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Does anxiety sensitivity correlate with startle habituation? An examination in two independent samples

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Abstract

Individuals with anxiety disorders have previously demonstrated abnormal habituation to aversiveness over time. As anxiety sensitivity (AS), or an individuals' propensity to fear anxiety-related sensations, has been shown to be a risk factor for anxiety disorders (particularly panic disorder), the present study examined whether AS was also associated with abnormal habituation. This association was examined in two independent samples of undergraduates (total N=178). Habituation was operationalized as the reduction in startle response to multiple startle probes presented over 2.5 minutes and three definitions of this reduction were employed. Results indicated that individuals with higher levels of AS evidenced deficits in startle habituation, but the strength of this relationship was somewhat dependent on the definition of startle habituation, with the most robust definition being an analysis of participants' individual slopes across all nine blinks. The present findings suggest that startle habituation is key mechanism underlying AS, and may help elucidate the role this risk factor plays in the pathogenesis of anxiety disorders.

Keywords

Anxiety sensitivity; startle habituation; startle reduction

Approximately 42 billion dollars are spent annually on anxiety disorder related costs including medications, psychosocial treatment, and lost work productivity (Greenberg et al., 1999). Consequently, research focusing on risk factors of anxiety disorders is imperative for the development of effective treatments and preventative interventions.

A large body of evidence indicates that several personality traits are putative risk factors for anxiety disorders (Clark, Watson, & Mineka, 1994). For instance, anxiety sensitivity (AS), or an individuals' propensity to fear anxiety-related sensations (Stewart, Taylor, & Baker, 1997), has been shown to longitudinally predict the onset of anxiety disorders (Hayward, Killen, Kraemer, & Taylor, 2000). Although AS may be associated with several anxiety disorders, evidence suggests that it may connote particular risk factor for panic disorder (Schmidt, Zvolensky, & Maner, 2006), given that those with high AS often fear panic-related symptoms such as rapid heart rate and racing thoughts. For example, in an examination of many anxiety disorders, Taylor et al. (1992) found that AS levels were highest in those with panic disorder. Notably, two prior investigations demonstrated that AS longitudinally predicted the onset of spontaneous panic attacks in non-clinical samples, even when controlling for trait anxiety (Schmidt, Lerew, & Jackson, 1999; Schmidt, Zvolensky, & Maner, 2006).

Numerous studies have also shown that individuals with anxiety disorders demonstrate deficits in affective responding (Grillon, 2002; Lang, Bradley, & Cuthbert, 1998; Rothbaum et al., 2001). More specifically, recent evidence suggests individuals with anxiety disorders have an increased tendency for heightened physiological responding to aversive stimuli (i.e., defensive responding; McTeague, Lang, Laplante, Bradley, 2011; McTeague & Lang, 2012). Although the majority of these studies have focused on responses to a single, aversive event (e.g., examining initial reactivity) or averaged responses across multiple events, there is a growing literature examining the ‘pattern’ (or course) of affective responding over time. Studies examining emotional responding over time (sometimes labeled affective chronometry) are critical, as reactivity and time course may play different roles in the development of anxiety disorders (Davidson, 1998; Davidson, Jackson, & Kalin, 2000).

Unfortunately, the definition and measurement of the time-course of emotional responding are fairly inconsistent in the literature. One way to examine the *time-course* of responding is to measure the gradual decrease in physiological responding to a stimulus over time, often termed habituation (Harris, 1943; Herry et al., 2010). According to classic work by Groves and Thompson (1970), habituation often consists of two components—a gradual decrease in reactivity to a repeated stimulus over time, and in some cases, sensitization or the temporary *enhancement* in responding to an aversive stimulus. The presence of sensitization indicates that reductions in responding over time may not best be defined as a solely linear decrease, and often involve more complex underlying processes. Consequently, when measuring responses over time, it is important to test for possible linear, quadratic, and/or cubic trends, especially in the context of psychophysiological responding.

Individuals with anxiety disorders have repeatedly been shown to display alterations in habituation over time. In one of the first reports of this phenomena, Lader and Wing (1964) found that anxious individuals had slower rates of habituation of the galvanic skin response compared with healthy controls. A more recent study found deficits in habituation of the electrodermal response in rape victims with PTSD relative to non-PTSD rape victims (Rothbaum et al., 2001). Patients with panic disorder have also demonstrated deficits in habituation of skin conductance responses when presented with aversive auditory tones (Roth, Ehlers, Taylor, Margraf, & Agras, 1990).

Although studies examining habituation have often employed diverse measures, one widely used psychophysiological index is the startle response. Previous research has consistently demonstrated that startle is sensitive to internal affective states such that appetitive motivation states (e.g., happiness) inhibit the startle response while aversive motivation states (e.g., fear, anxiety) potentiate the startle response (Lang, 1995; Lang, Bradley, & Cuthbert, 1998). This ‘affect modulation of startle’ has been observed using numerous emotional stimuli/inductions including the passive viewing of pictures (Bradley, Lang, & Cuthbert, 1993), film clips (Jansen & Frijda, 1994), and during threat of shock (Grillon et al., 2008; Nelson & Shankman, 2011). Moreover, unlike other psychophysiological markers of affect (e.g., skin conductance), startle modulation is particularly sensitive to changes in the valence (i.e., positive vs. negative) of the individual’s emotional state (Lang, Bradley, & Cuthbert, 1990).

Consistent with studies demonstrating affective responding deficits in those with anxiety disorders, prior investigations have also shown that AS relates to heightened reactivity to aversive stimuli (Holloway & McNally, 1987; Keogh & Mansoor, 2001; Keogh, Dillon, Georgiou, & Hunt, 2001; Lees, Mogg, & Bradley, 2003). However, no study to our knowledge has examined the relation between AS and habituation (or other *time-course* components of aversive responding). Thus, this is the primary aim of the present study.

Although this question has not yet been examined, personality traits similar to AS have been associated with abnormal rates of habituation. Negative Temperament (NT), a dimension closely related to Neuroticism (Watson, Clark, & Harkness, 1994), has been associated with lower rates of habituation (Coles, Gale & Kline, 1971; Norris, Larsen, & Cacioppo, 2007). However, while AS and NT are similar in that they both connote risk for anxiety disorders (Breslau, Davis, Andreski, & Peterson, 1991; Hirshfield & Klerman, 1979; Clark et. al., 1994), they are distinguishable in that NT is thought to represent a broad temperamental sensitivity to negative stimuli (Tellegen, 1985), whereas AS measure a more specific tendency to respond fearfully to symptoms of anxiety (McNally, 1989). Nevertheless, several researchers have argued that AS may not contribute incremental validity over and above trait NT (or perhaps trait anxiety; Lilienfeld, Turner, & Jacobs, 1993; Lilienfeld & Penna, 2001). Thus, a second aim of the present study is to examine whether AS is uniquely associated with the time-course of emotional responding, even when controlling for the broad personality constructs NT.

Accumulating evidence suggests that anxiety disorders and related personality traits are associated with deficits habituation of physiological responses. However, several studies have failed to demonstrate this association (e.g., Hoenig, Hochrein, Quednow, Maier, & Wagner, 2005; Ross et al., 1989). There are several potential explanations for these inconsistent findings. First, some previous studies have only employed psychophysiological measures that are only sensitive to changes in arousal (e.g., skin conductance), and not valance (Lang, Bradley, & Cuthbert, 1998).

Second, prior studies have used widely differing definitions of habituation. Some have defined it as the difference (or change) in responding from the first and last aversive stimulus (Ellwanger, Geyer, & Braff, 2003). Others have calculated the proportion change from the response to the first aversive stimulus to the last (see Nelson, Shankman, Olino, & Klein, 2011). Although both of these indices only utilize the initial and the final response, proportion change accounts for individual differences in initial response. A third, and more sophisticated, method is to examine the 'slope' or trajectory of the response (LaRowe et al., 2006). Modeling the slope allows one to observe whether there are other important features of the time course of responding including whether there are non-linear patterns, *when* responding levels-off, and if there is a sensitization effect. Given that each of these three definitions captures slightly different information and has been previously used in the literature with varying frequency, the present study examined the convergence across all three definitions.

In sum, the aim of this study was to:

1. Examine whether individual differences in AS was associated with startle habituation, defined as the reduction in startle responding over time
2. Examine whether this association remained present after adjusting for individual differences in NT.
3. Given limitations of previous definitions of habituation, the current study used three definitions of startle habituation - 1) raw habituation, the raw difference in eyeblink startle amplitude from the initial startle probe to the last; 2) percent change from first blink (PC), the amount of raw habituation compared to the initial blink amplitude; and 3) the slope of habituation over time, incorporating each individual blink.

Notably, we examined the relationship between AS and startle habituation in two samples, recruited from two independent larger protocols examining questions related to sensitivity to threat. Employing two samples was not only to try and replicate our initial finding, but also

to understand the robustness of the effects. Although some aspects of the two protocols were identical (e.g., the startle habituation task), there were also important methodological differences between the samples that warrants treating the data as two, separate samples. For instance, the two studies differed in certain aspects of administration of stimuli, (e.g., different decibel levels for the acoustic startle probe, the presence/absence of an EEG cap) and the timing of participant recruitment. Additionally, the experimental context differed between the two samples as Sample 1's experimental session included a reward task during which participants won money while Sample 2's session did not.

Method

Participants

Participants were selected from two separate projects investigating factors associated with the acoustic startle response in a fear-potentiated startle paradigm (Nelson & Shankman, 2011; Sarapas et al., under review). Both samples were recruited from Introductory to Psychology Subject Pools between 2007–2010. All participants gave informed consent, and received course credit for participation. Eligibility across both studies included right-handedness and no history of head trauma. The samples contained 108 and 69 participants, respectively. Inclusion criteria for the present study included having at least six of the nine possible baseline blinks present, with neither blink 1 nor blink 9 classified as *missing*, as well as blink 1 not scored as a *non-response* (see data analysis section below).¹ In both samples, those included vs. excluded from analysis did not differ on age, gender, ethnicity, ASI, or NT (all p 's > .10).

Questionnaires

Participants completed two self-report questionnaires, the Anxiety Sensitivity Index (ASI; Reiss et al. 1986; Taylor et al. 2007) and the General Temperament Survey (GTS) (Clark & Watson, 1990), at the end of the experimental session.

The ASI assesses an individual's degree of fear of anxiety-related sensations, stemming from catastrophic beliefs about those sensations (i.e., fear of death, heart attack, etc). Items are rated on a five-point scale, ranging from "Very Little" to "Very Much." Since the original publication of the 16-item ASI (Reiss et al., 1986), there have been two revisions/updates of the ASI - the 36 item ASI-R (Taylor & Cox, 1998), and the 18-item ASI-3 (which consists of a subset of ASI-R items; Taylor et al., 2007). Although participants in both samples answered questions that allowed us to construct all 3 versions of the ASI, we used the ASI-3 as the primary predictor for our analyses because it has been shown to have the best psychometric properties (Taylor et al., 2007).²

The GTS (Clark & Watson, 1990) contains 90 true-false statements developed to assess general aspects of temperament and personality. The present study used the Negative Temperament (NT) subscale of the measure, which includes 29 items that assess the tendency to experience negative emotions (e.g., guilt, anxiety, irritability, mistrust). This subscale has been shown to correlate highly with other broad negative affectivity construct such as neuroticism (Watson & Clark, 1992). NT includes items such as "My anger frequently gets the better of me."

¹In Sample 1, 7 were excluded because of mechanical error; 1, due to fewer than 6 of 9 usable blinks; 5, due to an unusable first blink; and 6, due to a missing 9th blink, resulting in 89 usable subjects. In Sample 2, 3 were excluded because of mechanical error; 5, due to fewer than 6 of 9 usable blinks; 5, due to an unusable first blink; and 3, due to a missing 9th blink, resulting in 53 usable subjects.

²Analyses with the ASI-R yielded a similar (although slightly weaker) pattern of results. None of our analyses were significant using the ASI-O.

In both samples, Cronbach's alphas indicated adequate reliability for both the ASI (alphas $> .94$) and NT (alphas $> .77$).

Procedure

For both studies, startle tones were presented using PSYLAB (Contact Precision Instruments; London, UK) and physiological data was recorded using a PC-based acquisition system (Neuroscan 4.3). Startle response was operationalized as the eyeblink response to nine 40 ms, 103db bursts of white noise presented binaurally through headphones for Study 1. Study 2 utilized a different sound card and this yielded 95db bursts of white noise. Thus, the aversive stimuli for Study 2 were slightly less intense than those used in Study 1 (although still within the recommended decibel level range according to published guidelines [Blumenthal et al., 2005]). The startle eyeblink in both samples was recorded using two electrodes placed over the orbicularis oculi muscle underneath the right eye and collected with a bandpass filter of 10–200 Hz at a sampling-rate of 1000 Hz. Although the upper end of this frequency band is below the Blumenthal et al. recommendation of 500 Hz, the missing bandwidth (200–500 Hz) was not likely to effect the experimental manipulation or the reliability of the results (A. Van Boxtel and T. Blumenthal, personal communications, December 14, 2009).

Following electrode placement, all participants sat in a sound-attenuated, electrically shielded booth. During a 2.5-minute baseline period, participants were told to relax and focus on a fixation cross on a monitor approximately one meter in front of them while 9 acoustic startle probes were administered through headphones. Interstimulus intervals (ISIs) between startle probes ranged between 15 and 20 seconds ($M = 17.22$ seconds).

Data Analysis

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. These definitions are in accordance with established guidelines (Blumenthal et al., 2005). For all analyses, gender was coded as 0 (males) and 1 (females), and continuous predictors (e.g., ASI) were mean centered. Descriptive analyses indicated that each startle blink was skewed in both studies, so each was normalized using a square-root transformation.

If a participant's first blink was unusable for any reason (i.e. missing or no response), we were unable to calculate a habituation score due to its definition being reliant on a raw difference or proportion compared to the first blink. However, participants were allowed to have the last blink coded as a non-response, as this is consistent with the definition of habituation. To ensure that each participant had an adequate number of blinks in which to model the course of their responding over time (particularly to model curvilinear effects), we only included subjects if they had at least 2/3 of the total blinks (i.e., 6 of 9).

Startle habituation was defined three ways. The first, termed *raw habituation*, was the difference between the amplitude of the first blink and the last (i.e., ninth) blink. The second

definition was the percent change from the first blink (PC), or the raw habituation score divided by the first blink. This represented the proportion of the first blink that changed over the course of the startle habituation phase.

The third definition of startle habituation looked at the individual change in blink magnitude over time using Random Coefficients Modeling (RCM; Hedeker & Gibbons, 2006). This analytic strategy tests not only for the presence of sample-wide (i.e., fixed) effects, but also subject-level (i.e., random) effects. RCM also allows for a more complete examination of the relationship between personality and startle response, primarily due its ability to: 1) incorporate data from the entire series of blinks, rather than just the first and last blinks, 2) account for the influence an individual subject may have on his/her own future repeated observations, and 3) test for the presence of linear and quadratic effects (Hedeker & Gibbons, 2006). Although RCM would have allowed participants with fewer than 6 of 9 blinks (the inclusion criteria for the other two definitions of habituation) to be included, we kept the Ns the same in order to best compare the results across definitions of habituation.

To test the main hypotheses using the first two definitions of startle habituation, levels of AS and NT were regressed onto startle reduction. The effects of gender and age were also examined as moderators as personality and measures of emotional reactivity may vary as a function of these demographic variables (Almeida & Kessler, 1998; Stewart et al., 1997), and startle response has been shown to decrease with age (Ford, Roth, Isaacks, White, Hood, & Pfefferbaum, 1995; Ludewig et al., 2003). Age did not differ between the samples and did not affect our analyses, and was therefore omitted from our models. The gender distribution, however, did vary between the samples. Thus, gender was included as a covariate in all analyses.³

All random coefficients models were run using the PROC MIXED procedure in SAS 9.2 (SAS Institute Inc., 2008). For these analyses, we first determined the variance-covariance structure that best described the data for each sample (see Hedeker & Gibbons, 2006) using tests of $-2 \log$ likelihood differences. The most appropriate model for both samples included two random effects (intercept and linear time), and fixed effects for ASI (or NT; mean-centered), a linear time effect, a quadratic time effect, gender, and two interactions: 1) linear time effect by gender, and 2) linear time effect by ASI. This model was used in all subsequent analyses as it was the best fit for our data. Blink number represented the variable of time and was coded from 0–8. In the RCM models, non-response blinks were coded two ways – 1) as missing values, and 2) as 0's (missing blinks were always coded as missing values). The pattern of results was nearly identical regardless of how non-responses were coded - thus we only present models in which they were coded as missing values.

Results

Sample Characteristics

Chi square and ANOVA analyses indicated that the samples did not differ on age, ethnicity, NT, or ASI (all p values $> .23$; see Table 1). The gender distribution varied between the two samples, with Sample 2 having a greater percentage of females than Sample 1. ASI was not associated with mean blink amplitude in Sample 1 ($p = .26$) but was correlated at a trend level in Sample 2 ($p = .09$). Figure 1 represents the mean startle response for each of the

³We also examined the relationship between each of our personality variables and startle onset latency across each of the 9 blinks, using an analyses strategy identical to what was used when startle amplitude was our dependent variable. None of these analyses yielded significant findings. These null findings are consistent with studies that have failed to find a relationship between anxiety-related traits and startle latency in non-clinical populations (Grillon, Ameli, Foot, & Davis, 1993).

nine blinks in both samples. Generally, participants appeared to exhibit a decrease in startle response across the course of the 2.5 minute period.

Relationship between ASI and startle habituation: raw habituation and PC habituation

First, we examined the relationship between AS and *raw habituation* and *PC habituation* in both samples (see first row of Table 2). Results revealed that AS was negatively associated with raw habituation in both samples, such that individuals with higher levels of AS had lower reduction scores. Using the *PC habituation* definition, AS was negatively associated with startle habituation in Sample 1 but not in Sample 2.⁴

Slope analyses using RCM

In both samples, RCM analyses revealed a significant negative linear ($b = -.606$, $t = -6.70$, $p < .0001$) and a positive quadratic effect of time ($b = .029$, $t = 2.68$, $p = .009$). Thus, on average, subjects' blink amplitudes decreased over time, but the rate of this decrease diminished over time. In addition, there were significant AS by time interactions in both samples, indicating that subjects' blink amplitudes decreased over time as a function of their AS score (see last row of Table 2). There were no significant AS by quadratic time effects.

To follow up significant AS by time interactions in the two samples, simple slopes analyses were conducted by recoding AS into two separate conditional predictors 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 AS where '0' represents 1 SD above and below the mean, respectively. Thus, 'high' and 'low' do not represent groups but relative levels on AS. In both samples, high and low AS were negatively associated with startle habituation (i.e., significant AS by time interaction), but subjects with lower AS showed steeper reductions in blink amplitude over the startle period than those with high AS (see Figures 2 and 3).

Effects of NT

AS was highly correlated with NT in each sample (r 's $> .50$). We therefore examined the relationship between NT and habituation in both samples. Results indicated that NT was not associated with startle reduction in either sample (both p 's $> .24$). More importantly, models for which AS was associated with habituation revealed that AS continued to be significantly associated with startle habituation when NT was added to the models. For example, the AS by time effect for RCM analyses had p -values of .05 and .008 in the two samples, respectively.

Discussion

Previous research has suggested that individuals with anxiety disorders exhibit abnormal rates of startle habituation over time (Ludewig et al., 2005). As AS is a putative risk factor for anxiety disorders (and panic disorder more specifically), the present study aimed to examine whether individual differences in AS were associated with rates of startle habituation in two separate samples.

Results from the current study suggest that individuals with high AS demonstrate deficits in startle habituation over time. Additionally, this finding was replicated in an independent sample that was qualitatively different (e.g., different recruited times, decibel volume, etc.). Even after adjusting for levels of NT, AS continued to be associated with the time course of

⁴This discrepancy between the two samples may be due to the fact that ASI was significantly associated with the first blink in Sample 2 ($r = -.404$, $p = .003$), but not Sample 1 ($r = -.037$).

startle responding, suggesting that deficits in habituation are specific to AS and not the broader construct of negative temperament. This is noteworthy given that some have argued that AS's association with anxiety may be accounted for by the shared variance between AS and traits like neuroticism (Lilienfeld et al., 1993).

The relationship between AS and the development of future anxiety disorders has been well documented (Schmidt et al., 1999; Schmidt et al., 2006). However, identifying the underlying processes and mechanisms behind this relationship allows for a deeper understanding of *why* certain traits function as risk factors for anxiety. The present findings suggest that one possible mechanism as to why AS is a risk factor for anxiety (and panic disorder more specifically) is that high levels of AS impair habituation processes. Several factors may explain this mechanism. First, the way individuals respond to aversive events may be instrumental in the development of anxiety disorders. For example, although many people experience a panic attack at some point in their lives (Kessler, Chiu, Jin, Ruscio, Shear, & Walters, 2006), only a subset (approximately 4.7% [NIMH]) go on to develop panic disorder.

Another (possibly related) reason that AS may relate to deficits in habituation is that AS has been associated with an attentional bias towards anxiety-related stimuli on tasks such as the dot-probe (Hunt, Keough, & French, 2006) and Stroop (Koven, Heller, Banich, & Miller, 2003). It is therefore plausible that individuals with higher levels of AS are more prone to become hyper-vigilant to aversive stimuli over time, thus resulting in prolonged reactivity and less habituation of physiological responding over time. Subsequently, these individuals may experience chronic anxious apprehension and go on to develop PD. This role of attentional bias may also relate to why individuals with PD (who presumably have high AS levels), have greater difficulty than non-PD individuals un-learning that cues are associated with threat (i.e., fear extinction; Michael et al., 2007; see also Bouton, Mineka, & Barlow, 2001).

It should be noted that many overlapping processes could have occurred during the baseline startle task to account for startle habituation. For instance, individuals may have demonstrated a reduction in startle responding due to habituation to the acoustic startle probes (indeed, studies have shown that startle probes are aversive; Grillon & Ameli, 1998). Alternatively, individuals' levels of anticipatory anxiety elicited by the experimental context may have reduced over the recorded period. That is, because the data for the present study was collected before a threat-of-shock task, it is possible that those with high AS had greater difficulty regulating anticipatory anxiety related to the remainder of the experiment. Future research is therefore needed to elucidate whether AS is associated with different types of reduction in defensive responding.

Another aim of the present study was to examine startle habituation using several definitions. This is an important aim as previous studies have used widely varying definitions (LaRowe et al. 2006; Rothbaum et al. 2001) and this may have contributed to the mixed findings in the habituation literature (see Ludewig, Ludewig, Geyer, Hell, & Vollenweider, 2002, also see Hoenig et al., 2005). Overall, our results indicated that modeling individual slopes using RCM and raw habituation yielded the most robust associations with AS. In contrast, the proportion of first blink (PC habituation) definition yielded weaker effects and thus may be a less optimal definition.

It is important to note that even though RCM and raw startle habituation yielded comparable results, the RCM analyses indicated that reduction in startle responding over time may involve both linear and curvilinear effects. Specifically, responses appeared to decrease linearly but this decrease decelerated over time. This highlights the potential utility of RCM

over raw habituation as RCM can help determine a more nuanced pattern of affective responding that would be missed from simply examining a raw change score. For example, it may be beneficial to examine the rate at which individuals' responding "levels-off" (or decelerates) in addition to examining individual differences in initial reactivity.

The current study had many strengths, including replication in a separate sample, the comparison of multiple definitions of habituation, and utilizing longitudinal statistical techniques to detect important differences in patterns of blink reactivity. However, it also had several limitations. First, while we evaluated the relationship between startle responding and personality in two separate samples, participants across studies were somewhat homogenous as they were all college students. Thus, the generalizability of our findings is limited. Second, we did not screen for the presence of psychiatric disorders and it is unknown whether the effects for AS represented risk for anxiety disorders or the presence of anxiety disorders. Third, our baseline startle period consisted of only 9 startle probes over the course of two and a half minutes. Future studies may benefit from measuring startle responses over the course of a longer time period such as several hours or days. Fourth, lab-based stressors, such as an acoustic startle probe, may be less ecologically valid than other stressors. Thus, future research is needed to determine whether there are differences in the relation between personality and reductions in defensive across more 'real life' aversive stimuli.

In conclusion, results from the current study suggest that AS is associated with deficits in baseline startle habituation. Further, the demonstrated relation between AS and the maintenance of aversive responding may underlie the relationship between AS and the onset of panic disorder. However, future research utilizing a prospective design is needed to more accurately elucidate the temporal order of personality, deficits in habituation, and anxiety disorder onset.

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Figure 1.
Mean EMG amplitude for each sample.

Figure 2.

Sample 1: ASI by linear time interaction.

Note. Linear time effect for low ASI: $b = -.664$, $t = -6.96$, $p < .0001$; linear time effect for high ASI: $b = -.548$, $t = -5.76$, $p < .0001$.

Figure 3.

Sample 2: ASI by linear time interaction.

Note. Linear time effect for low ASI: $b = -1.32$, $t = -11.12$, $p < .0001$; linear time effect for high ASI: $b = -1.09$, $t = -9.20$, $p < .0001$.

Table 1

Demographics and personality characteristics within each sample.

	Sample 1	Sample 2
% Female	59.6 ¹	73.6 ²
Age	19.46 (2.23)	19.89 (2.80)
ASI	18.69 (11.93)	21.19 (9.50)
NT	12.69 (7.66)	14.30 (7.42)
Mean Blink Magnitude	60.54 ¹ (55.73)	40.24 ² (30.26)
Blink 1	83.21 ¹ (72.94)	77.57 ¹ (56.64)
Blink 9	43.14 ¹ (52.34)	28.75 ¹ (34.72)
Ethnicity (%)		
African American	6.9	11.6
Caucasian	34.5	40.6
Asian	21.8	26.1
Hispanic/Latino	29.9	14.5
'Other'	6.9	7.2

Note. Data are presented as % of the current sample or mean (*SD*), when appropriate; numerical superscripts indicate significant differences in means from the other two samples.

Table 2

Results from linear regression analyses and random coefficients analyses in both samples.

	Sample 1	Sample 2
Regression - Raw		
Gender	$\beta = -.097$	$\beta = .103$
ASI	$\beta = -.234^*$	$\beta = -.328^*$
Regression - PC		
Gender	$\beta = -.068$	$\beta = .046$
ASI	$\beta = -.248^*$	$\beta = -.203$
Random Coefficients		
Linear	$b = -.606^{**}$	$b = -1.21^{**}$
Quadratic	$b = .029^*$	$b = .099^{**}$
Gender	$b = .990$	$b = -.566$
ASI	$b = -.001$	$b = -.119^*$
ASI* Time	$b = .005^*$	$b = .012^{**}$

Note.

* $p < .05$;

** $p < .01$.