnerability for PTSD when covarying for negative affect (e.g., Feldner et al., 2006). In the context of prior null findings, this dissertation research suggests that emotional learning tendencies implicated in anxiety disorders are contingent upon specific, rather than general, emotional traits.

This dissertation research may also reveal why trait specificity is important in predicting excessive aversive learning. Together, the present data suggest that specific emotional sensitivities are able to cause increased conditioned responding because they increase reactivity to certain classes of emotion-eliciting stimuli. In Experiment 1, mediational modeling suggested that disgust sensitivity was able to cause greater conditioned disgust responding, as revealed by eye movements, because it caused greater unconditioned disgust responding, as revealed by both eye movements and self-reported disgust. Likewise in Experiment 3, mediational modeling suggested that anxiety sensitivity was able to cause greater conditioned fear responding, as revealed by self-reported anxiety, because it caused greater unconditioned responding, as revealed by self-reported fear to the scream. To my knowledge, no prior studies have documented this distal effect of

emotional sensitivity on conditioned responding through unconditioned responding in anxiety-related disorders, and only one study has shown such an effect in an unselected sample (Olatunji et al., 2013). However, the proximal effects underlying these distal effects are well documented. First, the effects of anxiety sensitivity and disgust sensitivity on emotional reactivity to unconditioned fear (e.g., Holloway & McNally, 1987) and disgust stimuli (Olatunji et al., 2007), respectively, have been found to be highly robust. Indeed, such reactivity can be thought of as intrinsic to the definition of both constructs. Second, the effect of unconditioned responding on conditioned responding has also been found to be highly robust (e.g., Fitgerald & Teyler, 1970) and is codified in a basic law of Pavlovian conditioning: the stronger the UR, the stronger the CR (Bouton, 2007). Thus, the stress-diathesis model of associative learning in anxiety disorders that is suggested by this dissertation research is novel, yet supported in concept by a wealth of theory and research. This model is depicted in Figure XVII.
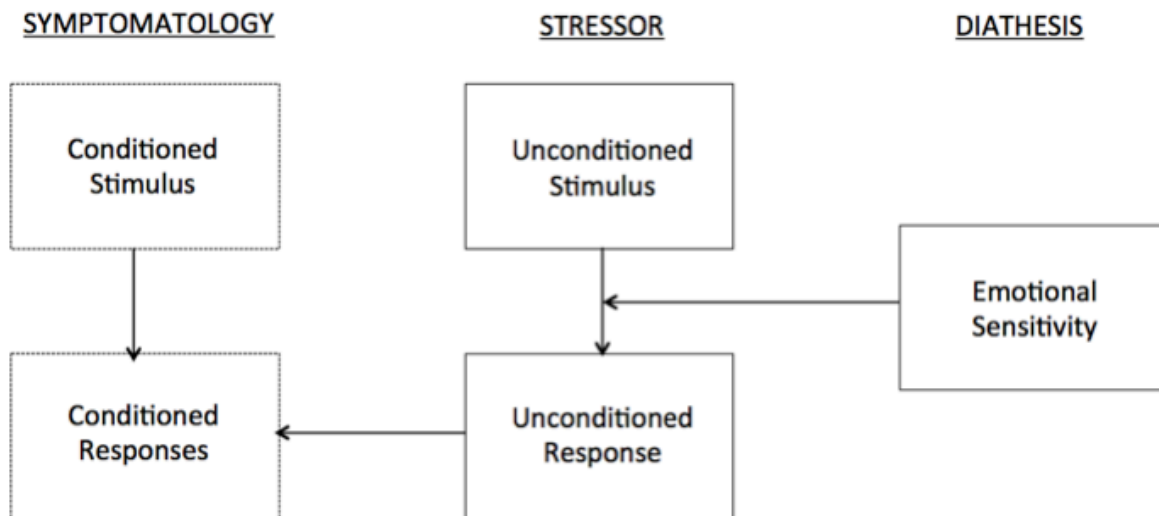

Figure XVII. Stress-diathesis model of associative learning in the etiology of anxiety-related disorders.

On this account, traits that cause increased sensitivity in specific forms of emotional responding act as diatheses for anxiety-related disorders by potentiating the effects of unconditioned aversive stimuli (e.g., traumatic stressors, invasive medical procedures, dog bites) on unconditioned emotional responding (e.g., fear, disgust), which in turn leads to stronger conditioned responses, which include anticipatory (e.g., anxiety) or evaluative (e.g., disgust) affective responses (Sevenster et al., 2011), as well as more distal forms of conditioned responding, such as attentional bias (Van Damme et al., 2006) or behavioral avoidance (Krypotos, Effting, Arnaudova, Klindt, & Beckers, 2014). All of these potentially conditioned responses are prominent features of the symptomatology of anxiety-related disorders (Mineka & Zinbarg, 2006).

Initially, this dissertation research hypothesized that more distal forms of conditioned responding would be a consequence of the conditioned emotional response. However, the present data did not provide a clear judgment on this hypothesis. Accordingly, the model in Figure XVII is preliminary, in that it does not specify relations between different forms of conditioned responding. The model is also preliminary in that it does not specify the types of learning that lead to excessive conditioned responding. In this dissertation research, all studies observed that excessive conditioned responding at extinction was related to trait diatheses. This excessive conditioned responding at extinction appeared to be related to increased excitatory learning at acquisition (e.g., Orr et al., 2001) in Experiment 3; however, Experiments 1 and 2 did not allow strong conclusions about the role of excitatory learning versus inhibitory learning in producing increased conditioned responding at extinction in individuals with elevated trait diatheses. Future research with more sophisticated integrations of attentional assessment (Mulckhuyse et al., 2013), as well as more sophisticated conditioning paradigms (e.g., Boddez et al., 2012) will be necessary to elaborate upon this general model.

Clinical implications

In addition to having implications for conceptualizing anxiety-related disorders, this work may also have implications for treatment. The findings that disgust and anxiety sensitivity lead to heightened aversive learning in contamination-based OCD and PTSD, respectively, suggest that preventative treatment for anxiety disorders could include targeting specific emotional sensitivities. Although both disgust sensitivity and anxiety sensitivity are stable individual differences, both traits exhibit plasticity in response to cognitive-behavioral treatments (Smits, Berry, Tart, & Powers, 2008; Olatunji et al., 2011). Indeed, a treatment referred to as "Anxiety Sensitivity Education and Reduction Training" has been shown to provide lasting attenuation of anxiety sensitivity (Schmidt et al., 2007; Keough & Schmidt, 2012). The present findings suggest that similar treatments that target specific emotional sensitivities could be applied proactively in order to prevent the learning of excessive disgust and fear responses that may play a role in the etiology of OCD and PTSD (e.g., Feldner et al., 2006; Schmidt et al., 2007). Such preventative treatment is particularly relevant to PTSD, because there are large groups of individuals (e.g., police cadets, military personnel) at risk for trauma exposure that can easily be identified. However, in the case of OCD and other anxiety disorders without a specific etiology, it may still be possible to identify individuals at risk for these disorders by considering family history or levels of emotional sensitivity as revealed by self-report measures.

Limitations and future directions

The present findings shed new light on the relations between emotional sensitivities, emotional reactivity, and aversive learning in anxiety-related disorders. However, future research is needed to address limitations of the present studies and thereby clarify the implications of the present findings. One limitation of the present research is that it cannot make strong inferences about the role of emotional sensitivities and learning processes in the etiology of anxiety-related

101

disorders, because each study was cross-sectional. This limitation could be addressed by assessing emotional sensitivities and learning tendencies, and then determining how these factors predict the subsequent development of anxiety-related disorders, through longitudinal or prospective research (e.g., Lommen et al., 2013). In examining these effects longitudinally, it would be useful to incorporate an experimental condition in which emotional sensitivity was reduced through targeted treatment (e.g., Schmidt et al., 2007). This experimental condition would allow stronger inferences about the causal role of emotional sensitivities, such as anxiety and disgust sensitivity, in potentiating emotional learning and thereby contributing to anxiety-related disorders.

Another limitation to the present research is that Experiments 2 and 3 each assessed only one type of emotional learning. Future research is needed to determine the role that specific emotional learning abnormalities play in contamination-based OCD and PTSD. One study has found impaired fear extinction learning in patients with OCD versus controls, as revealed by skin conductance (Milad et al., 2013); however, symptom severity was correlated with *enhanced* fear extinction learning in patients with OCD, suggesting that impairments in fear extinction learning are not closely related to OCD symptomatology. Whereas one would predict that contamination-based OCD primarily involves disgust learning abnormalities, PTSD may be predicted to involve learning abnormalities involving both emotions, as PTSD is characterized by peritraumatic disgust in addition to fear, and both peritraumatic emotions have been found to independently predict subsequent PTSD symptoms (Engelhardt, Olatunji, & de Jong, 2011). In addition, Badour and colleagues (2013) have found that PTSD severity is associated with disgust elicited by an idiographic trauma script, which these authors conceptualized as a "conditioned" disgust response. Accordingly, future research is needed to determine the extent to which disgust conditioning is relevant to the etiology of PTSD. One possibility hinted at by the research of Badour and colleagues (2013) is that disgust conditioning is particularly relevant to sexual trauma-related

102

PTSD, as survivors of sexual assault often report feeling contaminated as a feature of their PTSD. Further research is needed to determine how the relationship between disgust sensitivity and PTSD varies according to trauma type. Despite these limitations, this dissertation research provides new insight into the role of specific emotional sensitivities in potentiating emotional learning in contamination-based OCD and PTSD, and also provides insight into basic effects of disgust conditioning on attention.

REFERENCES

Algom, D., Chajut, E., & Lev, S. (2004). A rational look at the emotional Stroop

    phenomenon: A generic slowdown, not a Stroop effect. *Journal of Experimental*

    Psychology: General, 133, 323–338.

American Psychiatric Association. (2000). *Diagnostic and statistical manual of mental*

    disorders (Revised 4th ed.). Washington, DC: Author.

American Psychiatric Association. (2013). *Diagnostic and statistical manual of mental*

    disorders (5th ed.). Washington, DC: Author.

Amir, N., Beard, C., Burns, M., & Bomyea, J. (2009). Attention modification program

    in individuals with Generalized Anxiety Disorder. *Journal of Abnormal Psychology, 188,*

    28-33.

Armstrong, T., Bilsky, S. A., Zhao, M., & Olatunji, B. O. (2013). Dwelling on potential threat

    cues: an eye movement marker for combat-related PTSD. *Depression and Anxiety,*

    30, 497-502.

Armstrong, T., McClenahan, L., Kittle, J., & Olatunji, B. O. (2013). Don't look now!

    Oculomotor avoidance as a conditioned disgust response. *Emotion, 14,* 95-104.

Armstrong, T., & Olatunji, B. (2009). PTSD in the media: a critical analysis of the portrayal of

    controversial issues. *Scientific Review of Mental Health Practice*, *7*.

Armstrong, T., & Olatunji, B. O. (2012). Eye tracking of attention in the affective disorders: A

    meta-analytic review and synthesis. *Clinical Psychology Review, 32,* 704-72.

Armstrong, T., Olatunji, B. O., Sarawgi, S., & Simmons, C. (2010). Orienting and maintenance

    of gaze in contamination fear: Biases for disgust and fear cues. *Behaviour Research*

    and Therapy, 48, 402-408.

Armstrong, T., Sarawgi, S., & Olatunji, B. O. (2012). Attentional bias toward threat in

    contamination fear: Overt components and behavioral correlates. *Journal of Abnormal*

    Psychology, 121, 232-237.

Badour, C. L., Feldner, M. T., Blumenthal, H., & Knapp, A. (2013). Preliminary evidence for a

    unique role of disgust-based conditioning in posttraumatic stress. *Journal of*

    Traumatic Stress, *26*, 280-287.

Bannerman, R. L., Milders, M. V. & Sahraie, A. (2010). Attentional Bias to Brief

    Threat-Related Faces Revealed by Saccadic Eye Movements. *Emotion*, 10, 733-738.

Bannerman, R.L., Milders, M. & Sahraie, A. (2010). Attentional Cueing: Fearful bodies capture

    attention with saccades. *Journal of Vision, 23,* 1-14.

Bannerman, R.L., Milders, M., de Gelder, B., Sahraie, A. (2009) Orienting to threat: faster

    localization of fearful facial expressions and body postures revealed by saccadic eye

    movements. *Proceedings of the Royal Society B: Biological Sciences, 276,* 1635-41.

Bannerman, R.L., Milders, M. & Sahraie, A. (2009). Processing emotional stimuli: Comparison

    of saccadic and manual choice-reaction times. *Cognition and Emotion,* 23, 930-954.

Bar-Haim, Y., Lamy, D., Pergamin, L., Bakermans-Kranenburg, M. J., & van IJzendoorn, M. H.

    (2007). Threat-related attentional bias in anxious and non-anxious individuals: A meta-

    analytic study. *Psychological Bulletin, 133,* 1-24.

Barrett, H. C., & Kurzban, R. (2006). Modularity in cognition: Framing the debate. *Psychological*

    Review, 113, 628-647.

Beatty, J., & Lucero-Wagoner, B. (2000). The pupillary system. *Handbook of Pychophysiology*,

    2, 142-162.

Beckers, T., Krypotos, A. M., Boddez, Y., Effting, M., & Kindt, M. (2013). What's wrong with fear conditioning?. *Biological psychology*, *92*, 90-96.

Beevers, C. G., Lee, H. J., Wells, T. T., Ellis, A. J., & Telch, M. J. (2011). Association of predeployment gaze bias for emotion stimuli with later symptoms of PTSD and depression in soldiers deployed in Iraq. *American Journal of Psychiatry*, *168*, 735-741.

Blanchard, E. B., Jones-Alexander, J., Buckley, T. C., Foneris, C. A. (1996). Psychometric properties of the PTSD checklist (PCL). *Behaviour Research and Therapy, 34,* 669–673.

Bradley, M. M., Miccoli, L., Escrig, M. A., & Lang, P. J. (2008). The pupil as a measure of emotional arousal and autonomic activation. *Psychophysiology*, *45*, 602-607.

Boddez, Y., Baeyens, F., Hermans, D., & Beckers, T. (2013). Reappraisal of threat value: Loss of blocking in human aversive conditioning. *The Spanish Journal of Psychology*, *16*, E84.

Bouton, M. E. (2007). *Learning and behavior: A contemporary synthesis.* Sunderland, MA: Sinaue.

Brainard, D. H. (1997). The psychophysics toolbox. *Spatial vision*, *10*, 433-436.

Brewin, C. R., & Holmes, E. A. (2003). Psychological theories of posttraumatic stress disorder. *Clinical psychology review*, *23*(3), 339-376.

Burish, T.G., & Carey, MP. (1986). Conditioned aversive responses in cancer chemotherapy patients: Theoretical and developmental analysis. *Journal of Consulting and Clinical Psychology, 54,* 593-600.

Burns, G. L., Formea, G. M., Keortge, S., & Sternberger, L. G. (1995). The utilization of

    nonpatient samples in the study of obsessive compulsive disorder. *Behaviour Research and*

    Therapy, 33, 133-144.

Burns, G. L., Keortge, S. G., Formea, G. M., & Sternberger, L. G. (1996). Revision of the Padua

    Inventory of obsessive compulsive disorder symptoms: distinctions between worry,

    obsessions, and compulsions. *Behaviour Research and Therapy, 34,* 163-173.

Campbell, D. & Fiske, D. (1959). Convergent and discriminant validation by the multitrait-

    multimethod matrix. *Psychological Bulletin, 56,* 81-105.

Charash, M., & McKay, D. (2002). Attention bias for disgust. *Journal of Anxiety Disorders, 16,*

    529-541.

Cisler, J. M., & Koster, E. H. W. (2010). Mechanisms of attentional biases towards threat in

    anxiety disorders: An integrative review. *Clinical Psychology Review, 30*, 203-216.

Cisler, J. M., Wolitzky-Taylor, K. B., Adams, T. G., Babson, K. A., Badour, C. L., &

    Willems, J. L. (2011). The emotional Stroop task and posttraumatic stress disorder: a meta-

    analysis. *Clinical Psychology Review, 31,* 817-828.

Clark, L. A., & Watson, D. (1991). Tripartite model of anxiety and depression: psychometric

    evidence and taxonomic implications. *Journal of Abnormal Psychology, 100,* 316.

Cornelissen, F. W., Peters, E. M., & Palmer, J. (2002). The Eyelink Toolbox: eye tracking with

    MATLAB and the Psychophysics Toolbox. *Behavior Research Methods, Instruments, &*

    Computers, *34*, 613-617.

Cougle, J. R., Resnick, H., & Kilpatrick, D. G. (2009). A prospective examination of PTSD

    symptoms as risk factors for subsequent exposure to potentially traumatic events among

    women. *Journal of Abnormal Psychology*, *118*, 405.

Craske, M. G., Kircanski, K., Zelikowsky, M., Mystkowski, J., Chowdhury, N., & Baker, A. (2008). Optimizing inhibitory learning during exposure therapy. *Behaviour research and therapy, 46,* 5-27.

Davis, M., Falls, W. A., & Gewirtz, J. (2000). Neural systems involved in fear inhibition: extinction and conditioned inhibition. In M. Myslobodsky & I. Weiner (Eds.), *Contemporary issues in modeling psychopathology* (pp. 113–142).

De Houwer, J., Teige-Mocigemba, S., Spruyt, A., & Moors, A. (2009). Implicit measures: A normative analysis and review. *Psychological Bulletin, 135*, 347-368.

Derryberry, D., & Reed, M.A. (2002). Anxiety-related attentional biases and their regulation by attentional control. *Journal of Abnormal Psychology, 2,* 225–23.

Di Nardo, P. A., Guzy, L. T., Jenkins, J. A., Bak, R. M., Tomasi, S. F., & Copland, M. (1988). Etiology and maintenance of dog fears. *Behaviour Research and Therapy, 26,* 241−24

Dohrenwend, B. P., Turner, J. B., Turse, N. A., Adams, B. G., Koenen, K. C., & Marshall, R. (2006). The psychological risks of Vietnam for US veterans: a revisit with new data and methods. *Science*, *313*, 979-982.

Engelhard, I. M., Leer, A., Lange, E., & Olatunji, B. O. (in press). Shaking that icky feeling: Effects of Extinction and Counterconditioning on Disgust-related Evaluative Learning. *Behavior Therapy.*

Fani, N., Tone, E. B., Phifer, J., Norrholm, S. D., Bradley, B., Ressler, et al. (2012). Attention bias toward threat is associated with exaggerated fear expression and impaired extinction in PTSD. *Psychological medicine, 42,* 533.

Feldner, M. T., Lewis, S. F., Leen-Feldner, E. W., Schnurr, P. P., & Zvolensky, M. J. (2006). Anxiety sensitivity as a moderator of the relation between trauma exposure frequency and posttraumatic stress symptomatology. *Journal of Cognitive Psychotherapy*, *20*, 201-213.

First, M. B., Spitzer, R. L., Gibbon, M., & Williams, J. B. W. (1997). *User's guide for the Structured Clinical Interview for DSM–IV Axis I Disorders.* Washington, DC: American Psychiatric Press.

Fischer, B. & Weber, H. (1993). Express saccades and visual attention. *Behavioral and Brain Sciences, 16,* 553-610.

Flanagan, J. (1948). The Aviation Psychology Program in the Army Air Forces. *USAAF Aviation Psychology Research Report No. 1*. Washington, DC: US Government Printing Office.

Foa, E. B., Huppert, J. D., Leiberg, S., Langner, R., Kichic, R., Hajcak, G., et al. (2002). The Obsessive–Compulsive Inventory: Development and validation of a short version. *Psychological Assessment, 14,* 485–496.

Foa, E. B. & Kozak, M. J. (1986). Emotional processing of fear: Exposure to corrective information. *Psychological Bulletin, 99,* 20—35.

Forsyth, J. P., & Eifert, G. H. (1998). Response intensity in content-specific fear conditioning comparing 20% versus 13% CO_2-enriched air as unconditioned stimuli. *Journal of Abnormal Psychology, 107*, 291-304.

Fox, N. A., & Pine, D. S. (2012). Temperament and the emergence of anxiety disorders. *Journal Of The American Academy of Child And Adolescent Psychiatry*, *51*, 125.

Garner, M., Mogg, K. & Bradley, B. P. (2006). Orienting and maintenance of gaze to facial expressions in social anxiety. *Journal of Abnormal Psychology, 115,* 760-770.

Gibbs, N. A. (1996). Nonclinical populations in research on obsessive-compulsive disorder: A

   critical review. *Clinical Psychology Review, 16*, 729-773.

Granholm, E., Asarnow, R. F., Sarkin, A. J., & Dykes, K. L. (1996). Pupillary responses

   index cognitive resource limitations. *Psychophysiology, 33,* 457–461.

Grillon, C. (2002). Startle reactivity and anxiety disorders: aversive conditioning, context,

   and neurobiology. *Biological psychiatry*, *52*, 958-975.

Haidt, J., McCauley, C., & Rozin, P. (1994) . Individual differences in sensitivity to

   disgust: A scale sampling seven domains of disgust elicitors. *Personality and Individual*

   Differences, 16, 701-713.

Hakamata, Y., Lissek, S., Bar-Haim, Y., Britton, J. C., Fox, N. A., Leibenluft, E. et

   al. (2010). Attention bias modification treatment: A meta-analysis toward the

   establishment of novel treatment for anxiety. *Biological Psychiatry, 68,* 982-990.

Hellström, K., Fellenius, J., & Öst, L. (1996). One versus five sessions of applied tension in the

   treatment of blood phobia. *Behaviour Research and Therapy, 34*, 101-112.

Hermans, D., Crombez, G., Vansteenwegen, D., Baeyens, F., & Eelen, P. (2002). Expectancy-

   learning and evaluative learning in human classical conditioning: Differential effects of

   extinction. In S. P. Shohov, *Advances In Psychology Research* (pp. 17-40). Hauppauge,

   NY: Nova Science Publishers.

Hütter, M., & Sweldens, S. (2013). Implicit misattribution of evaluative responses:

   Contingency-unaware evaluative conditioning requires simultaneous stimulus

   presentations. *Journal of Experimental Psychology: General, 142,* 638-643.

Indovina, I., Robbins, T., Nunez-Elizalde, A., Dunn, B., Bishop, S.J. (2011) Fear-

   Conditioning Mechanisms Associated with Trait Vulnerability to Anxiety. *Neuron 69,*

   563-571.

Jones, C. R., Vilensky, M. R., Vasey, M. W., & Fazio, R. H. (2013). Approach behavior can mitigate predominately univalent negative attitudes: Evidence regarding insects and spiders. *Emotion, 13,* 989.

Keane, T., Fairbank, J., Caddell, J., Zimering, R., Taylor, K., & Mora, C. (1989). Clinical evaluation of a measure to assess combat exposure. *Psychological Assessment: A Journal of Consulting and Clinical Psychology, 1,* 53–55.

Keane, T. M., Zimering, R. T., & Caddell, J. M. (1985). A behavioral formulation of posttraumatic stress disorder in Vietnam veterans. *The Behavior Therapist*. *8,* 9-12.

Kelly, M. M., & Forsyth, J. P. (2007). Observational fear conditioning in the acquisition and extinction of attentional bias for threat: An experimental evaluation. *Emotion, 7*, 324-335.

Keogh, E., Ayers, S., & Francis, H. (2002). Does anxiety sensitivity predict post-traumatic stress symptoms following childbirth? A preliminary report. *Cognitive Behaviour Therapy*, *31*, 145-155.

Keough, M. E., & Schmidt, N. B. (2012). Refinement of a brief anxiety sensitivity reduction intervention. *Journal of Consulting and Clinical Psychology*, *80*, 766.

Kessler, R. C., Berglund, P., Demler, O., Jin, R., & Walters, E. E. (2005). Lifetime prevalence and age-of-onset distributions of DSM-IV disorders in the National Comorbidity Survey Replication. *Archives of General Psychiatry,* 62, 593-60.

Kılıç, E. Z., Kılıç, C., & Yılmaz, S. (2008). Is anxiety sensitivity a predictor of PTSD in children and adolescents? *Journal of Psychosomatic Research*, *65*, 81-86.

Kimble, M.O., Fleming, K., Bandy, C., Kim, J., & Zambetti, A. (2010). Eye tracking and visual attention to threating stimuli in veterans of the Iraq War. *Journal of Anxiety Disorders, 24,* 293-299.

Klumpp, H. & Amir, H. (2010) Preliminary Study of Attention Training to Threat and

  Neutral Faces on Anxious Reactivity to a Social Stressor in Social Anxiety. *Cognitive*

  Therapy and Research, 34, 263-271.

Konnopka, A., Leichsenring, F., Leibing, E., & König, H.-H. (2009). Cost-of-illness

  studies and cost-effectiveness analyses in anxiety disorders: A systematic review. *Journal*

  of Affective Disorders, 114, 14–31.

Krusemark, E. & Li, W. (2011). Do all threats work the same way? Divergent effects of

  fear and disgust on sensory perception and attention. *Journal of Neuroscience,*

  31, 3429-34.

Lang, P.J., Bradley, M.M., & Cuthbert, B.N. (2008*). International affective picture*

  system (IAPS): Affective ratings of pictures and instruction manual. Technical Report A-8.

  University of Florida, Gainesville, FL.

Lang, P. J., Davis, M., & Öhman, A. (2000). Fear and anxiety: Animal models and human

  cognitive psychophysiology. *Journal of Affective Disorders*, *61*, 137-159.

Lee, T., Lim, S., Lee, K., Kim, H., & Choi, J. (2009). Conditioning-induced attentional bias for

  face stimuli measured with the emotional stroop task. *Emotion, 9*, 134-139.

LeDoux, J. E., Cicchetti, P., Xagoraris, A., & Romanski, L. M. (1990). The lateral amygdaloid

  nucleus: sensory interface of the amygdala in fear conditioning. *The Journal of*

  Neuroscience, 10, 1062-1069.

Lishner, D. A., Cooter, A. B., & Zald, D. H. (2008). Addressing measurement limitations in

  affective rating scales: Development of an empirical valence scale. *Cognition and*

  Emotion, 22, 180-192.

Lissek, S. (2012). Toward an account of clinical anxiety predicated on basic, neurally mapped

mechanisms of pavlovian fear-learning: the case for conditioned overgeneralization.

Depression and Anxiety, 29, 257-263.

Lissek, S., Biggs, A. L., Rabin, S. J., Cornwell, B. R., Alvarez, R. P., Pine, D. S., & Grillon, C.

(2008). Generalization of conditioned fear potentiated startle in humans: Experimental

validation and clinical relevance. *Behaviour Research and Therapy, 46,* 678–687.

Lissek, S., & Grillon, C. (2012). Learning models of PTSD. In *The Oxford Handbook of

Traumatic Stress Disorders*. J.G. Beck & D. M. Sloan (Eds.) Oxford University Press.

Lissek, S., Pine, D. S., & Grillon, C. (2006). The "strong situation": A potential impediment to

studying the psychobiology and pharmacology of anxiety disorders. *Biological psychology,

72,* 265-270.

Lissek S., Powers, A. S., McClure, E. B., Phelps, E. A., Woldehawariat, G., Grillon, C., Pine, D.

S. (2005). Classical fear conditioning in the anxiety disorders: a meta-analysis. *Behaviour

Research and Therapy 43,* 1391–1424.

Lissek, S., Rabin, S. J., McDowell, D. J., Dvir, S., Bradford, D. E., et al. (2009). Impaired

discriminative fear-conditioning resulting from elevated fear responding to learned safety

cues among individuals with panic disorder. *Behaviour Research and Therapy 47,*

111–118.

Lissek, S., Rabin, S.J., Heller, R.E., Luckenbaugh, D., Geraci, M., Pine, D.S., & Grillon, C.

(2010). Overgeneralization of conditioned fear as a pathogenic marker of panic disorder.

American Journal of Psychiatry, 167, 47-55.

Lommen, M. J., Engelhard, I. M., Sijbrandij, M., van den Hout, M. A., & Hermans, D. (2013). Pre-trauma individual differences in extinction learning predict posttraumatic stress. *Behaviour research and therapy, 51,* 63-67.

Lundqvist, D., Flykt, A., & Öhman, A. (1998). *The Karolinska Directed Emotional Faces-KDEF.* CD-ROM from Department of Clinical Neuroscience, Psychology section, Karolinska Institutet, Stockholm, Sweden. ISBN 91–630–7164–9.

Mackintosh, N. J. (1983). *Conditioning and Associative Learning*. Oxford, UK: Clarendon Press.

MacLeod, C., Rutherford, E., Campbell, L., Ebsworthy, G., & Holker, L. (2002). Selective attention and emotional vulnerability: Assessing the causal basis of their association through the experimental manipulation of attentional bias. *Journal of Abnormal Psychology, 111,* 107-123.

Marshall, G. N., Miles, J. N., & Stewart, S. H. (2010). Anxiety sensitivity and PTSD symptom severity are reciprocally related: evidence from a longitudinal study of physical trauma survivors. *Journal of Abnormal Psychology*, *119*, 143.

Mason, E. C. & Richardson, R. (2010). Looking beyond fear: The extinction of other emotions implicated in anxiety disorders. *Journal of Anxiety Disorders, 24*, 63-70.

Matchett, G., & Davey, G. C. (1991). A test of a disease-avoidance model of animal phobias. *Behaviour Research and Therapy, 29*, 91-94.

McManus, F., Grey, N. and Shafran, R. (2008). Cognitive therapy for anxiety disorders: current status and future directions. *Behavioural and Cognitive Psychotherapy, 36,* 695-704.

Milad, M. R., Furtak, S. C., Greenberg, J. L., Keshaviah, A., Im, J. J., Falkenstein, M. J., et al. (2013). Deficits in conditioned fear extinction in obsessive-compulsive disorder and neurobiological changes in the fear circuit. *JAMA Psychiatry*, *70*, 608-618.

Milad, M. R., Pitman, R. K., Ellis, C. B., Gold, A. L., Shin, L. M., Lasko, N. B., et al. (2009). Neurobiological basis of failure to recall extinction memory in posttraumatic stress disorder. *Biological Psychiatry*, *66*, 1075-1082.

Mineka, S., & Zinbarg, R. (2006). A contemporary learning theory perspective on the etiology of anxiety disorders: It's not what you thought it was. *American Psychologist*, 61, 10-26.

Mogg, K., Bradley, B. P., Miles, F., & Dixon, R. (2004). Time course of attentional bias for threat scenes: Testing the vigilance-avoidance hypothesis. *Cognition and Emotion, 18*, 689-700.

Mogg, K., Garner, M., & Bradley, B.P. (2007). Anxiety and orienting of gaze to angry and fearful faces. *Biological Psychology, 76,* 163-169.

Mogg, K., Mathews, A., & Weinman, J. (1987). Memory bias in clinical anxiety. *Journal of Abnormal Psychology, 96*, 94-98.

Mulckhuyse, M., Crombez, G., & Van der Stigchel, S. (2013). Conditioned fear modulates visual selection. *Emotion*, *13*, 529.

Myers, K.M., & Davis, M. (2007). Mechanisms of fear extinction. *Molecular Psychiatry, 12,* 120–150.

Najmi, S., & Amir, N. (2010). The effect of attention training on a behavioral test of contamination fears in individuals with subclinical obsessive-compulsive symptoms. *Journal of Abnormal Psychology, 119*, 136-142.

Naragon-Gainey, K. (2010). Meta-analysis of the relations of anxiety sensitivity to the depressive and anxiety disorders. *Psychological bulletin*, *136*, 128.

Nelson, R. A., & Palmer, S. E. (2007). Familiar shapes attract attention in figure-ground displays. *Perception & Psychophysics, 69,* 382-392.

Neumann, D. L., & Waters, A. M. (2006). The use of an unpleasant sound as an

unconditional stimulus in a human aversive Pavlovian conditioning procedure. *Biological Psychology, 73,* 175-185.

Notebaert, L., Crombez, G., Van Damme, S., De Houwer, J., & Theeuwes, J. (2011). Signals of

threat do not capture, but prioritize, attention: a conditioning aproach. *Emotion*, *11*, 81-89.

Oaten, M., Stevenson, R. J., & Case, T. I. (2009). Disgust as a disease-avoidance mechanism.

Psychological Bulletin, 135, 303-321.

Olatunji, B. O., Armstrong, T., McHugo, M., & Zald, D. H. (2013). Heightened attentional

capture by threat in veterans with PTSD. *Journal of Abnormal Psychology*, *122*, 397.

Olatunji, B. O., Cisler, J. M., McKay, D., & Phillips, M. (2010). Is disgust associated with

psychopathology? Emerging research in the anxiety disorders. *Psychiatry Research, 175,* 1-10.

Olatunji, B. O., Cisler, J. M., & Tolin, D. T. (2007). Quality of life in the anxiety

disorders: A meta-analytic review. *Clinical Psychology Review, 27,* 572-581.

Olatunji, B. O., Forsyth, J. P., & Cherian, A. (2007). Evaluative conditioning of disgust:

sticky form of relational learning that is resistant to extinction. *Journal of Anxiety Disorders, 21,* 820-834.

Olatunji, B. O., Lohr, J. M., Sawchuk, C. N., & Tolin, D. F. (2007). Multimodal assessment of

disgust in contamination-related obsessive–compulsive disorder. *Behaviour Research and Therapy, 45,* 263–276.

Olatunji, B. O., Lohr, J. M., Sawchuk, C. N., & Westendorf, D. H. (2005). Using facial

> expressions as CSs and fearsome and disgusting pictures as UCSs: Affective responding

> and evaluative learning of fear and disgust in blood-injection-injury phobia. *Journal of*

> *Anxiety Disorders, 19,* 539-555.

Olatunji, B. O., Lohr, J. M., Smits, J. A., Sawchuk, C. N., & Patten, K. (2009). Evaluative

> conditioning of fear and disgust in blood-injection-injury phobia: Specificity and impact

> of individual differences in disgust sensitivity. *Journal of Anxiety Disorders, 23,*153-159.

Olatunji, B. O., Tart, C. D., Ciesielski, B. G., McGrath, P. B., & Smits, J. A. (2011). Specificity of

> disgust vulnerability in the distinction and treatment of OCD. *Journal of Psychiatric*

> *Research*, *45*, 1236-1242.

Olatunji, B. O., Tomarken, A., & Puncochar, B. D. (2013). Disgust propensity potentiates

> evaluative learning of aversion. *Emotion*, *13*, 881.

Olatunji, B. O., Williams, N. L., Tolin, D. F., Sawchuk, C. N., Abramowitz, J. S., Lohr, J. M., et

> al. (2007). The Disgust Scale: Item analysis, factor structure, and suggestions for

> refinement. *Psychological Assessment, 19,* 281-297.

Olatunji, B. O., & Wolitzky-Taylor, K. B. (2009). Anxiety sensitivity and the anxiety disorders: a

> meta-analytic review and synthesis. *Psychological Bulletin*, *135*, 974.

Orcutt, H. K., Erickson, D. J., & Wolfe, J. (2002). A prospective analysis of trauma exposure:

> The mediating role of PTSD symptomatology. *Journal of Traumatic Stress*, *15*, 259-

> 266.

Orr, S. P., Metzger, L. J., Lasko, N. B., Macklin, M. L., Peri, T., & Pitman, R. K. (2000). De

> novo conditioning in trauma-exposed individuals with and without posttraumatic stress

> disorder. *Journal of Abnormal Psychology, 109,* 290–298.

Orsillo, S. M. (2001). Measures for acute stress disorder and posttraumatic stress disorder. In *Practitioner's Guide To Empirically Based Measures Of Anxiety* (pp. 255-307). Springer US.

Pavlov, I. (1927). *Conditioned reflexes*. London: Oxford University Press.

Peri, T., Ben Shakhar, G., Orr, S. P., & Shalev, A. Y. (2000). Psychophysiologic assessment of aversive conditioning in postraumatic stress disorder. *Biological Psychiatry, 47,* 512–519.

Pergamin-Hight, L., Bakermans-Kranenburg, M. J., van IJzendoorn, M. H., & Bar-Haim, Y. (2012). Variations in the promoter region of the serotonin transporter gene and biased attention for emotional information: a meta-analysis. *Biological Psychiatry*, *71*, 373-379.

Pineles, S. L., Shipherd, J. C., Welch, L. P., & Yovel, I. (2007). The role of attentional biases in PTSD: Is it interference or facilitation? *Behaviour Research and Therapy, 45*, 1903-1913.

Pineles, S. L., Shipherd, J. C., Mostoufi, S. M., Abramovitz, S. M., & Yovel, I. (2009). Attentional biases in PTSD: More evidence for interference. *Behaviour Research and Therapy, 47,* 1050-1057.

Pischek-Simpsona, L. K., Boschen, M. J., Neumanna, D. L., & Waters, A. M. (2009). The development of an attentional bias for angry faces following Pavlovian fear. conditioning. *Behaviour Research & Therapy, 27,* 322-330.

Preacher, K. J., & Hayes, A. F. (2008). Asymptotic and resampling strategies for assessing and comparing indirect effects in multiple mediator models. *Behavior Research Methods, 40*, 879-891.

Preacher, K. J., Rucker, D. D., MacCallum, R. C., & Nicewander, W. A. (2005). Use of the extreme groups approach: a critical reexamination and new commendations. *Psychological methods*, *10*, 178.

Rachman, S. (1991). Neo-conditioningand the classical theory of fear acquisition. *Clinical Psychology Review, 11,* 155–173.

Rachman, S. (2004). Fear of contamination. *Behavior Research and Therapy, 42,* 1227–1255.

Rasmussen, S. A. & Eisen, J. L. (1992). The epidemiology and clinical features of obsessive-compulsive disorder. *Psychiatric Clinics of North America, 15,* 743-758.

Reinhard, G., Lachnit, H., & König, S. (2006). Tracking stimulus processing in Pavlovian pupillary conditioning. *Psychophysiology*, *43*, 73-83.

Rinck, M., & Becker, E. S. (2006). Spider fearful individuals attend to threat, then quickly avoid it: Evidence from eye movements. *Journal of Abnormal Psychology, 115*, 231-238.

Roseman, I. J., Spindel, M. S., & Jose, P. E. (1990). Appraisals of emotion-eliciting events: Testing a theory of discrete emotions. *Journal of Personality and Social Psychology, 59,* 899-915.

Rosen, G. M., & Lilienfeld, S. O. (2008). Posttraumatic stress disorder: An empirical evaluation of core assumptions. *Clinical Psychology Review, 28,* 837-868.

Royzman, E. B., Sabini, J. (2001). Something it takes to be an emotion: The interesting case of disgust. *Journal for the Theory of Social Behavior, 31,* 29–59.

Rozin, P., & Fallon, A. E. (1987). A perspective on disgust. *Psychological Review, 94,* 23–41.

Rozin, P., & Nemeroff, C. (1990). The laws of sympathetic magic: A psychological analysis of similarity and contagion. In J. W. Stigler, R. A. Shweder, & G. Herdt (Eds.), *Cultural psychology: Essays on comparative human judgment* (pp. 205–232). Cambridge, United Kingdom: Cambridge University Press.

Schienle, A., Stark, R., & Vaitl, D. (2001). Evaluative conditioning: A possible explanation for the acquisition of disgust responses? *Learning and Motivation, 32,* 65-83.

Schmidt, N. B., Eggleston, A. M., Woolaway-Bickel, K., Fitzpatrick, K. K., Vasey, M. W., & Richey, J. A. (2007). Anxiety Sensitivity Amelioration Training (ASAT): A longitudinal primary prevention program targeting cognitive vulnerability. *Journal of Anxiety Disorders, 21*, 302-319.

Schmidt, N.B., Richey, J.A., Buckner, J.D., & Timpano, K.R. (2009). Attention training for generalized social anxiety disorder. *Journal of Abnormal Psychology, 118,* 5-14.

Sevenster, D, Beckers, T, & Kind, M. (2012). Instructed extinction differentially affects the emotional and cognitive expression of associative fear memory. *Psychophysiology, 49,* 1426-1435.

Sheehan, D. V., Lecrubier, Y., Sheehan, K. H., Amorim, P., Janavs, J., Weiller, E. et al. (1998). The Mini-International Neuropsychiatric Interview MINI: The development and validation of a structured diagnostic psychiatric interview for DSM-IV and ICD-10. *Journal of Clinical Psychiatry, 59,* 22–33.

Siegle, G. J., Granholm, E., Ingram, R. E., & Matt, G. E. (2001). Pupillary and reaction time measures of sustained processing of negative information in depression. *Biological Psychiatry, 49*, 624-636.

Smith, T. C., Wingard, D. L., Ryan, M. A. K., Kritz-Silverstein, D., Slymen, D. J., Sallis, J. F., et al. (2008). Prior assault and posttraumatic stress disorder after combat deployment. *Epidemiology, 19,* 505-512

Smits, J. A., Berry, A. C., Tart, C. D., & Powers, M. B. (2008). The efficacy of cognitive-behavioral interventions for reducing anxiety sensitivity: A meta-analytic review. *Behaviour Research and Therapy*, *46*, 1047-1054.

Spielberger, C. D., Gorsuch, R. L., Lushene, R.,Vagg, P. R., & Jacobs, G. A. (1983). *Manual for the state trait anxiety inventory (form y): Self evaluation questionnaire*. Palo Alto, CA: Consulting Psychologists Press

Summerfeldt, L. J., & Endler, N. S. (1998). Examining the evidence for anxiety related cognitive biases in obsessive–compulsive disorder. *Journal of Anxiety Disorders, 12,* 579–598.

Tata, P. R., Leibowitz, J. A., Prunty, M. J., Cameron, M., & Pickering, A. D. (1996). Attentional bias in obsessional compulsive disorder. *Behaviour Research and Therapy, 34,* 53–60.

Taylor, S., Zvolensky, M. J., Cox, B. J., Deacon, B., Heimberg, R. G., Ledley, D. R., et al. (2007). Robust dimensions of anxiety sensitivity: development and initial validation of the Anxiety Sensitivity Index-3. *Psychological Assessment, 19,* 176.

Tolin, D. F., Lohr, J. M., Lee, T. C., & Sawchuk, C. N. (1999). Visual avoidance in specific phobia. *Behaviour Research and Therapy, 37*, 63-70.

Tottenham, N., Tanaka, J., Leon, A., McCarry, T., Nurse, M., Hare, T., et al. (2009). The NimStim set of facial expressions: Judgments from untrained research participants. *Psychiatry Research*, *168,* 242–249.

Tuerk, P., Grubaugh, A., Hamner, M., & Foa, E. (2009). Diagnosis and treatment of PTSD-related

    compulsive checking behaviors in veterans of the Iraq war: The influence of military

    context on the expression of PTSD symptoms. *American Journal of Psychiatry*, *166*,

    762-767.

Van Bockstaele, B., Verschuere, B., De Houwer, J., & Crombez, G. (2010). On the costs and

    benefits of directing attention towards or away from threat-related stimuli: A classical

    conditioning experiment. *Behaviour Research and Therapy, 48*, 692-697.

Van Damme, S., Crombez, G., Hermans, D., Koster, E.H.W., & Eccleston, C. (2006). The

    role of extinction and reinstatement in attentional bias to threat: A conditioning approach.

    Behaviour Research and Therapy, 44, 1555-1563.

Vansteenwegen, D., Iberico, C., Vervliet, B., Marescau, V., & Hermans, D. (2008). Contextual

    fear induced by unpredictability in a human fear conditioning preparation is related

    to the chronic expectation of a threatening US. *Biological Psychology, 77*, 39-46.

Wald, I., Degnan, K. A., Gorodetsky, E., Charney, D. S., Fox, N. A., Fruchter, E. et al.

    (2013). Attention to threats and combat-related posttraumatic stress symptoms:

    prospective associations and moderation by the serotonin transporter gene. *JAMA

    Psychiatry*, *70*, 401-408.

Wald, I., Shechner, T., Bitton, S., Holoshitz, Y., Charney, D. S., Muller, D., et al. (2011).

    Attention bias away from threat during life threatening danger predicts PTSD symptoms at

    one-year follow-up. *Depression and Anxiety, 28*, 406-411.

Watson, J. B., & Rayner, R. (1920). Conditioned emotional reactions. *Journal of Experimental

    Psychology, 3,* 1–14.

Weathers FW, Litz BT, Herman DS, et al. (1993) *The PTSD Checklist (PCL): Reliability, Validity,*

  and Diagnostic Utility. Paper presented at the Ninth Annual Conference of the ISTSS,

  San Antonio, TX.

Weierich, M. R., Treat, T. A., & Hollingworth, A. (2008). Theories and measurement of visual

  attentional processing in anxiety. *Cognition and Emotion, 22,* 985-1018.

Woody, S. R., & Teachman, B. A. (2000). Intersection of disgust and fear: Normative and

  pathological views. *Clinical Psychology: Science and Practice, 7,* 291-311.