Ignorance is Bliss:

Increasing Predictability Increases Fear Generalization in Individuals With Higher Neuroticism

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Abstract

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Fear generalization is a key player in understanding why some individuals feel unsafe in objectively non-threatening situations. Although fear is adaptive, it can persist when conditioned fear responses spread to similar but innocuous stimuli, leading to a proliferation of danger cues. Key constructs that may influence fear generalization are neuroticism, a personality trait associated with increased susceptibility to negative reactions (Barlow, Sauer-Zavala, Carl, Bullis, & Ellard, 2013), and unpredictability, a state of lacking foreknowledge about the likelihood of future aversive outcomes, which has been associated with increased psychological and physiological stress (e.g., Grillon, Baas, Cornwell, & Johnson, 2006). Undergraduates ($N = 129$) with varying degrees of neuroticism were randomized to high and low predictability conditions prior to fear acquisition. A fear generalization task measured online risk appraisals and attentional bias on a modified dot-probe paradigm in response to ambiguous stimuli morphed on a continuum between conditioned danger and safety cues. A go/no-go task measured inhibitory

control to examine its relationship with fear generalization. For those in the high predictability condition, individuals with higher neuroticism reported higher online risk ratings and increased attentional bias toward highly ambiguous stimuli. When ambiguous stimuli approached safety, these same individuals reported lower online risk ratings and increased attentional bias towards control stimuli. Fear generalization and response inhibition were not strongly correlated. Overall, increasing predictability information backfired for individuals with higher neuroticism in that increased fear of ambiguous stimuli. Predictability information may be iatrogenic when neuroticism is high and threat is ambiguous.

Ignorance is Bliss: Increasing Predictability Increases Fear Generalization in Individuals With Higher Neuroticism

Fear is a natural, commonplace, and adaptive emotional response that humans experience. However, fear can be maladaptive when fear persists even though the danger does not. One way in which fear learning can go awry is the process of fear overgeneralization, the tendency to extend conditioned fear responses to stimuli that resemble conditioned danger cues but are objectively not dangerous. Classical fear conditioning readily explains how a previously neutral conditioned stimulus comes to elicit conditioned fear (CS) after being paired with aversive unconditioned stimulus (US; Pavlov, 1927). For example, an individual who is bitten by the neighbor's dog may learn to fear that dog following the attack. Fear generalization may explain how that same individual may also come to fear other dogs with similar characteristics, animals in general, or even the place in which the attack occurred. This process can be conceptualized on a generalization gradient where a conditioned fear response gets weaker as stimuli become increasingly dissimilar to the feared conditioned stimulus (Lissek et al., 2008).

Similar to the experience of fear, the capacity to broadly generalize fear has also been considered to serve an adaptive function (e.g., Mineka, 1992). In an ever-changing world, an organism is more likely to survive if it learns to avoid potentially harmful stimuli. When an organism is faced with a novel stimulus, the organism may generalize previous learning based on the associative strength of characteristics shared with a similar conditioned stimulus (e.g., McLaren & Mackintosh, 2002). Generalization may then become maladaptive when individuals detect excessive threat in the face of innocuous cues, based on their similarity to a conditioned fear stimulus (Dusmoor, Mitroff, & LaBar, 2009). Lissek (2012) proposed that this form of exaggerated fear learning may be an underlying mechanism that explains why certain individuals

react fearfully to stimuli that do not in fact signal danger but somehow bear resemblance to aspects of the original conditioned danger cue. A proliferation of fear cues becomes detrimental to an individual's ability to register safety and may help explain the presence of exacerbated fear responding (Lissek, 2012).

The study of fear generalization in humans has grown substantially in the past decade (see Dymond, Dunsmoor, Vervliet, Roche, & Hermans, 2014, for a review). Lissek et al. (2008) developed a fear generalization paradigm that uses ten rings of gradually increasing size as conditioned stimuli and generalization stimuli. The largest or the smallest rings serves as the conditioned danger cue (CS+) and the conditioned safety cue (CS-), the former paired and the latter unpaired with an aversive conditioned stimulus; eight intermediately sized rings serve as generalization stimuli that form a continuum of similarity between the conditioned danger and safety cues. This paradigm found overgeneralization in patients with panic disorder (Lissek et al., 2010) and generalized anxiety disorder (GAD; Lissek et al., 2014a) compared to healthy controls. Subsequent research has employed neuroimaging to examine brain areas associated with fear generalization. In healthy adults, brain areas associated with fear arousal, such as the amygdala, stiatum, insula, and thalamus, show increased activation as stimuli become increasingly similar to CS+ (Dunsmoor, Prince, Murty, Kragel & LaBar, 2011; Lissek et al., 2014b), whereas brain areas associated with fear inhibition, such as the ventromedial prefrontal cortex (vmPFC) and ventral hippocampus, show increased activation as stimuli become increasingly similar to CS- (Lissek et al., 2014b). Consistent with these findings, individuals with GAD have shown deficient vmPFC function along a generalization gradient compared to healthy controls (Greenberg, Carlson, Cha, Hakack, & Mujica-Parodi, 2013). Fear generalization has been tested with a variety of stimuli, including faces (Dunsmoor, Prince, Murty, Kragel, &

LaBar, 2011; Glenn, Lieberman, & Hajcak, 2012), geometric shapes (e.g., Lissek et al., 2008), auditory stimuli (Norrholm et al., 2011), and wavelength color, (Dunsmoor & LaBar, 2013), suggesting that fear generalization is a robust phenomenon that can extend from simple paradigms to more complex models of fear learning.

Two factors that may underlie the degree to which fear generalizes are neuroticism and predictability. Neuroticism, a personality trait defined as a "tendency to experience negative, distressing emotions and to possess associated behavioral and cognitive traits" (p. 301, Costa & McCrae, 1987), may be a risk factor for fear overgeneralization. This increased tendency to respond with negative emotions to threat, loss, and frustration has been shown to be robustly correlated with a wide variety of both mental and physical health problems, making it a topic of profound public health significance (Lahey, 2009). More specifically, in a meta-analysis, a large association was found between neuroticism and anxiety disorders, suggesting that neuroticism may be a strong predictor of anxious responding (Maluoff, Thorsteinsson, & Schutte, 2005). Individuals with high levels of neuroticism are both more likely to experience stressful events and to react with more heightened and less regulated emotional responses to those life stressors (Lahey, 2009). Higher neuroticism is associated with greater sympathetic and hypothalamic-pituitary-adrenal reactivity (Futterman, Kemeny, Shapiro, & Fahey, 1994), as well as attenuated conditioned inhibition (He, Cassaday, Bonardi & Bibby, 2013). Neuroticism has been identified as a risk factor for developing anxiety and depression following negative life events (Fanous et al., 2002; Hutchinson & Williams, 2007) and may lead individuals to be particularly susceptible to negative affect in the face of uncertainty and ambiguity (Barlow, Sauer-Zavela, Carl, Bullis, & Ellard, 2013). Thus, neuroticism holds promise as a potential predictor of fear generalization.

The degree to which individuals feel that they can predict outcomes based on the presence or absence of a particular signal may influence the degree to which fear generalizes (e.g., Foa, Zinbarg, & Rothbaum, 1992). Unpredictability has been found to increase stress compared to conditions in which there is foreknowledge about the likelihood of a future aversive outcome, suggesting that predictability may serve to buffer fear. In the laboratory, animals consistently prefer a predictable over unpredictable US (e.g., shock), and unpredictable stressors are associated with more deleterious physiological and behavioral consequences compared to predictable stressors (Mineka & Kihlstrom, 1978). In healthy individuals, unpredictable stressors have been associated with increased behavioral avoidance, startle response, and subjective anxiety (Grillon, Baas, Cornwell, & Johnson, 2006). In clinical samples, patients with panic disorder (Grillon et al., 2008) and posttraumatic stress disorder (Grillon et al., 2009) experience heightened anxiety during periods of unpredictable, but not predictable threat. This vulnerability to unpredictability suggests that predictability may dampen stressful reactions for individuals prone to anxious responding, such as those with higher neuroticism.

Another candidate predictor of fear overgeneralization is deficient inhibition. Inhibitory control, defined as the ability to withhold responses to stimuli, is often considered a central component of executive functioning (Wright, Lipszyc, Dupuis, Thayaparajah, & Schachar, 2014), which in turn has been implicated as key player in adaptive fear learning (e.g., Lissek et al., 2005). Exaggerated fear responses are theorized to result from weak inhibitory control of the amygdala by the prefrontal cortex (Jovanovic & Ressler, 2010). Consistent with this, increased inhibitory control is consistently associated with frontal lobe activation in neuroimaging studies (e.g., Mostofsky et al., 2003; Wager et al., 2005). Furthermore, greater inhibitory control has been associated with improved treatment outcomes for fear-based disorders (Falconer, Allen,

Felmingham, Williams, & Bryant, 2013), suggesting that impairments in inhibition may be a risk factor for maladaptive fear learning such as fear overgeneralization. A commonly used measure of inhibitory control is the traditional go/no-go task, which involves two stimuli: a go stimulus and a no/go stimulus (Simmonds, Pekar, & Mostofsky, 2008). In these tasks, participants are instructed to respond rapidly to go stimuli and appropriately withhold responses to no-go stimuli, and failure to do the latter is indicative of inhibitory control deficits (Wright et al., 2014). An fMRI study examining the relationship between fear inhibition and performance on a go/no-go task found that impaired inhibition was associated with reduced neural activation of the prefrontal cortex during the go/no-go task (Jovanovic, Ely, Fani, Glover, & Gutman, 2013), lending support to the theory that inhibitory control may play a role in the modulation of fear.

Although fear generalization is a well-known phenomenon, we are not aware of any studies that have examined its relationship with neuroticism. Similarly, lack of predictability has been linked to increased fear arousal but not to the specific construct of fear generalization. The present study examined the interaction of predictability and neuroticism on the generalization of fear, as well as the relationship between fear generalization and inhibitory control. We measured trait neuroticism, manipulated whether individuals received predictability information prior to a fear generalization task, and examined fear generalization by measuring attentional bias and online risk ratings to stimuli across a generalization gradient. We also used a go/no-go task to examine the extent to which fear generalization was associated with inhibitory control. We hypothesized an interaction between neuroticism and predictability on the generalization of fear, such that individuals with higher neuroticism and low predictability would demonstrate greater fear as evidenced by greater attentional bias and higher online risk ratings on the fear generalization task. We also hypothesized that greater fear in the fear generalization task would

be associated with lower levels of inhibitory control as evidenced by decreased accuracy on the go/no-go task.

Method

Participants

Participants ($N = 129$) were undergraduate psychology students at a large metropolitan university. Students in introductory-level psychology classes participated in a psychology subject pool to sign up for a study examining how and why people react to different faces. Individuals who reported being between the ages of 18 and 65 years, fluent in English, and having normal or corrected hearing and vision were eligible to participate in the study. See Table 1 for participant characteristics.

Measures

Demographics questionnaire. This brief 12-item questionnaire included questions about gender, age, ethnicity, education level, and visual and auditory impairments.

Eysenck Personality Questionnaire - Revised Neurocitism (EPQ-R-N; Eysenck, Eysenck, & Barett, 1985). The 24-item EPQ-R-N scale assesses negative trait emotionality, including unstable mood, high reactivity to emotional stimuli, anxiety, and depression. Responses were dichotomous (1 = *no*, 2 = *yes),* with higher scores indicating higher levels of neuroticism. The EPQ-R has demonstrated good internal consistency ($\alpha = .85$ - .88, Eysenck et al., 1985), and the N scale has shown good test-retest reliability ($r = .89$, Eysenck & Eysenck, 1991).

Beck Depression Inventory (BDI-II; Beck, Steer, Ball, & Ranieri, 1996). The BDI-II is a 21-item self-report rating inventory that measures characteristic attitudes and symptoms of depression. Items are rated on a four-point Likert scale, and the anchors varying on the content of

each item (e.g., 0 = *I do not feel sad*; 3 = *I am so sad or unhappy I can't stand it*). BDI-II scores are calculated by summing responses to all items, with higher scores indicating more severe depression. The BDI-II has high internal consistency (α = .91, Beck et al., 1996) and good convergent validity with the Hamilton Psychiatric Rating Scale for Depression (r = .71, Beck et al., 1996) and the Beck Anxiety Inventory (r = .66, Beck et al., 1996).

State-Trait Anxiety Inventory (STAI; Spielberger et al., 1983). The STAI is a 40-item self-report measure of anxiety that examines both state (temporary; STAI-S) anxiety and trait (long-standing; STAI-T) anxiety scales. Items are rated on a four-point Likert scale (1 = *not at all*, 2 = *somewhat*, 3 = *moderately*, 4 = *very much so*). State and trait scales are separately scored by summing the responses to the twenty associated items for each scale, with higher scores indicating greater anxiety. The STAI-T has demonstrated good test-retest reliability (r = .73 - .86; Spielberger et al., 1983) and good convergent validity with other measures of trait anxiety (r = .52 - .80; Spielberger et al., 1983)

PTSD Scale-Self Report for DSM-5 (PS-SR5; Foa et al., 2015). The PS-SR5 is a 24-item self-report questionnaire that uses a trauma screen to identify prior exposure to specific traumatic events (i.e., serious life-threatening illness, physical assault, sexual assault, military combat, childhood abuse, accident, natural disaster, or other) and assesses the severity of DSM-5 PTSD symptoms related to the worst event. The PS-SR5 includes 20 questions that assess symptom severity, two questions that assess distress and interference, and two questions that assess symptom onset and duration. Responses to the symptom severity and distress and interference items were provided on 5-point Likert scale (0 = *not at all*, 1 = *once a week or less/a little*; 2 = *two to three times a week/somewhat*, 3 = *four to five times a week/very much*, 4 = *six or more times a week/severe*), and symptom severity was calculated by summing the 20 symptom

severity items, with higher total scores indicating higher symptom severity. The symptom onset and duration questions had two answer choices (onset: *less than 6 months*, *more than 6 months*; duration: *less than 1 month*, *more than 1 month).* In this study, the PS-SR5 was used as a continuous measure of PTSD severity only for participants who endorsed DSM-5 trauma exposure and related symptoms for at least one month. An earlier version of this measure, the Posttraumatic Diagnostic Scale, has diagnostic test-retest reliability of .83 (Foa, Cashman, Jaycox, & Perry, 1997) and is highly correlated with the PTSD Symptom Scale-Interview Version (r = .78, Powers, Gillihan, Rosenfield, Jerud, & Foa, 2012).

Paradigms

Fear generalization task. This task was based on existing generalization paradigms (Haddad, Lissek, Pine, & Lau, 2011; Haddad, Xu, Raeder, & Lau, 2012; Lissek et al., 2008) and programmed on E-Prime 2.0 software (Psychology Software Tools, Pittsburgh, PA). Two female neutral faces from the NimStim Set of Facial Expressions (Tottenham et al., 2009) served as the conditioned fear cue (CS+) and the conditioned safety cue (CS-), the former paired and the latter unpaired with an aversive unconditioned stimulus (US). The US consisted of a loud scream (Lau, 2008), 1s and 95 decibels, delivered through headphones and paired with a fearful face made by the same woman that served as the CS+. The "screaming lady" is a well-established paradigm that provides a strong conceptual association between the CS+ and US, and is relevant to biologically prepared fears (e.g., Haddad et al., 2012). The generalization stimuli (GS1, GS2, GS3, GS4) were gradually morphed versions of the CS+ and CS- ("Morpheus Photo Morpher", n.d.), designed to form a continuum of similarity between the conditioned stimuli (where GS1 most closely resembled CS+), thus examining fear responses across a generalization gradient. Two additional female neutral faces from the NimStim Set of Facial Expressions (Tottenham et

al., 2009) served as control stimuli. The fear generalization task consisted of four phases: pre-acquisition, acquisition, fear generalization test, and retrospective US distress ratings.

Phase 1: Pre-Acquisition. Six CS+, six CS-, 12 control stimuli, and 24 inter-trial intervals (ITIs), all without the US, were presented. In addition to familiarizing participants with the conditioned stimuli, it ensured equal exposure to all stimuli by the fear generalization task, in order to reduce novelty bias during the dot probe task. Stimuli were presented for 2s, with 1900ms ITIs.

Phase 2: Acquisition. Predictability was systematically manipulated at the beginning of the acquisition phase by randomizing participants to either high predictability or low predictability conditions. Participants in the high predictability condition were given additional information to enhance the predictability of the unconditioned stimulus during the study, whereas participants in the low predictability condition were not given additional information.

The high predictability instructions read: *"Now, you will see more faces. To enhance your sense of predictability, we will tell you exactly what is going to happen for the remainder of the experiment. This face [image of CS+] will almost always be followed by a screaming face. This face [image of CS-] will never be followed by a screaming face."*

The low predictability instructions read: *"Now you will see more faces."*

In both conditions, twelve conditioned fear cues (CS+) and twelve conditioned safety cues (CS-), with 24 ITIs were presented, in order to teach participants the US contingency. CS+ and CS- were counterbalanced and all stimuli were presented for 2s, with 1900ms ITIs. The CS+ co-terminated with the US 75% of the time, in order to maximize learning from a partial reinforcement schedule (Haddad, Lissek, Pine, & Lau, 2011). The remaining trials culminated with a blank screen for 1s.

Acquisition learning was assessed after the acquisition task via US expectancy ratings for the conditioned stimuli. The CS+ or CS- was presented and participants were instructed to "rate the likelihood of hearing a loud scream on a scale of 1-7" (1 = *extremely unlikely*, 7 = *extremely likely*). The US expectancy ratings were randomly ordered and never followed by the US.

Five participants were excluded because they did not learn the US contingency at acquisition, defined as having no difference in US expectancy ratings between CS+ and CS-.

Phase 3: Fear Generalization Test. To examine fear responses across the generalization gradient, online risk rating task blocks and dot probe task blocks were provided for conditioned stimuli (CS+ and CS-) and generalization stimuli (GS1, GS2, GS3, GS4). The fear generalization test alternated between four online risk rating task blocks and three dot probe task blocks, for a total of seven fear generalization test blocks. Across trials, the CS+ co-terminated with the US for 1s 50% of the time, in order to continue providing US reinforcement, but at a less frequent, random schedule compared to the acquisition phase. The remaining trials culminated with a blank screen for 1s. All trials also culminated with a 1900ms ITI.

Online risk ratings. Online risk ratings were collected to assess the degree of risk associated with each stimulus (e.g., Lissek et al., 2010). Four online risk rating task blocks consisted of 6 trials each for a total of 24 online risk rating trials, in addition to eight practice trials at the beginning using blank face placeholders. Stimuli were randomly presented for 500ms and appeared simultaneously with the prompt "Level of Risk?" Participants provided ratings on a 7-point Likert scale (1 = *no risk*, 7 = *high risk*).

Dot probe task. A dot probe task (e.g., Haddad et al., 2011) was used to assess presence and degree of attentional bias towards test stimuli (CS and GS stimuli), relative to control stimuli. Three dot probe blocks consisted of 16 trials each for a total of 48 dot probe trials, in

addition to eight practice trials at the beginning again using blank face placeholders. Each trial began with a 500ms central fixation point, a single + situated in the center of the screen, followed by pairs of faces that were presented for 500ms, one on the left side and one on the right side of the screen. The pair of faces always included one of the six test stimuli and one of two control stimuli. Once the pair of faces disappeared, a single asterisk probe appeared on the left or right side of the screen for 1100ms, which indicated whether participants should press left or right on a keyboard. Participants were instructed to focus on the fixation cross and then indicate the location of the asterisk probe on a keyboard as quickly as possible during the 1100ms. The stimuli and their location were counterbalanced. The location of the asterisk probe was also counterbalanced, such that the asterisk probes appeared equally on each side of the screen. The order of presentation after counterbalancing was random. The main dependent variable was attentional bias score, which was calculated by subtracting reaction times on congruent trials, where probes followed the test stimuli, from reaction times on incongruent trials, where probes followed the control stimuli. Positive attentional bias scores indicate an attentional bias towards the test stimuli (Haddad et al., 2011), with higher scores reflecting greater perception of threat (Bar-Haim, Lamy, Pergamin, Bakermans-Kranenburg, & van IJzendoorn, 2007; Britton, Lissek, Grillon, Norcross, & Pine, 2011; Cisler & Koster, 2010). Seven participants were excluded for having less than 50% accuracy scores.

Phase 4: Retrospective US Distress Ratings. Retrospective US Distress ratings were assessed to examine how distressed participants were by the US. The peak distress instructions read: "What was your highest level of distress in response to the loud scream you heard through the headphones?" The end distress instructions read: "By the end of the task, how distressed were you by the loud scream you heard through the headphones?" Peak distress and end distress

were rated using a 7-pointLikert scale (1 = *not at all distressed*, 7 = *highly distressed*).

Response inhibition go/no-go task. A simple go/no-go task (Falconer et al., 2008; Falconer et al., 2013) was also programmed on E-Prime 2.0 software (Psychology Software Tools, Pittsburgh, PA). In the go/no-go task, the word "PRESS" was repeatedly presented on a black computer screen for 500ms. Participants were instructed to press the spacebar when the word "PRESS" appeared in green and to inhibit a response when the word "PRESS" appeared in red. Thus, green signaled "go" and red signaled "no-go". The test phase consisted of 84 randomly presented trials, 75% of which were "go" trials (n = 63) and the remaining 25% of which were "no go" trials (n = 21), in order to create a tendency to respond (Falconer et al., 2013). The response time limit was the duration of the stimulus, and reaction times were assessed. A practice phase consisted of eight practice trials, six of which were "go" targets, and two of which were "no-go" targets, after which participants were informed that the real task was about to begin. Half way through the trials, participants were given a 20s break. All trials culminated with a 1143ms ITI. The main dependent variable for this task was a discrimination score, which was calculated by subtracting "false alarm rate", defined as percent of "no-go" trials that were incorrectly followed by a spacebar press, from "hit rate", defined as percent of "go" trials that were correctly followed by a spacebar press (Macmillan & Creelman, 2005).

Because stimulus discrimination required participants to differentiate between different colored words, red-green color blindness was assessed before and after the go-no/go task. Before the task, participants responded to four Ishihara Color Blindness Test Plates: 2, 4, 8, and 11 ("Isihara Color Test", n.d.). At the end of the task, participants were asked if they were able to discriminate between the red and green stimuli by indicating "yes" or "no" on a keyboard. Five participants had less than 100% accuracy on the Isihara Test Plates, and another two participants

responded “no” to being able to discriminate between red and green. However, all participants demonstrated greater than 90 percent accuracy on the go/no-go task, providing confidence to retain these participants in the analyses. However, two participants were removed due to multivariate outliers between this task and the fear generalization task.

Procedures

Study procedures took place in a large computer lab, equipped with PC computers with 18-inch color monitors, Windows XP software, and headphones. Participants were run in groups of four to eight and seated at individual computers and given headphones to wear. Computer stations were set up so that participants could not see other computer screens and were seated far away enough from each other so that the sound of the US could not be heard from another computer station. Stimuli were presented at a viewing distance of approximately 18 inches. After providing informed consent, participants completed EPQ-R-N and demographics self-report questionnaires. Participants then completed the fear generalization task and the go/no-go task. The order of the tasks was counterbalanced. For the fear generalization task, participants were randomized to either the high predictability condition or the low predictability condition. Upon completion of study procedures, participants were debriefed and compensated with course credit.

Results

Fear Generalization Task: Acquisition Phase

We used *t*-tests to examine differences in acquisition learning of the conditioned stimuli (CS+ and CS-) after the predictability manipulation between the high predictability and low predictability conditions. Means and standard deviations can be seen in Table 2. As expected, participants correctly learned the US contingency, as demonstrated by higher US expectancy ratings for the CS+ ($M = 5.96$, $SD = .91$) compared to the CS- ($M = 1.18$, $SD = .65$), $t(116) =$

50.35, $p < .001$, $d = 6.04$). The high and low predictability conditions did not differ in their post-acquisition US expectancy rating of CS+ (high predictability $M = 5.85$, $SD = 0.85$; low predictability $M = 6.07$, $SD = 0.97$) but did differ in their post-acquisition US expectancy rating of CS-, $t(115) = 2.30$, $p = .02$, $d = 0.41$, such that those in the high predictability condition ($M = 1.05$, $SD = 0.28$) had lower US expectancy ratings for the conditioned safety cue than the low predictability condition ($M = 1.32$, $SD = 0.88$). In other words, consistent with the manipulation effectively altering risk perceptions, the condition with more predictability information rated the conditioned safety cue as safer, compared to the condition who was left to figure out the US contingency on their own.

Fear Generalization Task: Fear Generalization Test

In order to examine our main hypotheses, we used linear regressions to predict online risk ratings and attentional bias scores. These regression analyses examined the predictors of predictability (high and low), neuroticism (EPQ-R-N), and the interaction effect of predictability x neuroticism. Dependent variables were examined for the two conditioned stimuli (CS+, CS-) and the four generalization stimuli (GS1, GS2, GS3, GS4). Means and standard deviations can be seen in Table 2 across predictability conditions.

Conditioned stimuli (CS+ and CS-). When examining online risk ratings and attentional bias scores, there were no significant main effects of predictability or neuroticism and no interaction of predictability x neuroticism for either the CS+ or CS-. In other words, there were no differences in online risk ratings or attentional bias for the conditioned danger cue and conditioned safety cue when examining predictability, neuroticism, or their interaction.

GS most approximating danger (GS1). When examining online risk ratings and attentional bias scores for the stimulus most approximating the danger cue, there were no

significant main effects of predictability or neuroticism and no interaction of predictability x neuroticism for GS1.

Most ambiguous GS (GS2 and GS3). We examined online risk ratings and attentional bias scores for the two most ambiguous test stimuli (GS2 and GS3).

Online risk ratings. When examining online risk ratings for the most ambiguous test stimuli, there was a main effect of neuroticism (b = -.20, $t(113)$ = -2.25, p = .03), which was modified by a predictability x neuroticism interaction (b = .41, $t(113)$ = 2.12, p = .04). For those in the high predictability condition, there was no simple effect of neuroticism. For those in the low predictability condition, there was a simple effect of neuroticism (b = -.39, $t(54)$ = -3.10, p < .01), such that those with higher neuroticism reported lower online risk ratings. See Figure 1a which shows that for those with higher neuroticism, less predictability led to safer appraisals of ambiguous stimuli. Accordingly, among those with higher neuroticism, the manipulation of increasing predictability increased perceptions of risk.

Attentional bias. When examining attentional bias scores for the most ambiguous stimuli, there was a main effect of predictability (b = -.41, $t(113)$ = -2.03, p = .05), which was modified by a predictability x neuroticism interaction (b = .39, $t(113)$ = 1.94, p = .06). For those in the high predictability condition, there was no simple effect of neuroticism. However, for those in the low predictability condition, there was a simple effect of neuroticism (b = -.29, $t(54)$ = 2.20, p = .03), such that those with higher neuroticism showed a lower attentional bias to the ambiguous stimulus. See Figure 1b. Similar to Figure 1a, among those with higher neuroticism, low predictability was associated with less attention to the ambiguous stimuli. Accordingly, among those with higher neuroticism, the manipulation of increasing predictability increased

attention to the ambiguous stimuli. Consistent with our findings from the online risk ratings, the predictability manipulation increased fear when neuroticism was higher.

GS most approximating safety (GS4). We next examined online risk ratings and attentional bias scores for the test stimulus most approximating the safety cue (GS4).

Online risk ratings. When examining online risk ratings for the stimulus most approximating the safety cue, there were no significant main effects or interactions. See Figure 2a, showing a clear perception that the stimulus was not dangerous, regardless of levels of predictability or neuroticism.

Attentional bias. When examining attentional bias scores, there was a main effect of predictability (b = .40, $t(113)$ = 2.00, p = .05), which was modified by a predictability x neuroticism interaction (b = -.45, $t(113)$ = -2.28, p = .03). For those in the high predictability condition, there was a simple effect of neuroticism (b = -.35, $t(59)$ = -2.89, p = .01), such that those with higher neuroticism demonstrated lower attentional bias to the test stimulus. For those in the low predictability condition, there was no simple effect of neuroticism. See Figure 2b, which shows that having additional predictability information when neuroticism was higher was associated with heightened vigilance toward the control stimulus. As seen in Figure 2a, participants recognized GS4 as clearly safe, which suggests that the attentional bias towards the control stimulus may result from participants with higher neuroticism and high predictability scanning for danger elsewhere in the environment.

Fear Generalization Task: Retrospective US Distress Ratings

US distress ratings were collected at the end of the fear generalization task in order to examine the degree to which participants found the screaming lady US to be aversive. We used similar linear regressions to predict retrospective peak distress, defined as the highest level of

distress caused by the US, and end distress, defined as the level of US distress by the end of the fear generalization task. These analyses examined the predictors of predictability (high and low) and neuroticism (EPQ-R-N), and the interaction effect of predictability x neuroticism.

For peak distress, there was no main effect of predictability or neuroticism, and no significant interaction between predictability x neuroticism. For end distress, there were significant main effects of predictability (b = .48, $t(113) = 2.44$, p = .02) and neuroticism (b = .20, $t(113) = 2.23$, p = .03), which were modified by a predictability x neuroticism interaction (b = -.39, $t(113) = -1.98$, p = .05). For those in the high predictability condition, there was no simple effect of neuroticism on end distress ratings. For those in the low predictability condition, there was a simple effect of neuroticism (b = .38, $t(113) = 3.04$, $p < .01$), such that those with higher neuroticism reported more end distress. In other words, although levels of peak US distress did not differ, participants lacking additional predictability who were higher in neuroticism reported experiencing more US distress at the end of the fear generalization task.

Go/No-Go Task

In order to examine our secondary hypothesis, we used zero-order correlations to explore the relationship between fear generalization and inhibitory control. Fear generalization variables included online risk ratings and attentional bias scores for conditioned stimuli (CS+ and CS-) and generalization stimuli (GS1, GS2, GS3, GS4). See Table 3. There was a trend toward an association between discrimination on the go/no-go task and online risk ratings for GS4, such that those with better discrimination on the go/no-go task reported lower online risk ratings for the stimuli most approximating the safety cue, r = -.18, p = .05. There were no significant associations between discrimination on the go/no-go task and any other stimuli, suggesting that fear generalization was not strongly associated with response inhibition.

Discussion

Increasing predictability for individuals with higher neuroticism did *not* necessarily reduce fear. Although the predictability manipulation reduced end distress to the feared stimulus (CS+) for those with higher neuroticism, the predictability manipulation backfired for these same individuals in the face of generalization stimuli, leading participants with higher neuroticism to provide higher online risk ratings and show more attentional bias towards to most ambiguous stimuli on the generalization gradient. As the generalization stimuli became safer, participants rated the stimuli as clearly safe, but the predictability manipulation still backfired in that it led individuals with higher neuroticism to show a strong attentional bias towards the control stimuli. Either way, providing additional information to individuals with higher neuroticism resulted in heightened fear in the face of generalization stimuli. Importantly, the interaction effect of neuroticism and predictability was more pronounced toward the safety end of the generalization gradient, highlighting the critical role of safety signal learning deficits.

Among individuals with higher neuroticism, increasing predictability information had no effect on attentional bias or online risk ratings of unambiguously risky (CS+) or safe (CS-) stimuli but did have an effect with more ambiguous stimuli. Fear of ambiguous stimuli depended on the degree of ambiguity and perceived risk of the stimulus. When the stimulus was maximally ambiguous (GS2 and GS3), participants with higher neuroticism found these stimuli to be riskier when they received additional predictability information. Thus, the extra predictability information increased their fear. When the ambiguous stimulus was "safer" (GS4), participants with higher neuroticism and additional predictability information found the stimulus to be safe, but were more vigilant of the control stimulus. Thus, the extra predictability information may have increased hypervigilance. Although it is possible to interpret this vigilance towards the

control stimulus as a novelty bias, this effect was not observed in the low predictability condition and the study controlled for equal exposure to stimuli by the time of the fear generalization task. Given participants' safe appraisal of GS4, hypervigilance to the control stimulus relative to GS4 may be indicative of participants scanning for danger elsewhere. In other words, giving extra information to individuals with higher neuroticism may have caused these individuals to find the control stimulus dangerous when GS4 was clearly safe.

Taken together, individuals with higher neuroticism used the additional predictability information in the wrong ways, such that providing the US contingency rule backfired whether the ambiguous stimulus was perceived to be dangerous or safe. At first glance, our finding that increasing predictability for those with higher neuroticism did not decrease fear appears to contradict literature suggesting that neuroticism is associated with a greater intolerance for uncertainty, unfamiliarity, and ambiguity (e.g., Barlow et al., 2013; Gray, 1982; Kagan, 1994). Consistent with a proclivity for predictability, the individuals with higher neuroticism in our study were more likely to rigidly cling onto the predictability information when it was provided, via forcing a predictable US contingency rule (which exclusively pertained to CS+ and CS-) in otherwise ambiguous, or less predictable, situations. This rigid use of the predictability information may have led these individuals to treat the most ambiguous stimuli (GS2 and GS3) as if they signaled danger (CS+). Furthermore, even when these individuals correctly appraised GS4 as "safe", they still demonstrated hypervigilance towards the neutral control stimulus it was paired with, suggesting a failure to feel safe when safety was warranted. In other words, the additional predictability information did not decrease fear of ambiguous stimuli in individuals prone to negative reactivity, which is consistent with the understanding of neuroticism as a non-specific vulnerability factor for negative emotionality and anxious responding (e.g., Clark, 2005;

Khan, Jacobson, Gardner, Prescott, & Kendler, 2005; Kotov, Gamez, Schmidt, & Watson, 2010; Lahey, 2009). The predictability manipulation was simply unable to override the powerful effects of neuroticism. Increased predictability not only failed to lower fear among individuals with higher neuroticism, but may have in fact exacerbated a tendency to react with greater threat by giving these individuals more information about threat expectancies.

Inhibition, as measured by the go/no-go task, was not strongly associated with online risk ratings or attentional bias scores on the fear generalization task. Participants with better discrimination reported lower online risk ratings for the generalization stimulus most approximating safety (GS4), but this was a small effect and likely a spurious finding, given that there were no other strong associations. Although fear overgeneralization has been associated with deficits in fear inhibition (Jovanovic & Ressler, 2010), this process may not directly map on to deficits in response inhibition in a simple go/no-go task. Consistent with this, a meta-analysis found differences in brain activation between simple go/no-go tasks, involving a single go stimulus and a single no-go stimulus, and complex go/no-go tasks, involving multiple associations or updating stimulus-response associations (Simmonds et al., 2008). Specifically, both simple and complex go/no-go tasks were associated with activation of the pre-supplementary motor area, but only complex go/no-go tasks demonstrated a distinct pattern of activation in right-lateralized prefrontal-parietal circuits. This finding may help explain why performance on the single cue go/no-go task in the present study was not strongly associated with performance on the fear generalization task, which involved not only responding to multiple cues but also reacting to learned stimulus-response associations in ambiguous contexts. Furthermore, Jovanovic and Ressler (2010) argue that while go/no-go task can be said to require inhibitory control via cognitive and motor response inhibition, it may not in fact involve

suppression of emotion, which may explain why fear generalization was not strongly associated with inhibitory control in the go/no-go task.

This study was limited in several ways. We studied undergraduate psychology students, though our sample reported a range of neuroticism, trait anxiety, and psychopathology. We did not examine rate of acquisition learning over time, as the US expectancy ratings for CS+ and CS- were only collected at the end of acquisition, rather than throughout the acquisition phase. Although it may have been interesting to examine potential differences in the rate at which the US contingency was learned, collecting online risk ratings throughout the acquisition phase may have interfered with learning. Further, rate of acquisition learning was not a main focus, as fear generalization was the construct of interest. We also did not assess online risk ratings for the control stimuli, since they were neutral in valence and were previously validated as such (Tottenham et al., 2009). However, given our finding that individuals with higher neuroticism and additional predictability information showed an attentional bias towards the control stimulus relative to GS4, future research might benefit from assessing the degree to which control stimuli were perceived as dangerous. Lastly, we did not include psychophysiological indices of fear because such measures were difficult in a large scale study, but these measures have good convergence with attentional bias tasks (Fani et al., 2012).

Our study has laid some initial groundwork for better understanding how neuroticism and predictability interact in the face of ambiguity. In line with emerging safety signal learning research showing a convergence of evidence for conditioning abnormalities on the safety end of the spectrum (Jovanovic, Kazama, Bachevalier, & Davis, 2012; Lissek et al., 2005), our findings point to more response variability on the safety end of the danger-safety continuum. In other words, what may separate maladaptive fear learning processes from healthier ones is not so

much an over-reactivity to dangr signals, but rather a failure to differentiate between danger and safety signals, arguing for a focus on safety signal learning as an important marker of maladaptive conditioning processes (Jovanovic et al., 2012). Given that many individuals encounter ambiguous stimuli more frequently than dangerous stimuli, it is important that we continue investigating how individuals respond in objectively ambiguous environments.

Our finding that increasing predictability does not necessarily help individuals with higher neuroticism feel safer in ambiguous situations challenges a common conceptualization of predictability as a factor that reduces fear and distress. Our findings tell a more nuanced story where the effect of predictability depends on personality factors as well as characteristics of a given stimulus. Future research should further examine how predictability behaves across the danger-safety continuum, and the extent to which the effect of predictability depends on individual characteristics. Consistent with our findings, a flight safety demonstration with information about exit procedures and cushion floating devices may have a different effect on healthy individuals compared to individuals with a fear of flying. In the face of an ambiguous cue, such as an engine noise or slight turbulence, a healthy individual may feel safer after witnessing a safety demonstration, whereas an individual with higher neuroticism may experience increased fear in spite of well-intentioned safety information. Given that neuroticism is associated with many negative physical and mental health outcomes, it is imperative that we better understand how to decrease its negative effects by examining whether seemingly obvious interventions (e.g., increasing predictability) could be potentially iatrogenic.

References

Bar-Haim, Y., Lamy, D., Pergamin, L., Bakermans-Kranenburg, L., & van IJzendoorn, M. H. (2007). Threat-related attentional bias in anxious and non-anxious individuals: a meta-analytic study. *Psychological Bulletin, 133*: 1–24. doi:10.1037/0033-2909.133.1.1

Barlow, D.H., Sauer-Zavela, S., Carl, J.R., Bullis, J.R., & Ellard, K.K. (2013). The Nature, Diagnosis, and Treatment of Neuroticism: Back to the Future. *Clinical Psychology Science,* 1-22. doi: 10.1177/2167702613505532.

Beck, A.T., Steer, R.A., & Brown, G. (1996). *Manual for the Beck Depression Inventory-II*. San Antonio, TX: Psychological Corporation.

Britton, J.C., Lissek, S., Grillon, C., Norcross, M.A., Pine, D.S. (2011) Development of anxiety: The role of threat appraisal and fear learning. *Depression and Anxiety, 28*, 5-17. doi: 10.1002/da.20733

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. doi: 10.1016/j.cpr.2009.11.003

Clark, L. A. (2005). Temperament as a unifying basis for personality and psychopathology. *Journal of Abnormal Psychology, 114*, 505–521. doi:10.1037/0021-843X.114.4.505

Costa, P.T., Jr., & McCrae, R.R. (1987). Neuroticism, somatic complaints, and disease: Is the bark worse than the bite? *Journal of Personality, 55*, 229-316.

Dunsmoor, J. E., & LaBar, K. S. (2013). Effects of discrimination training on fear generalization gradients and perceptual classification in humans. *Behavioral Neuroscience, 127*, 350-356. doi:10.1037/a0031933

Dunsmoor, J. E., Mitroff, S. R., & LaBar, K. S. (2009). Generalization of conditioned fear along a dimension of increasing fear intensity. *Learning & Memory, 16*, 460-469.

doi:10.1101/lm.1431609

Dunsmoor, J. E., Prince, S. E., Murty, V. P., Kragel, P. A., & LaBar, K. S. (2011). Neurobehavioral mechanisms of human fear generalization. *Neuroimage, 55*, 1878-1888. doi:10.1016/j.neuroimage.2011.01.041

Dymond, S., Dunsmoor, J. E., Vervliet, B., Roche, B., & Hermans, D. (2014). Fear generalization in humans: Systematic review and implications for anxiety disorder research. *Behavior Therapy*. doi:10.1016/j.beth.2014.10.001

Eysenck, H. J., & Eysenck, S. B. G. (1991). Eysenck Personality Scales (EPS Adult). London: Hodder & Stoughton.

Eysenck, S.B.G., Eysenck, H.J., & Barrett, P. (1985). A revised version of the psychoticism scale. *Personality of Individual Differences, 6*, 21-29.

Falconer, E., Allen, A., Felmingham, K.L., Williams, L.M., & Bryant, R.A. (2013). Inhibitory neural activity predicts response to cognitive-behavioral therapy for posttraumatic stress disorder. *Journal of Clinical Psychology, 74*, 895-901.

Falconer, E., Bryant, R., Felmingham, K. L., Kemp, A. H., Gordon, E., Peduto, A., Olivieri, G., AssDip, & Williams, L. M. (2008). The neural networks of inhibitory control in posttraumatic stress disorder. *Journal of Psychiatry and Neuroscience, 33*, 413-22.

Fani, N., Tone, E. B., Phifer, J., Norrholm, S. D., Bradley, B., Ressler, K. J., Kamkwalala, A., & Jovanovic, T. (2012). Attention bias toward threat is associated with exaggerated fear expression and impaired extinction in PTSD. *Psychological Medicine, 42*, 533-543. doi:10.1017/S0033291711001565

Fanous, A.H., Gardner, C.O., Prescott, C.A., Cancrp., R., & Kendler, K.S. (2002). Neuroticism,

major depression, and gender: A population-based twin study. *Psychological Medicine, 37*, 1163-1172. doi:10.1017/S003329170200541X

Foa, E.B. (2015). PTSD Scale-Self Report for DSM-5 Manual. *Manuscript in preparation.*

Foa, E.B., Cashman, L., Jaycox, L, & Perry, K. (1997). The validation of a self-report measure of posttraumatic stress disorder: The posttraumatic diagnostic scale. *Psychological Assessment, 9*, 445-451. doi:10.1037/1040-3590.9.4.445

Foa, E., Zinbarg, R., & Rothbaum, B. (1992). Uncontrollability and unpredictability in post-traumatic stress disorder: An animal model. *Psychological Bulletin, 112*, 218-238. doi: 10.1037/0033-2909.112.2.218

Futterman, A.D., Kemeny, M.E., Shapiro, D., & Faey, J.L. (1994). Immunological and physiological changes associated with induced positive and negative mood. *Psychosomatic Medicine, 56*, 499-511.

Gray, J. A. (1982). *The neuropsychology of anxiety*. New York, NY: Oxford University Press.

Greenberg, T., Carlson, J. M., Cha, J., Hajcak, G., & Mujica‐Parodi, L. R. (2013). Ventromedial prefrontal cortex reactivity is altered in generalized anxiety disorder during fear generalization. *Depression and Anxiety, 30*, 242-250. doi:10.1002/da.22016

Glenn, C. R., Lieberman, L., & Hajcak, G. (2012). Comparing electric shock and a fearful screaming face as unconditioned stimuli for fear learning. *International Journal of Psychophysiology, 86*, 214-219. doi:10.1016/j.ijpsycho.2012.09.006

Grillon, C., Baas, J.M.P, Cornwell, B., & Johnson, L. (2006). Contextual conditioning and behavioral avoidance in a virtual reality environment: Effect of predictability. *Biological Psychiatry, 60*, 752-759. doi:10.1016/j.biopsych.2006.03.072

Grillon, C., Lissek, S., Rabin, S., McDowell, D., Dvir, S., & Pine, D. (2008). Increased anxiety

during anticipation of unpredictable but not predictable aversive stimuli as a psychophysiologic marker of panic disorder. *American Journal of Psychiatry, 165*, 898-904. doi:10.1176/appi.ajp.2007.07101581

Grillon, C., Pine, S., Lissek, S., Rabin, S., Bonne, O., & Vythilingam, M. (2009). Increased anxiety during anticipation of unpredictable aversive stimuli in posttraumatic disorder but not in generalized anxiety disorder. *Biological Psychiatry, 66*, 47-53. doi:10.1016/j.biopsych.2008.12.028

Gross, J.J., & John, O.P. (2003). Individual differences in two emotion regulation processes: Implications for affect, relationships, and well-being. *Journal of Personality and Social Psychology, 85,* 348-362. doi:10.1037/0022-3514.85.2.348

Haddad, A.D.M., Lissek, S., Pine, D.S., & Lau, J.Y.F. (2011). How do social fears in adolescence develop? Fear conditioning shapes attention orienting to social danger cues. *Cognition and Emotion, 25*, 6, 1139-1147. doi:10.1080/02699931.2010.524193

Haddad, A.D.M., Xu, M., Raeder, S., & Lau, J.Y.F. (2012). Measuring the role of conditioning and stimulus generalization in common fears and worries. *Cognition and Emotion, 27,* 914-22. doi:10.1080/02699931.2012.747428

He, Z., Cassaday, H., Bonardi, C., & Bibby, P. (2013). Do personality traits predict individual differences in excitatory and inhibitory learning? *Frontiers in Psychology, 4*, 1-12. doi: 10.3389/fpsyg.2013.00245

Isihara Color Test. (n.d). In *Color Blindness*. Retrieved from http://www.colour-blindness.com.

Jovanovic, T., Ely, T., Fani, N., Glover, E. M., Gutman, D., Tone, E. B., Norrholm, S., Bradley,

B., & Ressler, K. J. (2013). Reduced neural activation during an inhibition task is associated with impaired fear inhibition in a traumatized civilian sample. *Cortex, 49*, 1884-1891. doi:10.1016/j.cortex.2012.08.011

Jovanovic, T., Kazama, A., Bachevalier, J., & Davis, M. (2012). Impaired safety signal learning may be a biomarker of PTSD. *Neuropharmacology, 62*, 695-704. doi:10.1016/j.neuropharm.2011.02.023

Jovanovic, T., & Ressler, K.J. (2010). How the neurocircuitry and genetics of fear inhibition may inform our understanding of PTSD. *American Journal of Psychiatry, 167*, 648-62. doi: 10.1176.

Kagan, J. (1994). Galen's prophecy: Temperament in human nature. New York, NY: Basic Books.

Khan, A. A., Jacobson, K. C., Gardner, C. O., Prescott, C. A., & Kendler, K. S. (2005). Personality and comorbidity of common psychiatric disorders. *The British Journal of Psychiatry, 186*, 190–196. doi: 10.1192/bjp.186.3.190

Kotov, R., Gamez, W., Schmidt, F., & Watson, D. (2010). Linking "big" personality traits to anxiety, depressive, and substance use disorders: A meta-analysis. *Psychological Bulletin, 136,* 768–821. doi:10.1037/a0020327

Lahey, B. B. (2009). Public health significance of neuroticism. *American Psychologist, 64,* 241-56. doi:10.1037/a0015309

Lau, J. Y., Lissek, S., Nelson, E. E., Lee, Y., Roberson-Nay, R., Poeth, K., Jenness, J., Ernst, M., Grillon, C., & Pine, D. S. (2008). Fear conditioning in adolescents with anxiety disorders: results from a novel experimental paradigm. *Journal of the American Academy of Child & Adolescent Psychiatry, 47*, 94-102. doi:10.1097/chi.0b01e31815a5f01

Lissek, S. (2012). Toward an account of clinical anxiety predicted on basic, neurally mapped mechanisms of pavlovian fear-learning: The case for conditioned overgeneralization. *Depression and Anxiety, 29*, 257-263. doi:10.1002/da.21922.

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. doi:10.1016/j.brat.2008.02.005

Lissek, S., Bradford, D.E., Alvarez, R.P., Burton, P., Espensen-Sturges, T., Reynolds, R.C., & Grillon, C. (2014). Neural substrates of classically conditioned fear-generalization in humans: a parametric fMRI study. *Social Cognitive and Affective Neuroscience, 9*, 1134-1142. doi:10.1093/scan/nst096

Lissek, S., Kaczkurkin, A.N., Rabin, S., Geraci, M., Pine, D.D., & Grillon, C. (2014). Generalized Anxiety Disorder Is Associated With Overgeneralization of Classically Conditioned Fear. *Biological Psychiatry, 75*, 909–915. doi:10.1016/j.biopsych.2013.07.025

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. doi:10.1016/j.brat.2004.10.007

Lissek, S., Rabin, S., Heller, R.E., Lukenbaugh, M.A., 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. doi:10.1176/appi.ajp.2009.09030410

Macmillan NA, Creelman CD. (2005). *Detection Theory: A User's Guide*. Mahwah, NJ: Lawrence Earlbaum Associates.

Maluoff, J. M., Thosteinsson, E. B., & Schutte, N. S. (2005). The relationship between the five-factor model of personality and symptoms of clinical disorders: A meta-analysis. *Journal of Psychopathology and Behavioral Assessment, 27,* 101-114. doi:10.1007/s10862-005-5384-y

McLaren I.P.L & Mackintosh N.J. (2002). Associative learning and elemental representation: II. Generalization and discrimination. *Animal Learning and Behavior, 30,* 177–200. doi:10.3758/BF03192828

Mineka S. (1992). Evolutionary memories, emotional processing, and the emotional disorders. In *D. Medin (Ed.), The psychology of learning and motivation: Advances in research and theory* (Vol. 28, pp. 161–206). New York: NY. Academic Press.

Mineka S. & Kihlstrom J.F. (1978): Unpredictable and uncontrollable events: A new perspective on experimental neurosis. *Journal of Abnormal Psychology 87*, 256– 271. doi:10.1037/0021-843X.87.2.256

Morpheus Photo Morpher. (n.d.). Retrieved from http://www.morpheussoftware.net.

Mostofsky, S. H., Schafer, J. G., Abrams, M. T., Goldberg, M. C., Flower, A. A., Boyce, A., Courtney, S.M., Calhoun, V.D., Kraut, M.A., Denckla, M.B., & Pekar, J.J. (2003). fMRI evidence that the neural basis of response inhibition is task-dependent. *Cognitive Brain Research, 17*, 419–430. doi:10.1016/S0926-6410(03)00144-7

Norrholm, S. D., Jovanovic, T., Briscione, M. A., Anderson, K. M., Kwon, C. K., Warren, V. T., Bosshardt, L., & Bradley, B. (2014). Generalization of fear-potentiated startle in the presence of auditory cues: a parametric analysis. *Frontiers in Behavioral Neuroscience, 8,* doi: 10.3389/fnbeh.2014.00361

Pavlov, IP. (1927). *Conditioned Reflexes: An Investigation of the Physiological Activity of the*

Cerebral Cortex. London: Oxford University Press.

Powers, Gillihan, Rosenfield, Jerud, & Foa. (2012). Reliability and validity of the PDS and PSS-I among participants with PTSD and alcohol dependence. *Journal of Anxiety Disorders, 26*, 617-623. DOI: 10.1016/j.janxdis.2012.02.013.

Schneider, W., Eschman, A., and Zuccolotto, A. (2012). *E-Prime Reference Guide.* Pittsburgh: PA. Psychology Software Tools, Inc.

Simmonds, D. J., Pekar, J. J., & Mostofsky, S. H. (2008). Meta-analysis of Go/No-go tasks demonstrating that fMRI activation associated with response inhibition is task-dependent. *Neuropsychologia, 46*, 224-232. doi:10.1016/j.neuropsychologia.2007.07.015

Spielberger, C.D., Gorsuch, R.L., Lushene, P.R., Vagg, P.R., & Jacobs, A.G. (1983). *Manual for the State-Trait Anxiety Inventory (Form Y).* Palo Alto: CA. Consulting Psychologists Press, Inc.

Tottenham, N., Tanaka, J. W., Leon, A. C., McCarry, T., Nurse, M., Hare, T. A., Marcus, D. J., Westerlund, A., Casey, B. J., & Nelson, C. (2009). The NimStim set of facial expressions: Judgments from untrained research participants. *Psychiatry Research, 168,* 242-249. doi: 10.1016/j.psychres.2008.05.006

Wager, T. D., Sylvester, C. Y., Lacey, S. C., Nee, D. E., Franklin, M., & Jonides, C. (2005). Common and unique components of response inhibition revealed by fMRI. *NeuroImage, 27*, 323–340. doi:10.1016/j.neuroimage.2005.01.054

Wright, L., Lipszyc, J., Dupuis, A., Thayapararajah, S. W., & Schachar, R. (2014). Response inhibition and psychopathology: A meta-analysis of go/no-go task performance. *Journal of Abnormal Psychology*. doi:10.1037/a0036295

Figure 1a. *Online risk ratings for most ambiguous stimuli (GS2 and GS3)*

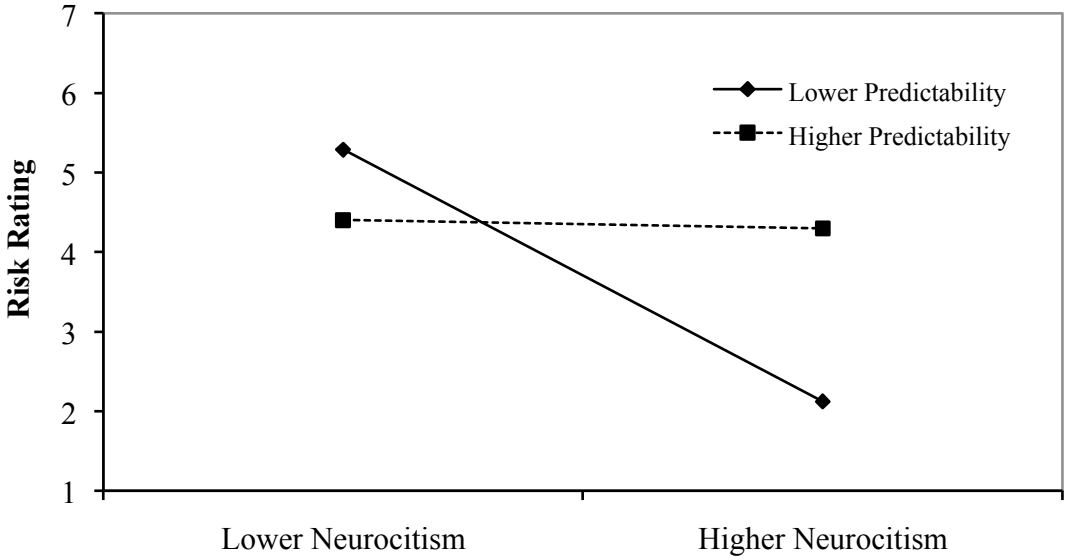

Figure 1b. *Attentional bias for most ambiguous stimuli (GS4)*

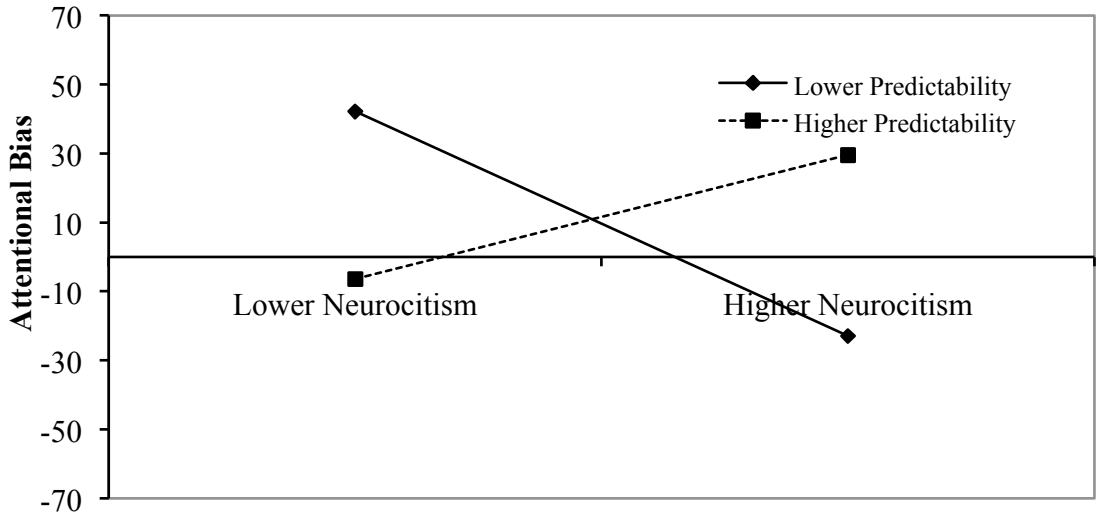

Figure 2a. *Online risk ratings for GS most approximating safety (GS5)*

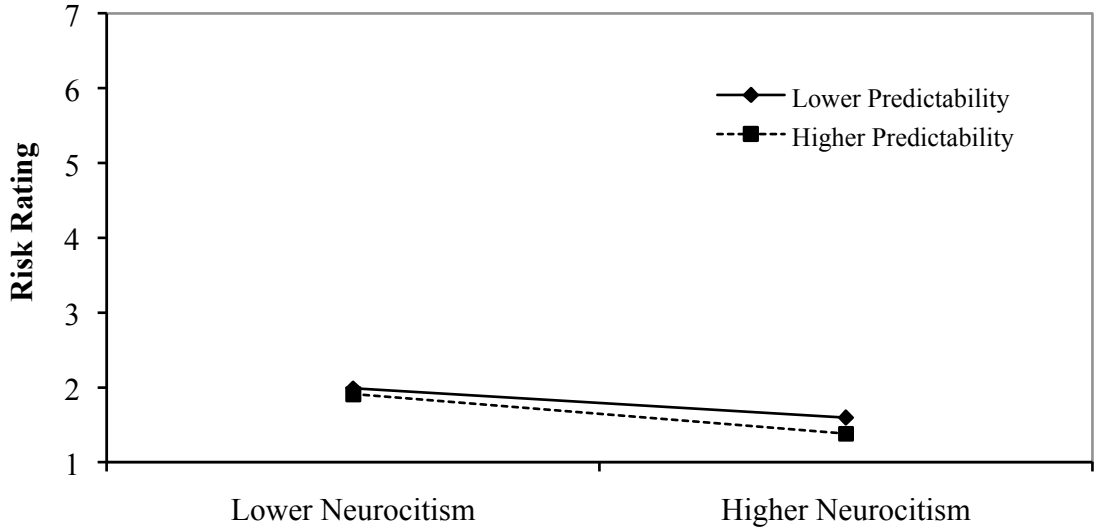

Figure 2b. *Attentional bias for stimulus most approximating safety (GS5)*

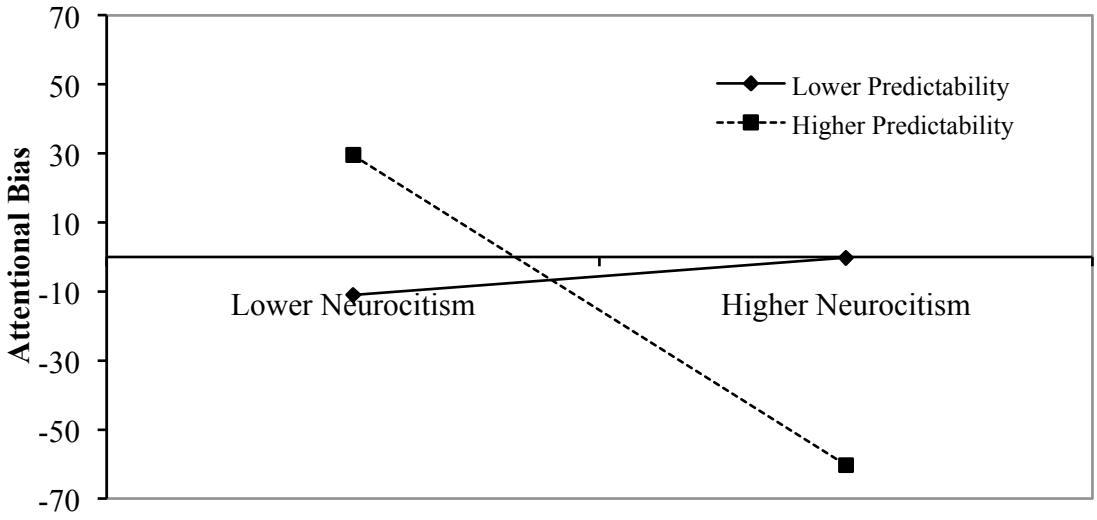

Table 1. *Baseline measures for low and high predictability conditions*

	Low Predictability (n = 56)		High Predictability (n = 61)		Range
	M	*SD*	*M*	*SD*	
Age (years)	19.21	*1.07*	19.00	*0.89*	18-22
Gender (% female)	66.1%		54.1%		
Ethnicity (% Caucasian)	39.3%		41.0%		
Neuroticism (EPQ-R-N)	10.21	*5.00*	8.56	*4.73*	0-23
Crit A Exposure (PSS-SR5)	16.2%		16.4%		
PTSD Severity (PSS-SR5)	13.67	*11.90*	12.10	*13.85*	0-38
Depression Severity (BDI-II)	9.22	*6.77*	9.32	*7.18*	1-33
Trait Anxiety (STAI-T)	40.64	*9.66*	40.20	*9.81*	23-66
State Anxiety (STAI-S)	37.50	*8.45*	36.08	*8.74*	20-62

Note. EPQ-R-N = Eysenck Personality Questionnaire - Revised - Neuroticism. PSS-SR5 = PTSD Symptom Scale - Self Report for DSM 5. BDI-II = Beck Depression Inventory-II. STAI-T = State-Trait Anxiety Inventory-Trait. STAI-S = State-Trait Anxiety Inventory-State.

Table 2. *Attention bias and online risk ratings for low and high predictability conditions*

	Low Predictability *(n* = 56)		High Predictability *(n =61)*	
	M	*SD*	*M*	*SD*
US Expectancy Ratings				
CS+	6.07	*0.97*	5.85	*0.85*
CS-	1.32*	*0.88*	1.05*	*0.28*
Attentional Bias Scores				
CS+	32.49	*60.99*	27.18	*65.61*
GS1	-0.50	*50.10*	14.60	*53.89*
GS2	10.99	*62.17*	13.58	*55.32*
GS3	13.29	*49.41*	6.98	*67.57*
GS4	-6.23	*50.15*	-3.88	*52.57*
CS-	20.77	*53.75*	21.73	*70.10*
Online Risk Ratings				
CS+	5.28	*1.41*	5.57	*1.15*
GS1	5.31	*1.45*	5.45	*1.34*
GS2	3.88	*1.77*	4.36	*1.63*
GS3	2.05	*1.09*	2.03	*1.08*
GS4	1.82	*1.02*	1.71	*0.90*
CS-	1.84	*1.05*	1.72	*0.92*

Note. CS+ = danger conditioned stimulus; CS- = safety conditioned stimulus; GS1-4 = generalization stimulus on a continuum of danger (1) to safety (4). US Expectancy Ratings: rated after acquisition on a scale of 1 (*extremely unlikely to be followed by US*) to 7 (*extremely likely to be followed by US*). Attentional Bias Scores: collected during the fear generalization test and calculated by subtracting reaction times on congruent trials from reaction times on incongruent trials, where positive scores indicate attentional bias towards the test. Online Risk Ratings: collected during the fear generalization test and rated on a scale of 1 (*no risk*) to 7 (*high risk*). *$p < .05$.

Table 3. *Association Between Fear Generalization and Go/No-Go* Tasks

Variable	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.
Attentional Bias Scores Fear Generalization Task													
1. CS+	--												
2. GS1	.01	--											
3. GS2	.21*	-.10	--										
4. GS3	.09	.08	.02	--									
5. GS4	-.16	.23*	.08	-.13	--								
6. CS-	.62**	-.03	.18*	.05	.00	--							
Online Risk Ratings Fear Generalization Task													
7. CS+	-.15	.03	-.06	-.03	-.00	.01	--						
8. GS1	-.11	-.02	-.09	-.03	.03	-.03	.85**	--					
9. GS2	-.15	-.03	.11	-.09	.05	.02	.52**	.59**	--				
10. GS3	-.18	-.01	-.05	-.10	-.01	-.13	.13	.15	.31**	--			
11. GS4	-.12	-.09	-.03	-.13	-.04	-.07	-.08	-.06	.17	.75**	--		
12. CS-	-.06	-.13	.02	-.13	-.09	-.07	-.10	-.06	.16	.73**	.92**	--	
Discrimination Go/No-Go Task													
13. Discrimination	.07	-.00	-.05	.06	.02	.04	.07	.13	-.01	-.12	-.18*	-.14	--

Note. CS+ = danger conditioned stimulus; CS- = safety conditioned stimulus; GS1-4 = generalization stimulus on a continuum of danger to safety; Attentional Bias Scores: collected during the fear generalization test, where positive scores indicate attentional bias towards the test stimulus. Online Risk Ratings: collected during the fear generalization test and rated on a scale of 1 (*no risk*) to 7 (*high risk*); Discrimination: collected during go/no-go task and calculated by subtracting false alarm rate from hit rate; *$p < .05$; **$p < .01$