

The Relation between Symptoms of Bulimia Nervosa and Obsessive-Compulsive Disorder: A Startle
Investigation

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Abstract

Bulimia nervosa (BN) and obsessive-compulsive disorder (OCD) co-occur at greater rates than chance and may have shared mechanisms of dysfunction. One of these proposed mechanisms is a hyper-responsive aversive system as indicated by heightened startle response to aversive stimuli. The present study examined this hypothesis using two types of aversive stimuli: disorder specific (e.g., high-caloric food pictures for BN, contamination pictures for OCD) and non-disorder specific (e.g., knife). Temporal parameters of aversive responding were also examined by assessing startle response in anticipation of and following picture presentation. The sample consisted of 114 undergraduate females selected to have a broad range of BN and/or OCD symptomatology. OCD symptoms were associated with increased startle potentiation during the anticipation and presentation of contamination pictures, and BN symptoms were associated with increased startle potentiation during disorder-related contamination pictures (e.g., sink, toilet). BN symptoms were also associated with increased startle potentiation during and following the presentation of food pictures (though the former effect was only a trend). Additionally, the interaction of BN and OCD symptoms was associated with elevated startle responding during the presentation of contamination and threat stimuli. Overall, the present study provides evidence that BN and OCD symptoms are associated with heightened aversive responding to disorder-specific stimuli, and comorbid BN and OCD symptoms are associated with heightened aversive responding across disorder-specific and non-specific aversive stimuli. Clinical and theoretical implications are discussed.

Keywords: bulimia nervosa, OCD, aversive system, startle

Introduction

Bulimia nervosa (BN) and obsessive-compulsive disorder (OCD) co-occur at significantly greater rates than chance in both clinical and community samples (Angst et al., 2004; Hudson et al., 2007) and share many common phenotypic features (Godart, Flament, Perdereau, & Jeammet, 2002; Lilenfeld et al., 1998; see Altman & Shankman, 2009 for review). Longitudinal and family studies also suggest that BN and OCD may have shared mechanisms of dysfunction that partially account for their co-occurrence; however, the exact nature of these mechanisms has yet to be elucidated (Bellodi et al., 2001; Bulik, Sullivan, Fear, & Joyce, 1997; Kaye et al., 2004; Milos et al., 2002; Speranza et al., 2001; Thornton & Russell, 1997). The present study examined whether one potential mechanism – heightened aversive system activation – may contribute to the heightened comorbidity between BN and OCD.

Aversive Motivational System and Startle Response

Lang's (1995) theory of emotional and motivational processes proposes that appetitive and aversive systems play a critical role in influencing behavior. Specifically, the appetitive system is activated when encountering pleasant/rewarding stimuli and promotes approach-oriented behaviors. In contrast, the aversive system is activated by unpleasant/threatening stimuli and is associated with avoidance or withdrawal behaviors. Psychopathological conditions can be characterized in terms of abnormal appetitive and/or aversive system activation. For example, OCD can be characterized by high aversive motivation (e.g., individuals with OCD may avoid germs). BN can also be characterized by high aversive motivation (e.g., rejection of food through purging), but unlike OCD, is also associated with high appetitive motivation (e.g., binges; Kaye & Oberndorfer, 2010). In sum, heightened aversive system activation may be a shared mechanism of BN and OCD that contributes to their high co-occurrence.

Lang (1995) also proposes that aversive system activation is associated with increased defensive responding, such as the startle response. Startle is an ideal tool for examining the specificity and/or commonality of aversive motivation in BN and OCD, because it potentiates when the individual is in an aversive state (i.e., fear-potentiated startle) and can thus be used to measure in-the-moment responses to stimuli. Startle is also advantageous over other measures of aversive motivation, such as self-report, because

it is less susceptible to retrospective recall biases and demand characteristics; and neuroimaging because of its cost-effectiveness. Interestingly, only a limited number of studies have examined startle in BN. For example, BN and control participants have been shown to have comparable startle response when presented with aversive pictures (e.g., pointed gun; Drobles et al., 2001; Freiderich et al., 2006; Mauler et al., 2006). Even fewer studies have examined fear-potentiated startle in OCD. Kumari, Kaviani, Raven, Gray, and Checkley (2001) found that, relative to controls, OCD was associated with elevated startle during positive, negative, and neutral film clips, suggesting that OCD may be associated with heightened overall (and not fear-potentiated) startle response.

Disorder-Specific Aversiveness

Although the few startle studies for BN and OCD do not support the theory that individuals with these conditions exhibit general heightened aversive system activation, Grillon and Baas (2003) argue that startle studies in psychopathology should use stimuli that are directly relevant to the disorder (or symptom) of interest. For example, relative to controls, individuals with a spider phobia have been shown to exhibit potentiated startle while being presented pictures of spiders, but not non-specific aversive pictures (e.g., threatening weapons; Hamm et al., 1997). Similarly, McTeague and colleagues (2009) found that, compared to controls, individuals with social phobia demonstrated potentiated startle during disorder-specific scripts (e.g., public speaking failure and social confrontation) but not non-specific aversive scripts (e.g., physical attack by animal). However, in a similar study, panic disorder and post-traumatic stress disorder (PTSD) were not associated with potentiated startle during disorder-specific stimuli (Cuthbert et al., 2003). Thus, in order to assess aversive system activation using startle it may be important to use disorder-specific stimuli for certain (but not other) disorders.¹

The few studies that have examined startle potentiation to disorder-specific stimuli in BN suggest that idiographic aversive stimuli elicit heightened startle response in BN individuals compared to controls. For example, Drobles and colleagues (2001) examined startle during the presentation of food pictures in female undergraduates with analog BN (i.e., high on binge-purge subscale, low on restraint subscale) and controls. Results indicated that, relative to controls, BN participants had potentiated startle during food

pictures, consistent with food serving as an aversive stimulus. Analogous results were found in a similar study using patients with BN (Mauler, Hamm, Weike, & Tuschen-Caffier, 2006; although see Friederich et al., 2006 for conflicting results).

To the best of our knowledge, no study has examined startle response in OCD during disorder-specific pictures. However, studies have examined this question using other methodologies. In an fMRI investigation, Shapira and colleagues (2003) found that, relative to controls, OCD participants evidenced greater activation in the insula, basal ganglia, and parahippocampal regions while viewing contamination pictures, but there were no group differences during non-specific threat and neutral pictures. Similarly, Phillips and colleagues (2000) found that OCD participants with washing compulsions showed differential activation in the insula and visual regions during washing-relevant pictures compared to individuals with checking compulsions and controls. Overall, these results lend support to a disorder-specific, and potentially symptom-specific, aversive response to clinically-relevant stimuli in OCD.

Models of Comorbidity

Although a limited number of studies have examined the startle response in BN and OCD in separate reports, no startle study has examined these two disorders simultaneously. There are several advantages of examining startle responsivity in a single report. First, examining two psychopathologies that co-occur significantly in the same study would allow a test of whether a putative mechanism is unique to a disorder (relative to the other) or common to them both. Second, such a study could help identify a mechanism (or mechanisms) for the co-occurrence of the two disorders.

For example, comorbid BN/OCD may be an extreme form (i.e., multiform) of BN. If this was the case, then individuals with BN/OCD would exhibit heightened startle response to BN-specific stimuli but not OCD-specific stimuli. Alternatively, a threshold model would suggest that individuals with both the pure disorder (A) and comorbid disorders (AB) develop their condition when they cross the threshold for risk for pure disorder A, but those with both AB cross a second threshold (on the same or perhaps a different dimension). This model might predict that BN and OCD would be associated with heightened startle to disorder-specific stimuli, but comorbid participants would also exhibit heightened startle to non-specific (and

potentially other) aversive stimuli (for other models of comorbidity, see Klein & Riso, 1993; Neale & Kendler, 1995).

Present Study

In a sample of college-aged females, the present study examined whether BN and/or OCD symptoms were associated with heightened startle response to disorder-specific and/or non-specific aversive stimuli and whether co-occurrence of the symptoms leads to a similar or different response. Given the heterogeneity of OCD (Leckman et al., 2010), we focused on contamination fears as these symptoms have been shown to be the most related to eating pathology (Hasler et al. 2005; Matsunaga et al., 1999).

The present study had three primary aims. First, we examined whether elevated BN symptoms were associated with heightened startle response during BN-specific (i.e., food pictures) and not OCD-specific (i.e., contamination pictures) or non-specific (i.e., threat pictures) aversive stimuli. Second, we examined whether elevated OCD symptoms were associated with heightened startle response during OCD-specific and not BN-specific or non-specific aversive stimuli. Third, we examined whether BN and OCD symptoms interacted to predict startle response to the aversive stimuli. As startle studies have not examined whether those with comorbid BN and OCD exhibit different aversive responses than those with one disorder alone, we did not have a specific hypothesis for the pattern of these interactions.

An additional aim of this study was to explore whether BN and/or OCD symptoms predicted the time course of emotional responding. Studies examining group differences in the time course rather than just the immediate (or average) emotional reaction are critical (Nelson, Shankman, Klein, & Olino, 2011). For example, group differences in the anticipation of and recovery from aversive stimuli may elucidate critical emotional regulatory processes in individuals with psychopathology (Larson, Nitschke, & Davidson, 2007; Nitschke et al., 2002). The temporal dynamics (i.e., “affective chronometry”, Davidson, 1998) of responding may be particularly important for individuals with BN and/or OCD. For example, the aversiveness induced by food and contamination may linger even after the stimuli are no longer present due to difficulty terminating certain thoughts or actions (Svaldi, Griepenstroh, Tuschen-Caffier, & Ehring, 2012; Szechtman & Woody, 2005). Thus, the present study also examined startle during the period before the pictures are

presented (i.e., while participants anticipated the stimulus) and after picture presentation (i.e., while participants recovered from the stimulus).

Methods

Participants

Female undergraduates ($N = 125$) were recruited from an introduction to psychology course at the University of Illinois at Chicago. Only female participants were recruited as individuals with BN and OCD are approximately three and two times more likely to be female, respectively (Hudson et al., 2007; Ruscio, Stein, Chiu & Kessler, 2010; Torres et al., 2006). Participants were invited into the study from a larger pool of ~900 students based on their scores on the Bulimia subscale of the Eating Disorder Inventory-3 (EDI-3; Garner, 2004) and the Contamination Fears subscale of the Schedule of Compulsions, Obsessions, and Pathological Impulses (SCOPI; Watson & Wu, 2005) (see below for descriptions of these scales). Binge-purge behaviors and contamination fears are low frequency behaviors in the general population (i.e., the behaviors are positively skewed in the general population, Hudson et al., 2007; Ruscio et al., 2010). Therefore, we oversampled those who scored high on the EDI-3 Bulimia and the SCOPI Contamination Fears subscales in order for bulimic behaviors and contamination fears to be normally distributed. This was achieved by first inviting those who were high and low on the EDI-3 Bulimia and SCOPI Contamination Fears subscales, and then monitoring the distribution of the sample on these variables during recruitment and targeting specific percentiles to complete the distribution. This approach was effective as both variables in the final sample were normally distributed as evidenced by 1) no skewness or kurtosis values exceeding an absolute value of one and 2) examination of histograms. Scores on the EDI-3 Bulimia and SCOPI Contamination Fears subscales were stable between initial assessment and laboratory visit ($r = .82$ and $r = .62$, respectively). The percentages of the final sample who were from the 1st, 2nd, 3rd, and 4th quartile of the ~900 screened participants were 19.3%, 24.6%, 6.1%, and 50.0% for the EDI-3 and 39.5%, 10.5%, 12.3%, and 37.7% for the SCOPI. Scores on the EDI-3 Bulimia and SCOPI Contamination Fears subscales were not correlated with each other within the larger subject pool population, $r = -.02$, *ns*, or the sample used in the present study, $r = -.13$, *ns*.

Measures

Demographics. Participants first completed self-report questionnaires assessing age, ethnicity, body mass index (BMI), and alcohol and drug use (separate variables) in the last 30 days. Next, participants reported the number of hours since they last ate (i.e., 0-1, 2-4, 4-6, 6-12, or 12+ hours ago). As food deprivation has been shown to influence startle response (see Drobles et al., 2001; Mauler et al., 2006) this variable (Deprivation Time) was used as a covariate in the analyses. Of note is that participants were asked to have a meal 2-3 hours before the experiment. Participants were also instructed to avoid eating, smoking or drinking caffeinated beverages in the hour before the experiment.

Eating Disorder Inventory–3 (EDI-3). The EDI-3 (Garner, 2004) is a 91-item self-report measure which assesses the presence of eating disorder symptoms. All items on the EDI-3 are rated on a 6-point scale ranging from 1 (Never) to 6 (Always). Given the nature of the sample, in order to increase the sensitivity of detecting bulimic symptoms, the present study used the nonclinical scoring method (which adds up the responses to each item) rather than the clinical scoring method (which codes the three least pathological responses as zero). The EDI-3 is organized into 12 primary subscales, and research has demonstrated that the subscales have satisfactory internal consistency and good discriminant validity (Clausen, Rosenvinge, Friborg, & Rokkedal, 2011). As mentioned above, the present study focused on the EDI-3 Bulimia. Cronbach's alpha was 0.88 for the EDI-Bulimia subscale.

The Schedule of Compulsions, Obsessions, and Pathological Impulses (SCOPI). The SCOPI (Watson & Wu, 2005) is a 47-item factor-analytically derived self-report measure which assesses behaviors related to OCD. All items are rated on a 5-point scale ranging from 1 (Strongly Disagree) to 5 (Strongly Agree). In addition to providing a total score, the SCOPI yields subscales of particular OCD symptomatology. As previously mentioned, given the heterogeneity in OCD (Leckman et al., 2010), the present study focused on the SCOPI Contamination Fears subscale. All of the SCOPI subscales have been shown to have high test-retest reliability, good convergent validity with other OCD measures (e.g., OCI-R and Y-BOCS) and adequate discriminant validity in samples of students, adults, and general psychiatric outpatients (Watson & Wu, 2005). Cronbach's alpha was 0.89 for the Contamination Fears subscale.

Procedure

Following electrode placement, participants were seated in an electrically shielded, sound-attenuated booth approximately 3.5-ft from a 19-in computer monitor presented at a 15° viewing angle. To prevent early exaggerated startle responding, participants completed a 2.5-min baseline habituation task in which 9 acoustic startle probes were administered while a black fixation cross was presented against a white background (data not presented). Immediately following the baseline habituation task, participants were given instructions on the picture-viewing task (presented below).

Stimuli were regulated by Contact Precision Instruments (London, UK) and startle data were recorded using a PC-based acquisition system (Neuroscan 4.3). Startle response was operationalized as the eye blink response elicited by 50-ms, 103db bursts of white noise presented binaurally through headphones. The startle eye blink was recorded using two electrodes placed over the obicularis oculi muscle underneath the right eye and collected using a low pass filter of 500 Hz at a sampling-rate of 1000 Hz. A ground electrode was placed along the midline of the forehead.

Picture-Viewing Task. Forty pictures were selected from the International Affective Picture System (IAPS; Lang, Bradley & Cuthbert, 2008). These pictures included ten pictures each of high caloric food (e.g., candy, ice cream; see Drobles et al., 2001), contamination pictures (e.g., dirty toilet, dirty sink; garbage; see Shapira et al. 2003), aversive personal threat (e.g., animal attack, pointed gun), and neutral content (e.g., lamp) based on normative valence and arousal ratings for women (Lang et al., 2008).² In a quasi-random order, pictures were presented in two blocks of 20 pictures, with each block containing five pictures of each of the four picture types. Each block was separated by approximately 5-min. No more than two pictures of a given valence were presented consecutively. Immediately before each picture, participants were presented with text for 4-s which indicated the category of the coming picture (ANTIC phase). Participants were told that the text was to prepare them for the category of the upcoming stimulus picture (“FOOD” for food pictures; “DIRTY” for contamination pictures; “THREAT” for aversive personal threat pictures; “NEUTRAL” for neutral pictures). Each picture was then presented on the screen for 5-s (PIC phase), followed by a plus sign for 12-18-s (POST-PIC phase; mean interstimulus interval was 15-s).

A total of 84 acoustic startle probes were delivered during the course of the experiment. Probes were presented during 7 trials of each of the four conditions (Food, Contamination, Threat, and Neutral) and three phases of the task (ANTIC, PIC, and POST-PIC) during the following probe times: ANTIC (1 to 2-s before the picture onset), PIC (2 to 4-s post-picture onset) and POST-PIC (between 1.5 and 6-s after picture offset). The 84 acoustic startle probes were equally distributed across conditions and phases (i.e., probes occurred in each combination of picture condition and task phase).

Following the second block, electrodes were removed and participants went into a separate room where they were shown the 40 pictures again and asked to rate each picture on arousal and valence using the 9-point manikin scale (Lang et al., 2008). Picture ratings were obtained to examine whether BN and/or OCD symptoms were uniquely associated with startle response or were more broadly associated with another aversive response ‘channel’ (i.e., self-report). Finally, after finishing the picture ratings participants completed the EDI-3 and SCOPI measurements.

Data Reduction. Startle blinks were scored according to published guidelines (Blumenthal et al., 2005). Data were first rectified and then smoothed using a FIR filter with a band pass of 28-40 Hz. Blink response was defined as the peak amplitude of EMG activity within the 20-150-ms period following startle probe onset relative to baseline (average baseline EMG level for the 50-ms preceding the startle probe onset). Each peak was identified by software but examined by hand to ensure acceptability (e.g., not a double blink). Blinks were scored as non-responses if EMG activity during the 20-150-ms post-stimulus timeframe did not produce a blink peak that was visually differentiated from baseline activity. Blinks were scored as missing if the baseline period was contaminated with noise, movement artifact, or if a spontaneous or voluntary blink began before minimal onset latency and thus interfered with the startle probe-elicited blink response. Startle data were skewed and kurtotic and were therefore square root transformed to achieve a normal distribution.

Of the 125 participants, 8 were excluded from analyses because they elicited fewer than 3 of 7 blinks within a condition (remaining $N = 117$). Due to technical error, 107 participants only received 83 startle probes instead of 84. All analyses were run with these 107 participants only and revealed the same pattern of results as the entire sample; therefore results from the 117 participants are reported below. For the final

sample, a total of 9.87% of trials were omitted due to unscorability (an average of 7.27 per participant, $SD = 7.66$).

Data Analyses

First, we examined whether EDI-3 Bulimia and SCOPI Contamination Fears subscales were associated with startle during the neutral pictures. Neither subscale was significantly correlated with startle during the neutral pictures (all p 's $> .10$); therefore, we calculated difference scores between the aversive (e.g., Food, Contamination, and Threat) and neutral conditions (i.e., fear-potentiated startle).

Second, hierarchical multiple regression analyses were used to evaluate the association between BN and/or OCD symptoms (independent variables) and startle potentiation (dependent variable). Hierarchical regressions were employed with Deprivation Time entered in Step 1, main effects of Bulimia and Contamination Fears entered in Step 2, and the interaction of Bulimia X Contamination Fears entered in Step 3. Continuous independent variables were centered to reduce non-essential multicollinearity (Aiken & West, 1991). To follow up significant interactions, simple slopes analyses were conducted by recoding one of the independent variables into two separate conditional independent variables 1 SD above (i.e., 'high') and below (i.e., 'low') the mean (Aiken & West, 1991; Holmbeck, 2002). This analytic approach does not arbitrarily dichotomize a continuous variable, but rather creates separate 'high' and 'low' levels of the independent variable where '0' represents 1 SD above and below the mean on the independent variable, respectively. Thus, 'high' and 'low' do not represent groups but relative levels on the independent variable. For the secondary analyses involving ANTIC and POST-PIC phases, data analyses were similar to the PIC phase analyses, except that the dependent variables were startle potentiation in anticipation of the picture stimuli and following the picture stimuli, respectively.

Finally, similar analyses were conducted for the self-report picture ratings of valence and arousal. That is, hierarchical regressions were employed with Deprivation Time entered in Step 1, main effects of Bulimia and Contamination Fears (both centered) entered in Step 2, and the interaction of Bulimia X Contamination Fears entered in Step 3.

Analyses revealed that age, ethnicity, drug use in the last 30 days, and BMI were not associated with any of the dependent variables (all p 's $> .10$), and therefore were not used as covariates in the analyses. However, alcohol use in the last 30 days was inversely associated with startle potentiation during several conditions. Further examination of these results revealed that there were three participants who reported drinking alcohol on 20-39 occasions over the last 30 days and were outliers driving these correlations. When these three participants were excluded from analyses, alcohol use in the last 30 days was no longer associated with startle. Thus, these three participants were excluded (final $N = 114$).

Results

Descriptive Statistics and Clinical Characteristics

Descriptive statistics and clinical characteristics are presented in Table 1. Participants were approximately 20 years-old, ethnically heterogeneous, and on average, had BMIs in the normal range. Participants varied in the amount of time elapsed since they last ate: 0-1 (17.5%), 2-4 (50.0%), 4-6 (13.2%), 6-12 (13.2%) and 12+ hours ago (6.1%). Although participants were all undergraduates, the sampling strategy yielded a sample that had a mean SCOPF Contamination Fears score ($M = 35.25$, $SD = 8.88$) that was comparable to that of OCD patient samples ($M = 35.08$; $SD = 9.95$ Watson & Wu, 2005), and a mean EDI-3 Bulimia score ($M = 15.24$, $SD = 6.62$) that was comparable to that of eating disorder patient samples ($M = 14.39$, $SD = 9.35$; Clausen et al., 2011). Additionally, EDI-3 scores were associated with clinically significant behaviors – specifically, a higher likelihood of binge eating, eating in secret, and a loss of control over eating during the 28 days prior to the experimental session (all r 's $> .53$).

Association between Symptoms and Startle Potentiation³

PIC Phase

Food pictures. For food pictures, greater Deprivation Time was associated with reduced startle potentiation at a trend level, $\beta = -.16$, $t(113) = -1.77$, $p < .08$. In other words, the longer it had been since participants last ate food, the smaller (at a trend level) was their startle potentiation to food pictures. Additionally, our hypothesis for Bulimia symptoms was partially supported, as greater Bulimia symptoms were associated with increased startle potentiation at a trend level, $\beta = .16$, $t(113) = 1.67$, $p < .10$.

Contamination Fears and the interaction of Bulimia X Contamination Fears were not associated with startle potentiation.

Contamination pictures. Greater Contamination Fears were associated with increased startle potentiation to the contamination pictures, $\beta = .22$, $t(113) = 2.36$, $p < .05$. Results also indicated a significant Bulimia X Contamination Fears interaction to these pictures, $\beta = .21$, $t(113) = 2.30$, $p < .05$ (see top of Figure 1). Follow-up analyses revealed that for participants with lower Bulimia symptoms, Contamination Fears were not associated with startle potentiation, $\beta = .03$, $t(113) = 0.27$, *ns*. However, for participants with higher Bulimia symptoms, greater Contamination Fears were associated with increased startle potentiation, $\beta = .39$, $t(113) = 3.31$, $p < .001$.

Contamination pictures were comprised of a combination of dirty toilets (3 pictures), dirty sinks (2 pictures), garbage (4 pictures), and general scenes (1 picture). For individuals with BN symptoms, it was therefore possible that toilet pictures may have been associated with vomiting and sink pictures may have been associated with food preparation. Thus, the present study conducted additional analyses with contamination pictures separated into non-BN (i.e., 4 garbage pictures and 1 general picture) and BN-related stimuli (3 toilet pictures and 2 sink pictures).⁴

For non-BN contamination pictures, greater Contamination Fears were again associated with increased startle potentiation, $\beta = .22$, $t(113) = 2.38$, $p < .05$. Interestingly, for BN-related contamination pictures, both Bulimia, $\beta = .22$, $t(113) = 2.43$, $p < .05$, and Contamination Fears, $\beta = .28$, $t(113) = 3.01$, $p < .01$, were associated with increased startle potentiation. The Bulimia X Contamination Fears interaction was not significant for BN-related contamination pictures, $\beta = .13$, $t(113) = 1.48$, *ns* or non-BN related contamination pictures, $\beta = .09$, $t(113) = 0.93$, *ns*.

General Threat pictures. Greater Contamination Fears was associated with increased startle potentiation to general threat pictures, $\beta = .23$, $t(113) = 2.47$, $p < .05$. In addition, the interaction of Bulimia X Contamination Fears was associated with startle potentiation, $\beta = .19$, $t(113) = 2.00$, $p < .05$. Follow-up analyses revealed that, for participants with lower Bulimia symptoms, Contamination Fears were not

significantly associated with startle potentiation, $\beta = .07$, $t(113) = 0.54$, *ns*. However, for participants with higher Bulimia symptoms, higher Contamination Fears were associated increased startle potentiation, $\beta = .38$, $t(113) = 3.20$, $p < .01$ (see bottom of Figure 1).

ANTIC Phase

For food pictures, there were no significant effects on startle potentiation during the ANTIC phase. For contamination pictures, both greater Bulimia, $\beta = .19$, $t(113) = 2.04$, $p < .05$, and Contamination Fears symptoms, $\beta = .25$, $t(113) = 2.64$, $p < .01$, were associated with increased startle potentiation. The Bulimia X Contamination Fears interaction was not significant for contamination pictures during the ANTIC phase. As with the PIC phase analyses, the contamination pictures were divided into BN-related and non-BN contamination pictures. For non-BN contamination pictures, our hypotheses were partially supported as greater Contamination Fears were associated with increased startle potentiation at a trend level ($\beta = .16$, $t(113) = 1.72$, $p < .09$) although Bulimia symptoms were not, $\beta = .08$, $t(113) = 0.87$, *ns*. For BN-related contamination pictures, there were no significant effects. Lastly, for general threat pictures, there were no significant effects on startle potentiation during the ANTIC phase.

POST-PIC Phase

Higher Bulimia symptoms were associated with increased startle potentiation during the POST-PIC phase of the food pictures condition, $\beta = .20$, $t(113) = 2.20$, $p < .05$. Results also indicated a significant Bulimia X Contamination Fears interaction for these pictures, $\beta = .20$, $t(113) = 2.19$, $p < .05$. Follow-up analyses revealed that for participants with higher Bulimia symptoms, Contamination Fears were not associated with startle potentiation, $\beta = .04$, $t(113) = 0.32$, *ns*. However, for participants with lower Bulimia symptoms, greater Contamination Fears were associated with *decreased* startle potentiation, $\beta = -.30$, $t(113) = -2.43$, $p < .05$. For contamination and threat pictures, there were no significant effects or interactions during the POST-PIC phase.

Association between Symptoms and Picture Ratings

Food Pictures. Our hypothesis was partially supported, as greater Bulimia symptoms were associated with more negative valence ratings at a trend level, $\beta = .17$, $t(113) = 1.82$, $p < .08$. There were no effects for arousal ratings.

Contamination Pictures. Greater Contamination Fears were associated with more negative valence ratings, $\beta = .30$, $t(113) = 3.26$, $p < .01$, and greater arousal ratings, $\beta = -.26$, $t(113) = -2.82$, $p < .01$. Bulimia symptoms and the interaction of Bulimia X Contamination Fears were not associated with valence or arousal ratings of the contamination pictures.

Threat Pictures. Greater Contamination Fears were also associated with more negative valence ratings, $\beta = 0.27$, $t(113) = 2.87$, $p < .01$, and greater arousal ratings, $\beta = -.20$, $t(113) = -2.09$, $p < .05$. Bulimia symptoms and the interaction of Bulimia X Contamination Fears were not associated with valence or arousal ratings of the threat pictures.

Discussion

The present study examined the association between BN and/or OCD symptoms and startle response to disorder-specific and non-specific aversive stimuli in a sample of college-aged females. To the best of our knowledge, this is the first investigation of the independent and interactive effects of BN and OCD symptoms on aversive responding. There were several noteworthy findings.

Disorder-Specific Aversiveness

BN and Food Pictures: Aversive System, Reward System, or Both? In partial support of our hypotheses, BN symptoms were associated with increased startle potentiation and negative valence ratings of high-caloric food pictures. Previous research has reported increased startle potentiation during the presentation of similar food pictures in individuals with binge-purge behaviors and in a clinical sample of BN patients (Drobes et al., 2001; Mauler et al., 2006). Conversely, in control participants, startle response has been shown to be *attenuated* during food pictures, suggesting appetitive system activation in those without eating pathology (Drobes et al., 2004; Mauler et al., 2006). Results from the present study provide partial support for the notion that food elicits aversive system activation in BN, although this conclusion is tempered by the fact that this effect only approached significance.

On the other hand, if high-caloric foods are aversive for those with BN symptoms, it is interesting that such stimuli would trigger an appetitive drive to consume large quantities (i.e., bingeing). As previously mentioned, BN is a unique disorder characterized by both high appetitive (e.g., binges) and aversive motivation (e.g., purges). BN may therefore be more associated with an ambivalent (rather than purely aversive) relationship with food (particularly high-caloric food; Harrison, Treasure, & Smillie, 2011; Roefs et al., 2005). Moreover, this ambivalence may be particularly evident for those in the present college-aged female sample rather than a clinical sample (although the mean EDI-3 score of the present sample was comparable to that of eating disorder patients [Clausen et al., 2011] and BN scores were associated with clinically significant behaviors such as binge eating). It is important to note, however, that these ideas are highly speculative as the present study did not include a measure of appetitive system activation. Thus, while the present study partially supports an association between BN symptoms and aversive system activation, it is *also* possible that in BN food is associated with variation in appetitive and aversive system activation – both within and across individuals (Smyth et al., 2007). This is an important future direction for work on motivational mechanisms in BN.

Contamination pictures and OCD. To the best of our knowledge, this is the first study to examine startle response to contamination pictures in those with OCD symptoms. The present study found that OCD contamination fears were associated with increased startle potentiation, negative valence ratings, and arousal ratings of contamination pictures. These findings provide strong evidence that in individuals with OCD symptoms, the aversive system becomes activated during the presentation of contamination pictures. These results also support neuroimaging studies which have shown increased activation in fear and disgust-related areas of the brain (e.g., amygdala, insula) to disorder-specific pictures in individuals with OCD symptoms (Cisler et al., 2009).

Interestingly, BN symptoms were also associated with increased startle response to contamination pictures, but only those containing dirty sinks and toilets and not pictures containing garbage and general contamination stimuli. Pictures of sinks and toilets may have triggered memories or feelings related to binge and purge behaviors (e.g., food preparation and vomiting, respectively), and in individuals with elevated BN

symptoms, increased startle potentiation. One may speculate that this suggests that BN is associated with increased aversive system activation to a number of different disorder-specific stimuli, including those related to both binge *and* purge behaviors.

There are several theoretical implications of the disorder-specific results for BN and OCD. Phenotypic and genetic studies examining the hierarchical structure of psychopathology have often identified two separable (albeit correlated) factors of externalizing and internalizing psychopathology, with internalizing psychopathology further dividing into fear (e.g., panic disorder, phobias) and distress/misery factors (Kendler et al., 2003; Krueger, 1999; Watson, 2005). Interestingly, startle studies have generally shown that fear-related disorders are associated with elevated startle potentiation to aversive scenes while distress/misery disorders are associated with normal or perhaps diminished startle potentiation to aversive scenes (Cuthbert et al., 2003; McTeague et al., 2009; see Vaidyanathan, Patrick, & Cuthbert, 2009 for review). Thus, the present results for disorder-specific pictures may suggest that BN and OCD are more like fear-related disorders than distress/misery disorders. This is notable as studies on the hierarchical structure of psychopathology have often not included OCD and eating disorders in their analyses due to their relatively low base rates (although see Forbush & Watson, 2013). Of course, future studies are needed to examine the relation between these conditions and other internalizing (and externalizing) psychopathologies further.

The disorder-specific results for OCD and BN may also relate to Barlow's triple-vulnerability theory for emotional disorders (Barlow, 2002; Suarez, Bennet, Goldstein, and Barlow, 2009). This model proposes three "diatheses" of emotional disorders: 1) a generalized biological propensity to experience clinically significant negative mood; 2) a psychological vulnerability emerging in childhood through dysfunctional parenting or ineffective coping from an unexpected stressful event; and 3) a specific psychological vulnerability which develops out from maladaptive learning (either through direct experience or through social learning processes) that certain stimuli are threatening, even though they are objectively not. In relation to the present study, it may be that through early experiences individuals with increased BN symptoms learned that high-caloric food was aversive while individuals with OCD symptoms learned that

contaminating was aversive. Additionally, these stimuli may have triggered a 'generalized biological propensity' thus activating their respective aversive systems.

Non-Specific Aversiveness and Comorbidity

Contamination fears (but not BN symptoms) were associated with increased startle potentiation during non-specific threat pictures. As previously mentioned, Kumari and colleagues (2001) found that, relative to controls, OCD was associated with elevated startle across positive, negative, and neutral film clips. The present study partially replicates this finding in that contamination fears were associated with multiple aversive stimuli (contamination and general threat). However, results diverge from Kumari et al. in that OCD was not associated with startle potentiation to all classes of pictures (i.e., not food pictures). Thus, the present study suggests that OCD may not be associated with a general heightened startle potentiation, but only startle potentiation to particular types of stimuli (and perhaps only aversive stimuli).

Interestingly, the interaction of BN symptoms and OCD contamination fears was also associated with startle responding during general aversive pictures. Specifically, participants with elevated BN symptoms *and* contamination fears exhibited heightened startle responding to contamination and non-specific threat pictures. This suggests that those who have both BN symptoms and contamination fears exhibit a heightened sensitivity to OCD-specific *and* non-specific aversiveness compared to those who only have BN or OCD. That is, compared to those who only have symptoms in one domain, those with both BN and OCD symptomatology may have heightened aversive system activation to multiple types of stimuli.

In a prior review, Altman and Shankman (2009) examined whether the literature on eating disorders and OCD comorbidity fit with extant models of comorbidity (Klein & Riso, 1993; Neale & Kendler, 1995). Although there were methodological limitations to the studies included in this review, the literature largely supported the model that the co-occurrence between eating disorders and OCD may be due to a common underlying liability or risk mechanism. However, if response to disorder-specific aversiveness are liabilities specific to the respective disorders (BN and OCD), the present results portray a somewhat different (or at least nuanced) picture. As those with co-occurring BN/OCD symptoms showed a liability to contamination

and threat, but not food pictures the comorbid condition may be an atypical form (or multiform) of OCD, despite having phenomenological features of BN (see Sallet et al., 2010).

Results from the present study are also consistent with a threshold explanation for the high rates of comorbidity between BN and OCD (Neale & Kendler, 1995). The thresholds model posits that individuals with both the pure disorder (OCD) and comorbid disorders (BN/OCD) develop their condition when they cross the threshold for liability for pure disorder OCD, but those with both BN/OCD cross a second threshold (on the same or perhaps different dimension). Although speculative, it is possible that response to the disorder-specific threat pictures represents the first threshold and response to the non-specific threat pictures represents a second threshold. In other words, those with co-occurring BN and OCD symptoms could be a more extreme/atypical form of OCD, in that they crossed the first threshold (i.e., heightened response to contamination pictures) and the second threshold (i.e., non-specific threat). There are of course many caveats for this hypothesis and thus different designs (e.g., twin studies, longitudinal studies) are needed in order to examine this further.

Anticipation and Recovery Phases

Most psychopathological studies on emotional reactivity examine response during the presentation of stimuli and not other temporal components of responding. As an exploratory aim, the present study also examined whether BN and OCD symptomatology were associated with anticipatory and recovery phases of stimulus presentation. Interestingly, contamination fears were associated with increased startle potentiation while anticipating contamination pictures. Thus, in individuals with elevated contamination fears symptoms, there may be increased aversive system activation while anticipating disorder-specific contamination pictures.

BN symptoms were associated with increased startle potentiation during the recovery period following the presentation of food pictures. This result may reflect difficulty regulating negative affect following food presentation. The dual pathway model of bulimia suggests that bingeing and purging are done in an effort to regulate negative affect (Stice, 1994). Thus, if those with BN symptoms have difficulty

recovering from negative affect, they may engage in binge/purge behaviors in an effort to reduce any lingering negative affect.

Limitations

The present study had several notable limitations that warrant consideration. First, though our sample included individuals with clinically significant bulimia symptoms and elevated contamination fears, results may not generalize to those with DSM-defined BN or OCD or to treatment seeking samples. Additionally, the use of a non-clinical sample was likely a reason for our non-significant correlation between BN and OCD symptoms as clinical samples have consistently reported high rates of comorbidity between the two disorders (Altman & Shankman, 2009; Swinbourne & Touyz, 2007). Relatedly, compared to clinic or treatment-seeking samples, the present sample was likely less impaired and had fewer comorbid problems such as Major Depressive Disorder (Braun, Sunday, & Halmi, 1994), a classic phenomenon known as Berkson's bias (Berkson, 1946). Thus, while the present design allowed for an examination of "purer" (albeit likely milder) forms of the disorders, it is critical that future studies test the present hypotheses with clinic or treatment seeking samples.

Second, the sample was exclusively comprised of college-aged females; thus results cannot be generalized to men and samples with wider age ranges. Although men with eating disorders are more concerned with muscularity than thinness, studies have shown that men experience negative affect prior to binges (Womble et al., 2001). Third, we did not distinguish fear/anxiety from disgust, a distinction that has received growing interest in the OCD literature (particularly contamination-related OCD; see Cisler et al., 2009). Future studies should specifically include measures that distinguish these two emotions (e.g., EMG activity in the levator labii superioris; Yartz and Hawk, 2002) in order to understand the specific contributions that these two emotions play in disorder-specific aversiveness sensitivity. Fourth, even though individuals were selected based on their BN and OCD symptomatology, the mechanisms examined in this study may not be specific to those two psychopathologies (e.g., aversive system activation to high caloric foods may be involved to all eating disorders).

Conclusions

In summary, the results of the current study provide support for the role of disorder-specific aversive sensitivity in individuals experiencing BN symptoms and OCD contamination fears. Higher BN symptoms were associated with increased startle potentiation during and after the presentation of food pictures (though the former effect was only a trend). Higher contamination concerns were associated with increased startle potentiation in anticipation of and during presentation of contamination pictures, and BN symptoms were associated with increased startle potentiation to BN-related contamination picture (e.g., sinks, toilets). Additionally, the present study found evidence of increased specific and non-specific aversive responding in those with co-occurring BN symptoms and contamination concerns. Although preliminary, these results provide evidence for common and unique mechanisms that may lead to BN, OCD, and their co-occurrence.

References

- Aiken, L. S., & West, S. G. (1991). *Multiple regression: Testing and interpreting interactions*. Newbury Park, CA: Sage Publications.
- Altman, S. E., & Shankman, S.A. (2009). What is the association between obsessive-compulsive disorder and eating disorders? *Clinical Psychology Review, 29*, 638–646. doi:10.1016/j.cpr.2009.08.001
- American Psychiatric Association (1994), *Diagnostic and Statistical Manual of Mental Disorders, 4th edition (DSM-IV)*. Washington, DC: American Psychiatric Association.
- Angst, J., Gamma, A., Endrass, J., Goodwin, R., Ajdacic, V., Eich, D., et al. (2004). Obsessive-compulsive severity spectrum in the community: prevalence, comorbidity, and course. *European Archives of Psychiatry and Clinical Neuroscience, 254*, 156-164. doi:10.1007/s00406-004-0459-4
- Barlow, D. H. (2002). *Anxiety and its disorders: The nature and treatment of anxiety and panic* (2nd ed.), The Guilford Press, New York.
- Barlow, D. H., Allen, L. B., & Choate, M. L. (2004). Toward a unified treatment for emotional disorders. *Behavior Therapy, 35*, 205-230. doi:10.1016/S0005-7894(04)80036-4
- Bellodi, L., Cavallini, M.C., Bertelli, S., Chiapparino, D., Roboldi, C., & Smeraldi E. (2001). Morbidity risk for obsessive-compulsive spectrum disorders in first degree relatives of patients with eating disorders. *American Journal of Psychiatry, 158*, 563–9. doi:10.1176/appi.ajp.158.4.563
- Berkson, J. (1946). Limitation of the application of fourfold table analysis to hospital data. *Biometric Bulletin* , 2, 47-53. <http://dx.doi.org/10.2307/3002000>
- Berridge, K. C. (2009). ‘Liking’ and ‘wanting’ food rewards: Brain substrates and roles in eating disorders. *Physiology & Behavior, 97*, 537-550. doi:10.1016/j.physbeh.2009.02.044
- Blumenthal, T. D., Cuthbert, B. N., Filion, D. L., Hackley, S., Lipp, O. V., & van Boxtel, (2005). Committee report: Guidelines for human startle eyeblink electromyographic studies. *Psychophysiology, 42*, 1–15. doi:10.1111/j.1469-8986.2005.00271.x

- Braun, D.L., Sunday, S.R., Halmi, K.A. (1994). Psychiatric comorbidity in patients with eating disorders. *Psychological Medicine*, 24, 857-867. <http://dx.doi.org/10.1017/S0033291700028956>
- Bulik, C.M., Sullivan, P.F., Fear, J.L., & Joyce, P.R. (1997). Eating disorders and antecedent anxiety disorders: A controlled study. *Acta Psychiatrica Scandinavica*, 96, 101-107. doi:10.1111/j.1600-0447.1997.tb09913.x
- Carter, J.C., Aime, A.A. and Mills, J.S. (2001). Assessment of bulimia nervosa: a comparison of interview and self-report questionnaire methods. *International Journal of Eating Disorders*, 30, 187–192. doi:10.1002/eat.1071
- Cisler, J. M., Olatunji, B. O., & Lohr, J. M. (2009). Disgust, fear, and the anxiety disorders: A critical review. *Clinical Psychology Review*, 29(1), 34-46. doi:10.1016/j.cpr.2008.09.007
- Cuthbert, B. N., Lang, P. J., Strauss, C., Drobos, D., Patrick, C.J., & Bradley, M.M. (2003). The psychophysiology of anxiety disorder: Fear memory imagery. *Psychophysiology*, 40, 407-422. doi:10.1111/1469-8986.00043
- Davidson, R. (1998). Affective style and affective disorders: Perspectives from Neuroscience. *Cognition & Emotion*, 12, 307-330. doi:10.1080/026999398379628
- Drobos, D. J., Miller, E. J., Hillman, C. H., Bradley, M. M., Cuthbert, B. N., & Lang, P. J. (2001). Food deprivation and emotional reactions to food cues: implications for eating disorders. *Biological Psychology*, 57, 153-177. doi:10.1016/S0301-0511(01)00093-X
- Fairburn, C. G., & Beglin, S. J. (1994). Assessment of eating disorders: Interview or self-report questionnaire? *International Journal of Eating Disorders*, 16, 363-370.
- Fairburn, C.G. & Cooper, Z. (1993). The Eating Disorder Examination. In: C.G. Fairburn and G.T. Wilson, Editors, *Binge eating: Nature, assessment and treatment* (12th ed.), Guilford Press, New York, pp. 317–360.
- Forbush, K. T. & Watson, D. (2013). The structure of common and uncommon mental disorders. *Psychological Medicine*, 43, 97-108. doi: 10.1017/S0033291712001092

- Freiderich, H., Kumari, V., Uher, R., Riga, M., Schmidt, U., & Campbell, I. (2006). Differential motivational responses to food and pleasurable cues in anorexia and bulimia nervosa: a startle reflex paradigm. *Psychological Medicine*, *36*, 1327. doi:10.1017/S0033291706008129
- Garner, D. (2002). Measurement of eating disorder psychopathology. In: Fairburn, C.G. and Brownell, K.D., Eds. *Eating disorders and obesity: A comprehensive handbook* (2nd ed.), New York, Guilford Press, pp. 141–146.
- Godart, N.T, Flament, M., Perdereau, F., & Jeammet, P. (2002). Comorbidity between eating disorders and anxiety disorders: A review. *International Journal of Eating Disorders*, *32*, 253–270. doi:10.1002/eat.10096
- Gray, J. A. (1994). Framework for a Taxonomy of Psychiatric Disorder. In Goozen, S. H. M. V., Poll, N. E. V. D., & Sergeant, J. A. (Eds). *Emotions: essays on emotion theory*, (pp. 29-59). New Jersey: Lawrence Erlbaum Associates.
- Grillon, C. & Baas, J. (2003): A review of the modulation of the startle reflex by affective states and its application in psychiatry. *Clinical Neurophysiology*, *114*, 1557–1579. doi:10.1016/S1388-2457(03)00202-5
- Hamm, A. O., Cuthbert, B. N., Globisch, J., & Vaitl, D. (1997). Fear and the startle reflex: Blink modulation and autonomic response patterns in animal and mutilation fearful subjects. *Psychophysiology*, *34*, 97-107. doi:10.1111/j.1469-8986.1997.tb02420.x
- Harrison, A., Treasure, J., & Smillie, L.D. (2011). Approach and avoidance motivation in eating disorders. *Psychiatry Research*, *188*, 396-401. doi: 10.1016/j.psychres.2011.04.022.
- Hasler, G., LaSalle-Ricci, V. H., Ronquillo, J. G., Crawley, S. A., Cochran, L. W., Kazuba, D., Greenberg, B. D., et al. (2005). Obsessive-compulsive disorder symptom dimensions show specific relationships to psychiatric comorbidity. *Psychiatry Research*, *135*, 121-132. doi:10.1016/j.psychres.2005.03.003
- Holmbeck, G. N. (2002). Post-hoc probing of significant moderational and mediational effects in studies of pediatric populations. *Journal of Pediatric Psychology*, *27*(1), 87 -96. doi:10.1093/jpepsy/27.1.87
- Hudson, J.I., Hiripi, E., Pope, H.G., & Kessler, R.C. (2007). The prevalence and correlates of eating

- disorders in the national comorbidity survey replication. *Society of Biological Psychiatry*, 61, 348-358. doi:10.1016/j.biopsych.2006.03.040
- Kaye, W.H., Bulik, C.M., Thornton, L., Barbarich, N., Masters, K., & Price Foundation Collaborative Group. (2004). Comorbidity of anxiety disorders with anorexia and bulimia nervosa. *American Journal of Psychiatry*, 161, 2215-2221. doi:10.1176/appi.ajp.161.12.2215
- Kaye, W.H. & Oberndorfer, T. (2010). Appetitive regulation in anorexia nervosa and bulimia nervosa. In: Kaye, W.H. and Oberndorfer, T., Eds. *The Oxford Handbook of Eating Disorders*. New York, Oxford University Press, pp. 75-102.
- Kendler, K.S., Prescott, C.A., Myers, J., & Neale, M.C. (2003). The structure of genetic and environmental risk factors for common psychiatric and substance use disorders in men and women. *Archives of General Psychiatry*, 60, 929-937.
- Klein, D.N. & Riso, L.P. (1993). Psychiatric Disorders: Problems of Boundaries and Comorbidity. In Costello, C.G. (Ed.) *Basic issues in psychopathology*. (pp.19-66). New York: Guilford Press.
- Koch, M. (1999). The neurobiology of startle. *Progress in Neurobiology*, 59, 107-128. doi:10.1016/S0301-0082(98)00098-7
- Krueger, R.F. (1999). The structure of common mental disorders. *Archives of General Psychiatry*, 56, 921-926.
- Kumari, V., Kaviani, H., Raven, P.W., Gray, J.A., & Checkley, S.A. (2001). Enhanced startle reactions to acoustic stimuli in patients with obsessive-compulsive disorder, *American Journal of Psychiatry*, 158, 134-136. doi:10.1176/appi.ajp.158.1.134
- Lang, P. J. (1995). The emotion probe: studies of motivation and attention, *The American Psychologist*, 50, 372-85. doi:10.1037//0003-066X.50.5.372
- Lang, P.J., & Bradley, M.M. (2010). Emotion and the motivational brain. *Biological Psychology*, 84: 437-450. doi:10.1016/j.biopsycho.2009.10.007
- Lang, P.J., Bradley, M. M., & Cuthbert, B. N. (1990). Emotion, attention, and the startle reflex. *Psychological Review*, 97, 377-395.

- 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.
- Larson, C.L., Nitschke, J.B., & Davidson, R.J. (2007). Common and distinct patterns of affective response in dimensions of anxiety and depression. *Emotion, 7*, 182-191. doi:10.1037/1528-3542.7.1.182
- Leckman, J. F., Denys, D., Simpson, B. H., Matiax-Cols, D., Hollander, E., Saxena, S., . . . Stein, D.J. (2010). Obsessive-compulsive disorder: a review of the diagnostic criteria and possible subtypes and dimensional specifiers for DSM-V. *Depression and Anxiety, 27*, 507 – 527. doi:10.1002/da.20669
- Lilenfeld, L.R., Kaye, W.H., Greeno, C.G., Merikangas, K.R., Plotnicov, K., Pollice, C., et al. (1998). A controlled family study of anorexia nervosa and bulimia nervosa: psychiatric disorders in first-degree relatives and effects of proband comorbidity. *Archives of General Psychiatry, 55*, 603-610. doi:10.1001/archpsyc.55.7.603
- Luce, K.H. & Crowther, J.H. (1999). The reliability of the eating disorder examination self-report questionnaire version (EDE-Q). *International Journal of Eating Disorders, 25*, 349–351. doi:10.1002/(SICI)1098-108X(199904)25:3<349::AID-EAT15>3.3.CO;2-D
- Matsunaga, H., Kiriike, N., Miyata, A., Iwasaki, Y., Matsui, T., Fujimoto, K., et al. (1999). Prevalence and symptomatology of comorbid obsessive–compulsive disorder among bulimic patients, *Psychiatry and Clinical Neuroscience, 53*, 661–666. doi:10.1046/j.1440-1819.1999.00622.x
- Mauler, B. I., Hamm, A. O., Weike, A. I., & Tuschen-Caffier, B. (2006). Affect regulation and food intake in bulimia nervosa: emotional responding to food cues after deprivation and subsequent eating. *Journal of Abnormal Psychology, 115*, 567–579. doi:10.1037/0021-843X.115.3.567
- McTeague, L. M., Lang, P. J., Laplante, M. C., Cuthbert, B. N., Strauss, C. C., & Bradley, M. M. (2009). Fearful imagery in social phobia: Generalization, comorbidity, and physiological reactivity. *Biological Psychiatry, 65*, 374-382. doi: 10.1016/j.biopsych.2008.09.023.

- Milos, G., Spindler, A., Ruggiero, G., Klaghofer, R., & Schnyder, U. (2002). Comorbidity of obsessive-compulsive disorders and duration of eating disorders. *International Journal of Eating Disorders, 31*, 284-289. doi:10.1002/eat.10013
- Neale, M. C., & Kendler, K. S. (1995). Models of comorbidity for multifactorial disorders., *American Journal of Human Genetics, 57*, 935.
- Nelson, B., Shankman, S., Olino, T., & Klein, D. (2011). Defining reactivity: How several methodological decisions can affect conclusions about emotional reactivity in psychopathology. *Cognition and Emotion, 25*, 1439 – 1459. doi:10.1080/02699931.2010.551185
- Nitschke, J.B., Larson, C.L., Smoller, M.J., Navin, S.D., Pederson, A.J., Ruffalo, D., et al. (2002). Startle potentiation in aversive anticipation: evidence for state but not trait effects. *Psychophysiology 39*, 254– 258. doi:10.1111/1469-8986.3920254
- Nitschke, J.B., Sarinopoulos, I., Mackiewicz, K.L., Schaefer, H.S., & Davidson, R.J. (2006). Functional neuroanatomy of aversion and its anticipation. *Neuroimage, 29*, 106-116. doi:10.1016/j.neuroimage.2005.06.068
- Phillips, M.L., Marks, I.M., Senior, C., Lythgoe, D., O'Dwyer, A.M., Meehan, O., et al. (2000). A differential neural response in obsessive-compulsive disorder patients with washing compared with checking symptoms to disgust. *Psychological Medicine, 30*, 1037–1050. doi:10.1017/S0033291799002652
- Rhee, S. H., Hewitt, J. K., Corley, R. P., Willcutt, E. G., & Pennington, B. F. (2005). Testing hypotheses regarding the causes of comorbidity: Examining the underlying deficits of comorbid disorders. *Journal of Abnormal Psychology, 114*, 346-362. doi:10.1037/0021-843X.114.3.346
- Robinson, T. E., & Berridge, K. C. (2000). The psychology and neurobiology of addiction: an incentive-sensitization view. *Addiction, 95*, 91-117. doi:10.1080/09652140050111681
- Roefs, A., Herman, C.P., MacLeod, C.M., Smulders, F.T.Y., & Jansen, A. (2005). At first sight. How do restrained eaters evaluate high-fat palatable foods? *Appetite, 44*, 103–114.

- Ruscio, A.M., Stein, D.J., Chiu, W.T., & Kessler, R.C. (2010). The epidemiology of obsessive-compulsive disorder in the National Comorbidity Survey Replication. *Molecular Psychiatry*, *15*, 53-63. doi:10.1038/mp.2008.94
- Sallet, P.C., de Alvarenga, P.G., Ferrao, Y., de Mathis, M.A., Torres, A.R., Fleitlich-Bilyk, B. (2010). Eating disorders in patients with Obsessive-Compulsive Disorder: Prevalence and clinical correlates. *International Journal of Eating Disorders*, *43*, 315-325. doi:10.1002/eat.20697
- Shapira, N. A., Liu, Y. , He, A.G., Bradley, M.M., Lessig, M.C. James, G.A., et al. (2003). Brain activation by disgust-inducing pictures in obsessive-compulsive disorder, *Biological Psychiatry*, *54*, 751-756. doi:10.1016/S0006-3223(03)00003
- Smyth, J. M., Wonderlich, S. A., Heron, K. E., Sliwinski, M. J., Crosby, R. D., Mitchell, J. E., & Engel, S. G. (2007). Daily and momentary mood and stress are associated with binge eating and vomiting in bulimia nervosa patients in the natural environment. *Journal of Consulting and Clinical Psychology*, *75*, 629-638. doi:10.1037/0022-006X.75.4.629
- Speranza, M., Corcos, M., Godart, N., Loas, G., Guilbaud, O., Jeammet, P., & Flament, M. (2001). Obsessive compulsive disorders in eating disorders. *Eating Behaviours*, *2*, 193-207. doi:10.1016/S1471-0153(01)00035-6
- Suárez, L., Bennett, S., Goldstein, C., & Barlow, D.H. (2009). Understanding anxiety disorders from a “triple vulnerabilities” framework. In: Antony, M.M., & Stein, M.B., editors. *Oxford handbook of anxiety and related disorders*. New York: Oxford. pp. 153-172.
- Svaldi, J., Griepenstroh, J., Tuschen-Caffier, B., & Ehring, T. (2012). Emotion regulation deficits in eating disorders: A marker of eating pathology or general psychopathology? *Psychiatry Research*, *197*, 103-111. doi:10.1016/j.psychres.2011.11.009
- Swinbourne, J. M., & Touyz, S. W. (2007). The co-morbidity of eating disorders and anxiety disorders: a review. *European Eating Disorders Review*, *15*, 253-274. doi: 10.1002/erv.784

- Szechtman, H., & Woody, E. (2004). Obsessive-Compulsive Disorder as a disturbance of security motivation. *Psychological Review*, *111*, 111-127. doi:10.1037/0033-295X.111.1.111
- Thornton, C. & Russell, J. (1997). Obsessive compulsive comorbidity in the dieting disorders. *International Journal of Eating Disorders*, *21*, 83-87. doi:10.1002/(SICI)1098-108X(199701)21:1<83::AID-EAT10>3.0.CO;2-P
- Torres, A.R., Prince, M.J., Bebbington P. L., et al. (2006). Obsessive-compulsive disorder: prevalence, comorbidity, impact and help-seeking in the British National Psychiatric Morbidity Survey of 2000. *American Journal of Psychiatry*, *163*, 1978–1985. doi:10.1176/appi.ajp.163.11.1978
- Vaidyanathan, U., Patrick, C.J., & Cuthbert, B.N. (2009). Linking dimensional models of internalizing psychopathology to neurobiological systems: Affect-modulated startle as an indicator of fear and distress disorders and affiliated traits. *Psychological Bulletin*, *135*, 909-942.
- Watson, D. (2005). Rethinking the mood and anxiety disorders: A quantitative hierarchical model for DSM-V. *Journal of Abnormal Psychology*, *114*, 522-536.
- Watson, D., & Wu, K. D. (2005). Development and validation of the Schedule of Compulsions, Obsessions, and Pathological Impulses (SCOPI). *Assessment*, *12*, 50–65. doi:10.1177/1073191104271483
- Wilson, G., Kumari, V., Gray, J. & Corr, P. (2000). The role of neuroticism in startle reactions to fearful and disgusting stimuli. *Personality and Individual Differences*, *29*, 1077 – 1082. doi:10.1016/S0191-8869(99)00255-X
- Womble, L. G., Williamson, D. A., Martin, C. K., Zucker, N. L., Thaw, J. M., Netemeyer, R., Lovejoy, J. C., et al. (2001). Psychosocial variables associated with binge eating in obese males and females. *International Journal of Eating Disorders*, *30*, 217-221. doi:10.1002/eat.1076

Footnote

¹ The aforementioned studies also highlight the heterogeneity of anxiety disorders and that startle potentiation during viewing of aversive scenes is more associated with fear-related disorders (e.g., social phobia) than with distress-related disorders (e.g., depression/GAD; Watson, 2005; Vaidyanathan et al., 2009).

² IAPS pictures included: food- 7200, 7220, 7230, 7340, 7350, 7402, 7405, 7410, 7430, 7451, 7461, 7470; contamination - 2730, 9290, 9291, 9300, 9301, 9302, 9340, 9341, 9390, 9395; threat - 1050, 1120, 1300, 1525, 1932, 6230, 6242, 6250, 6510, 6560; and neutral - 5395, 7002, 7010, 7012, 7055, 7100, 7150, 7161, 7175, 7248.

³ The pattern of results for the PIC, ANTIC, and POST-PIC phases of the food picture analyses were identical when Deprivation Time was not included as a covariate.

⁴ We thank one of the anonymous reviewers for raising this point.

Table 1.

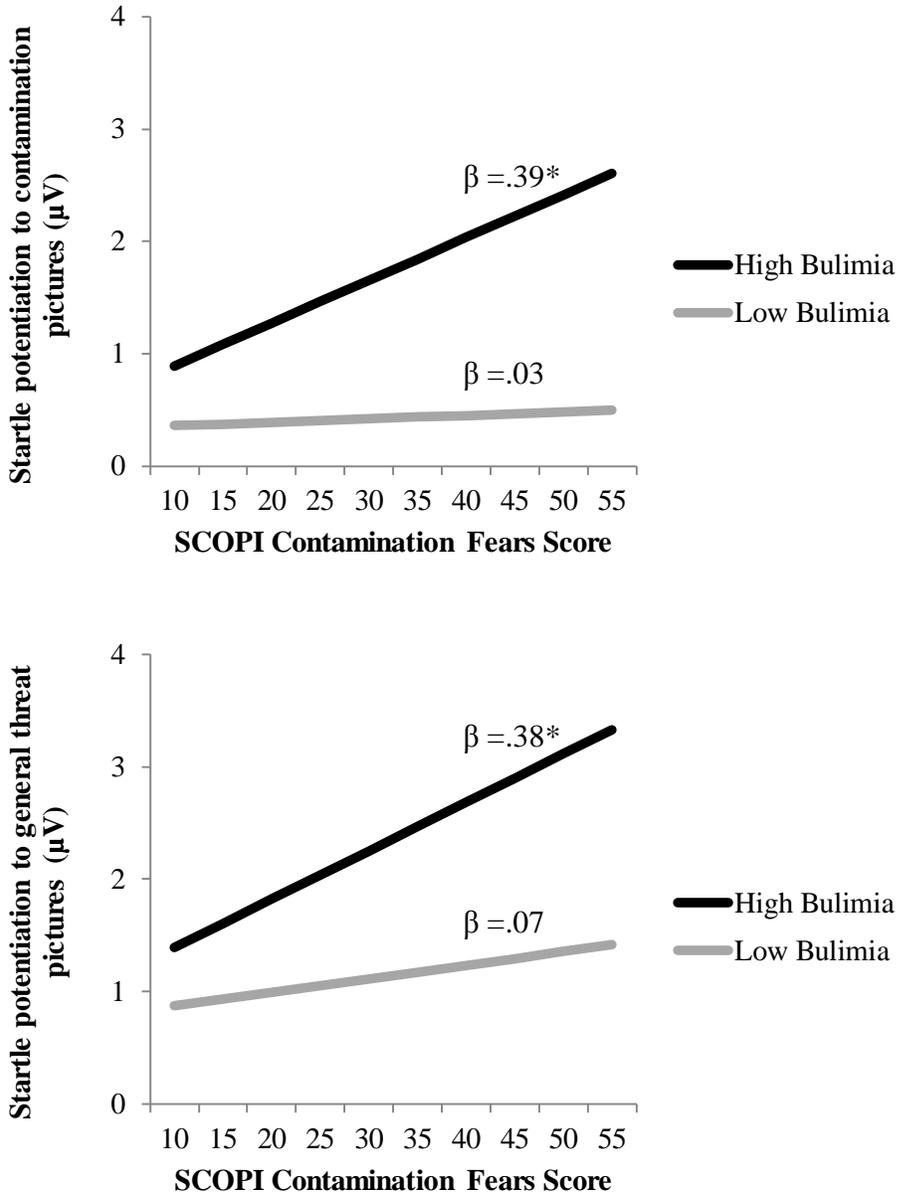
Demographics and Clinical Characteristics

Variable	<i>M</i>	<i>SD</i>	Range
Age	20.00	2.95	18.11 - 43.43
BMI	23.66	5.45	16.91-43.91
Ethnicity			
Caucasian		35.1%	
African-American		9.6%	
Latino		24.6%	
Asian or Pacific Islander		22.8%	
Other		7.9%	
EDI-3 Bulimia	15.24	6.20	7 - 38
SCOPI Contamination Fears	35.25	8.88	14 - 57

Note. BMI = Body Mass Index; EDI-3 = Eating Disorder Inventory-3; SCOPI = Schedule of Compulsions, Obsessions, and Pathological Impulses.

Figure 1.

Bulimia Symptoms Moderates the Effect of Contamination Fears on Startle Potentiation during Presentation of Contamination Pictures (Top) and General Threat Pictures (Bottom)



Note. Startle data were square root transformed.

* $p < .05$.