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Personality and Fear Conditioning: Effects of Neuroticism

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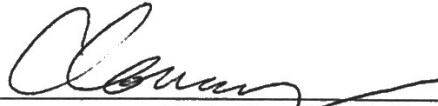
Personality and Fear Conditioning: Effects of Neuroticism

A thesis submitted in partial fulfillment of the requirement
for the degree of Bachelor of Science in Psychology from
The College of William and Mary

by

Rachel Maku C. Orleans-Pobee

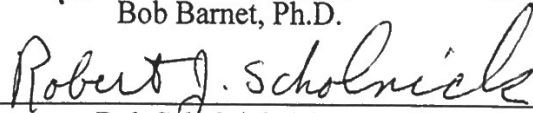
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Abstract

Fear conditioning is an associative learning paradigm that can be used to examine the acquisition and extinction of learned fear in various populations. Unusual patterns in fear conditioning are known to be associated with different types of psychopathology, and anxiety in particular has been studied extensively in relation to fear conditioning. However, far less is known about fear conditioning in nonclinical samples, particularly with regards to personality. The aim of the current study is to examine the acquisition and extinction of conditioned fear as it relates to neuroticism. The study utilized both physiological and subjective measures of learned fear, allowing for comparison across domains of fear expression. Eyeblink startle responses indicated that fear conditioning did not take place, with no significant differences in startle response magnitude in the presence of the conditioned and the unconditioned stimulus. Neuroticism was not found to be associated with greater eyeblink startle to either stimulus type. However, subjective fear ratings revealed an increase in fear of the conditioned stimulus following the acquisition phase, and a decrease in fear of the conditioned stimulus following the extinction phase, indicating that fear conditioning did in fact take place. Neuroticism was positively correlated with fear of the conditioned stimulus in the acquisition phase, indicating that more neurotic individuals may in fact acquire fear more readily than less neurotic individuals. Neuroticism was also associated with greater fear of the conditioned stimulus following extinction, suggesting that neurotic individuals may have difficulty learning when a stimulus no longer predicts threat. These findings indicate that neuroticism does impact both acquisition and extinction of conditioned fear, and there is a need for further replication in order to better understand the discrepancies between physiological and subjective measures in assessing fear conditioning.

Personality and Fear Conditioning: Effects of Neuroticism

Fear conditioning

Fear conditioning is a well-researched associative learning paradigm that can highlight differences in the way individuals with various clinical symptoms react to potentially threatening stimuli. It has been successfully utilized in laboratory settings for decades, with particular value in examining disorders associated with fear and anxiety. In fear conditioning procedures, a previously neutral stimulus such as an image or tone (called a conditioned stimulus; CS+) is repeatedly paired with a naturally aversive unconditioned stimulus (US), such as a shock or unpleasant sound, that produces a natural fear response (unconditioned response; UR). A second conditioned stimulus (CS-), is repeatedly presented in the absence of the US. After several presentations of the US in conjunction with the CS+, an association between the two is formed. The CS+ begins to serve as a cue of impending threat, thus eliciting the fear response, while the CS- serves as a safety cue (Grillon, 2002b).

There are two phases in the typical fear conditioning paradigm: acquisition and extinction. The term acquisition refers to the development of the fear response (CR) to the CS+ (Du, Jaaniste, Champion, & Yap, 2008), and is induced through repeated pairings of the CS+ with the US. Conversely, extinction occurs gradually as the subject learns that the CS+ is no longer associated with the threat that it previously signaled (Myers & Davis, 2007), and is induced by repeatedly presenting the CS+ in the absence of the US. Contrary to earlier conceptualizations of the extinction process, extinction is now generally believed to result from the learning of new information (that is, learning that the CS+ no longer predicts threat), rather than from the process of unlearning, or the weakening of previously formed associations (Lipp,

2006). Taken together, the magnitude and persistence of fear responses in acquisition and extinction indicate an individual's conditionability.

Anxiety and neuroticism in fear conditioning

Several personality traits and clinical symptoms have been associated with performance in fear conditioning tasks. Anxiety in particular is closely linked to fear conditioning; the role of conditioning in the etiology of anxiety disorders has been suggested as early as the 1920s (Watson & Rayner, 1920) and has been studied extensively both in human (Franks, 1961; LeDoux, 2014) and animal models (McNish, Gewirtz, & Davis, 1997). Numerous studies have demonstrated that anxious patients, compared to controls, exhibit greater fear responses to conditioned stimuli (Eysenck, 1979a; Ashcroft, Guimarães, Wang, & Deakin, 1991).

In addition to trait anxiety, individuals with anxiety disorders such as posttraumatic stress disorder (PTSD) or generalized anxiety disorder demonstrate an increased fear-potentiated startle effect in the presence of both the CS+ and CS- during acquisition, as well as sustained fear-potentiated startle during extinction, as compared to controls (Glover et al., 2011; Norrholm et al., 2011; Pitman & Orr, 1986). Researchers have found that deficiencies in extinction of the fear response may explain the development of PTSD symptoms (Orr, Metzger, Lasko, Macklin, Peri, & Pitman, 2000). Such findings may also indicate impaired discrimination (the ability to differentiate between the CS+ as a threat cue and the CS- as a safety cue) in anxiety patients; this overgeneralization provides insight into the development of anxiety-related disorders (Lissek, 2012). Conversely, because anxiety disorders such as specific phobia are characterized by cue-specific fear (Indovina, Robbins, Núñez-Elizalde, Dunn, & Bishop, 2011), specific phobia patients exhibit greater differences in fear response to the CS+ and CS-, rather than heightened fear response generalized to both stimuli (Dymond, Schlund, Roche, & Whelan, 2014).

Constructs related to anxiety, including neuroticism, have also received considerable attention in the fear conditioning literature. Neuroticism is a personality construct much broader in scope than anxiety, referring to a disposition to experience negative affective states such as anxiety, depression, and hostility (Hur, Jordan, Berenbaum, & Dolcos, 2015). High neuroticism is associated with increased reactivity to all stressors as measured by autonomic arousal (Santibanez & Schroeder, 1988; Reynaud et al., 2012; Londsorf et al., in press), and neurotic subjects are believed to exhibit greater conditionability (Eysenck, 1979b). The relationship between neuroticism and fear conditionability may be explained by the overlap between anxiety and neuroticism: because aversive conditioned responses resemble anxiety (Grillon, 2002b), it follows that neuroticism, sharing many similarities with anxiety, is associated with greater fear conditionability.

Measuring conditioned fear

There are various methods used to examine the learned fear response. Lang (1985) postulated three different dimensions through which humans express fear: verbal, behavioral, and physiological. The verbal level of fear expression can be easily assessed through self-report measures. However, accurate subjective report of negative emotions and experiences, including fear, can be difficult to obtain from individuals with high levels of anxiety, as they are often unable or unwilling to report experiencing such emotions (Beckers, Krypotos, Boddez, Effting, & Kindt, 2013). This can preclude the effective assessment of fear in these groups, an issue that is particularly relevant to fear conditioning studies as anxiety symptoms can be of interest when examining the acquisition and extinction of fear. Behavioral indices of fear provide a common solution to this problem, often utilizing implicit measurement techniques such as reaction time, which are less subject to cognitive influence (Teachman, Gregg, & Woody, 2001).

Although verbal and behavioral measures of fear are ubiquitous throughout the current literature, physiological measures of fear are of particular value, as they allow for experimental procedures that closely parallel those used with animal models (Lipp, 2006). Such physiological measures traditionally include electrodermal activity and cardiovascular activity, that is, increases in skin conductance (induced by perspiration) or heart rate indicate autonomic nervous system arousal, which can be considered expression of fear at the physiological level (Grillon, 2002b). Studies have revealed an association between electrodermal activity and declarative knowledge of the conditioned fear, indicating that the physiological expression of fear may be influenced by cognitive factors (Soeter & Kindt, 2010). This may suggest that electrodermal activity alone is insufficient in measuring fear. To address the issues associated with either subjective, behavioral, or physiological indices of fear alone, a combination of these methodologies can often be effective in assessing conditioned fear. In particular, a combination of self-report and physiological indices is often employed, with measures specifically targeting valence, arousal, and action tendency providing an effective measure of fear (Beckers et al., 2013).

One particularly effective physiological measure is the fear-potentiated startle effect. Fear-potentiated startle refers to the increase (potentiation) of the startle reflex during a state of fear, caused in fear-conditioning by the anticipation of an aversive stimulus (Grillon, 2002b). The effect was first demonstrated in fear conditioning procedures with rats (Brown, Kalish, & Farber, 1951), and has since been demonstrated in humans (Grillon, Ameli, Woods, Merikangas, & Davis, 1991; Lipp, Sheridan, & Siddle, 1994). Fear-potentiated startle can be more effective than other physiological measures of fear including electrodermal activity, as the startle-eliciting stimuli, or startle probes, are under the complete manipulation of the experimenters. Fear-

potentiated startle is also less sensitive to non-specific arousal (Khemka et al., 2017), which often occurs in experimental settings. Furthermore, it allows for direct comparison between human and animal models (Grillon, 2002b), allowing for a deeper understanding of the mechanisms underlying fear learning across all species.

Although any sudden visual, auditory, or haptic stimulus may serve as the startle probe, the startle probe is typically a loud sound with fast, nearly instantaneous rise time (Khemka, Tzovara, Gerster, Quednow, & Bach, 2017). In many studies, a short burst of “white” noise serves as the startle probe (Pittig et al., 2014; Chin, Nelson, Jackson, & Hajcak, 2015), but others have used puffs of air to the face (Ross, 1961), a method of startle elicitation that is particularly useful in populations with impaired hearing. The startle response is most commonly measured using electromyography (EMG) to measure the electrical activity of the orbicularis oculi muscles, located below the lower eyelid. Contraction of these muscles causes the eyeblink component of the startle response (Grillon & Baas, 2003). Potentiation of eyeblink magnitude in the presence of the CS+ (relative to eyeblink magnitude in the presence of the CS-) indicates that fear conditioning has transpired, thus, fear-potentiated startle serves as an operational measure of fear (VanElzakker, Dahlgren, Davis, Dubois, & Shin, 2014).

Conditioning paradigms

There are several variable aspects of fear-conditioning procedures, and experimental procedures differ greatly in the extant literature. One central feature of fear conditioning that has gained significant attention in recent work is reinforcement rate, or the percentage of CS+ presentations that are paired with the US, reinforcing the association between the two stimuli. Continuous reinforcement schedules (in which the US is presented in 100% of CS+ trials) produce rapid acquisition of fear, but also produce rapid extinction (Reinhardt et al., 2010;

Phelps, Delgado, Nearing, & LeDoux, 2004). In contrast, partial reinforcement (in which the reinforcement rate is less than 100%) has been found to increase resistance to extinction, slowing down the extinction process (Phelps et al., 2004). This attenuated extinction resulting from partial reinforcement is referred to as the partial reinforcement extinction effect (PREE), and has been reliably demonstrated in operant conditioning procedures as well as classical conditioning (Amsel, 1958; Pittig, Schulz, Craske, & Alpers, 2014). However, slower extinction often occurs at the expense of acquisition, and optimal experimental settings may comprise a combination of the two types of reinforcement schedule, with partial reinforcement in the first part of the acquisition phase, and continuous reinforcement in the latter portion (Grady, Bowen, Hyde, Totsch, & Knight, 2016).

Another factor with considerable influence on fear conditioning is the level of ambiguity surrounding the threat cue. Strong situations, or experimental settings in which unambiguous cues clearly predict the aversive or rewarding US, typically produce uniform results across participants (Ickes, 1982). This can be useful when manipulation of specific experimental conditions is of interests and individual differences are a source of noise (Lissek, Pine, & Grillon, 2006). Weak situations, conversely, involve events that are less clearly defined, and may be more effective in revealing individual differences in fear and or arousal. This has been demonstrated in anxious populations by Grillon et al., whose findings revealed that PTSD patients show greater startle potentiation than controls when shock electrodes were attached but no explicit threat cue was presented (i.e., a weak situation), whereas no group differences were revealed when the threat cue was presented (i.e., a strong situation; Grillon, Morgan, Davis, & Southwick, 1998). Further evidence of the anxiogenic nature of weak situations is seen in studies examining neuroticism. Craske et al. (2009) demonstrated that neuroticism potentiates startle

response only in conditions that moderately indicated threat of shock, but not in conditions that were more directly related to the threat. Taken together, these findings indicate that neuroticism is associated with increased startle response, and that weak situations may be associated with potentiated startle response due to their ambiguity.

The present experiment

The present study aims to examine the effects of neuroticism on conditioned fear, utilizing a partial reinforcement schedule (80% reinforcement rate) rather than a continuous reinforcement schedule in order to slow the rate of acquisition and prolong extinction across all participants. Creating a weaker situation through partial reinforcement will more effectively highlight individual differences in conditionability, while still maintaining a high enough reinforcement rate and clear enough threat cue to elicit cued, rather than contextual fear. Fear acquisition and extinction will be assessed through startle reactivity, a measure of fear that is more sensitive to stimulus valence and less subject to cognitive interference than other widely used physiological methods. The experimental procedure also includes self-report measures that will allow for the subjective appraisal of fear, as well as self-reported contingency awareness and aversion to the unconditioned stimulus, which may modulate conditionability across participants. While neuroticism has been examined in fear conditioning studies aimed at understanding either anxiety or contextual fear in aversive conditioning (Guimaraes et al., 1991; Hur et al., 2015), only a handful of studies in the existing literature focus on understanding the role of neuroticism in conditioning procedures using specific cued threat.

Based on previous findings in the fear conditioning literature, we predict that neuroticism will enhance the fear-potentiated startle effect. However, in accordance with previous studies (Craske et al., 2009), we expect that participants with higher neuroticism will show less

discrimination between the two stimuli and will demonstrate fear-potentiated startle in the presence of both the CS+ and the CS-.

Method

Participants

The sample was comprised of undergraduate students ($N=20$) enrolled in Introductory Psychology courses at The College of William and Mary. Eligibility was restricted to students who were at least 18 years of age, with the age of the final sample ranging from 18 to 21 years ($M=18.85$, $SD=1.04$). Participants received as compensation one credit toward required research participation. Of the 20 participants, 6 (30%) were male and 14 (70%) were female. 16 participants (80%) identified themselves as White, with 2 participants (10%) identifying as Black and 2 participants (10%) identifying as “Other- Asian”.

Measures

Neuroticism. The Big Five Inventory is a 44-item self-report measure that assesses the five dimensions of personality commonly known as the Big Five Factors: openness, conscientiousness, extraversion, agreeableness, and neuroticism (John & Srivastava, 1999). Neuroticism was measured using the neuroticism subscale (BFI-N), which incorporates six facets of neuroticism: anxiety, angry hostility, depression, self-consciousness, impulsiveness, and vulnerability (John & Srivastava, 1999). Individuals were instructed to indicate the degree to which they agreed with the items by responding to each item on a five-point Likert scale with response options ranging from “*disagree strongly*” to “*agree strongly*”. Items included statements such as “I see myself as someone who can be moody” and “I see myself as someone who worries a lot”. Neuroticism was scored on a scale from 1 to 5 by calculating the mean

response to all 8 items of the BFI-N subscale. Higher scores indicated a greater degree of neuroticism, while lower scores represent greater emotional stability.

Stimuli and apparatus

Images of a green cube and a blue disc served as conditioned stimuli, with CS+ and CS- assignment counterbalanced across participants. Stimuli were presented for 8 seconds, separated by a 12-second inter-stimulus interval (ISI). During the first four seconds of each CS presentation, the words “scream sound?” appeared alongside a visual analogue scale, and the participant was instructed to rate the degree to which they expected to hear the scream sound during this trial. The acoustic startle probe was a 100-dB burst of white noise, delivered binaurally through headphones for a duration of 50 ms. Startle probes were presented in CS+ trials, CS- trials, and in the ISI at different rates across phases of the experiment. Probe onset time was randomized, but was at least 4 seconds after stimulus onset, when the visual analogue scale for scream expectancy ratings had disappeared from the screen, and no more than 5 seconds after stimulus onset.

Electromyography (EMG) activity of the orbicularis oculi muscles of the right eye was recorded using two reusable shielded electrodes filled with a conductive gel (BIOPAC Systems Inc., Essen, Germany). All electrode signals were amplified through the BIOPAC MP150 data acquisition device, and were recorded and processed using AcqKnowledge software. Data were filtered, rectified, and smoothed using a time constant of 20 ms, and each response was manually inspected for motion artifacts. Startle responses were then defined as the difference (in microvolts) between the maximum and minimum amplitude of the EMG waveform recorded between 20 and 150 ms following each startle probe onset.

Procedure

Prior to beginning the experimental procedure, all participants read and signed informed consent documents. Next, participants underwent a psychophysiological workup during which EMG recording equipment was attached. After having the skin below the participant's left eye cleaned with an abrasive gel, the two EMG electrodes were attached below the left eye on the orbicularis oculi muscles to measure startle eyeblink reflex.

Immediately following the psychophysiological workup, the participant began the battery of self-report questionnaires. After the participant completed the first two measures (approximately 10 minutes after beginning the questionnaires), the experimenter tested the contact impedance between the two EMG electrodes, using a portable impedance checker. Impedance was recorded, and EMG electrodes were reattached in instances where the impedance was 50 k Ω or greater. Following the impedance check, participants then completed the remainder of the questionnaires.

The participants then completed a computerized fear conditioning task in which the CS+ (a geometric shape) was paired with a 92-dB audio clip of a woman screaming, presented for 100 ms. The CS-, another geometric shape of a different color, was always presented in the absence of the scream sound. Instructions were delivered both in the computer program and verbally by the experimenter. Participants were asked to focus on the computer screen, but were not explicitly instructed to pay attention to which shape was paired with the scream sound. The task began with a three-minute baseline period, during which four acoustic startle probes were presented randomly, with an interval of at least 15 seconds between probes. This was followed by a habituation phase consisting of 2 CS+ trials and 2 CS- trials, with startle probes presented in all trials and with no reinforcement (i.e., no scream sound was played). During this phase,

participants were asked to provide ratings of the valence, arousal, and fearfulness associated with each shape using a scale with response options ranging from 1 to 7. This was followed by an acquisition phase, comprised of two blocks. Each block included 5 CS+ trials and 5 CS- trials presented in pseudorandom order (i.e., no more than 2 consecutive presentations of the same CS image), for a total of 20 trials (10 CS+ and 10 CS-) in this phase. In each of the two blocks, startle probes were presented in 4 of the 5 CS+ trials, 4 of the 5 CS- trials, and 5 of the 10 ISIs. During acquisition, the CS+ was reinforced with the scream sound in 4 out of 5 trials (i.e., 80%). Scream expectancy ratings were recorded during the first 4 seconds of stimulus onset in each trial. That is, participants were asked to indicate the extent to which they expected the scream sound to occur during a given CS presentation by using the mouse to click a point on a visual analogue scale running from 0 (i.e., absolutely sure no scream) to 100 (i.e., certain scream; see Figure 1). At the end of the 20 trials, participants again provided ratings of valence, arousal, and fearfulness for each stimulus. This was followed by the extinction phase, consisting of 8 presentations of the CS+ and 8 presentations of the CS-. Startle probes were presented in 6 of the 8 presentations of each stimulus type, and in 8 of the 16 ISIs. All trials were non-reinforced, and expectancy ratings were again recorded through the visual analogue scale during the first 4 seconds of each trial. At the end of the phase, participants provided ratings of valence, arousal, and fearfulness for each stimulus. Participants also indicated which of the two stimuli they believed to have been paired with the scream sound, as well as their level of certainty regarding their answer. The experiment lasted approximately one hour.

Data analysis

Mean values were calculated for each stimulus type (CS+ or CS-) for each of the two acquisition blocks. The extinction phase was also divided into two blocks, consisting of the first

four trials and the last four trials for each stimulus type. Mean values were also computed for each stimulus type for the first and second half of extinction trials. A two way repeated measures analysis of variance (ANOVA) was conducted, with block (first vs. second) and stimulus type (CS+ vs. CS-) as within-subjects factors, and with neuroticism (BFI-N) as a covariate.

Results

Fear acquisition

Mean startle responses during both the acquisition and extinction phases are displayed in Table 2. A repeated measures ANOVA revealed no main effect of stimulus type, $F(1, 18) = .592$, $p = .45$, or block, $F(1, 18) = .659$, $p = .43$, after controlling for neuroticism. The interaction effect between stimulus type and block was also not significant, $F(1, 18) = .590$, $p = .45$. When controlling for neuroticism, startle responses decrease for both CS types over time (see Figure 2). In CS+ trials, the startle response decreased from Block 1 ($M = 3666.67$, $SD = 2768.19$) to Block 2 ($M = 2834.96$, $SD = 2455.80$), while the startle response in CS- trials decreased from Block 1 ($M = 4204.87$, $SD = 4204.87$) to Block 2 ($M = 2942.69$, $SD = 2429.34$).

Subjective ratings of fear provided immediately following the acquisition phase were significantly higher for the CS+ ($M = 4.85$, $SD = 2.11$) than for the CS- ($M = 2.4$, $SD = 1.64$), $t(19) = 5.517$, $p < .001$, indicating that differential fear acquisition did take place as measured by self-report indices (see Figure 4).

Fear extinction

Mean eyeblink amplitudes by trial are shown in Figure 2. A repeated measures ANOVA yielded no main effects of stimulus type, $F(1, 18) = .464$, $p = .50$, or of block, $F(1, 18) = .562$, $p = .46$. No significant interaction effects were found between stimulus type and block, $F(1, 18) = .622$, $p = .44$.

Subjective fear ratings provided upon completion of the extinction phase showed a significant difference between subjective fear of the CS+ ($M = 3.95$, $SD = 1.54$) and of the CS- ($M = 2.95$, $SD = 1.82$), $t(19) = 2.814$, $p < .05$ (see Figure 6). However, this effect size was much smaller than the differences between CS+ and CS- fear when assessed after acquisition.

Neuroticism

Neuroticism was normally distributed across participants ($M=2.919$, $SD=.96$), with scores ranging from 1.25 to 4.625. There were no missing items in any responses. Neuroticism was not correlated with eyeblink startle in the presence of either stimulus type either in acquisition or extinction. However, there was a strong positive correlation between neuroticism and self-reported fear of the CS+ during acquisition (see Figure 5), $r(18) = .666$, $p < .05$. Neuroticism was also correlated with self-reported fear of the CS+ during extinction, $r(18) = .505$, $p < .05$ (see Figure 7).

Discussion

Past research has effectively measured conditioned fear using the fear-potentiated startle paradigm in various populations. Therefore, the goal of this study was to examine fear conditioning by measuring startle eyeblink reflex, with respect to neuroticism. We aimed to highlight differences in conditioned fear resulting from individual differences in neuroticism, through the use of a partial reinforcement schedule and by incorporating both subjective and physiological measures of fear. We expected results of the current experiment to reveal increased eyeblink startle response in the presence of the CS+ as compared to the CS-, with highly neurotic participants generally demonstrating greater fear of both stimulus types. Specifically, we expected higher neuroticism to be associated with increased startle eyeblink magnitude, with an interaction with block and stimulus type so that the startle response is larger in later trials and to

the CS+. However, findings did not reveal potentiation of the startle reflex in the presence of either stimulus type. Furthermore, neuroticism was not associated with increased startle response in either block, or to any stimulus type.

Our primary and most unexpected finding is the equivalence of startle reactivity in the presence of the CS+ and in the presence of the CS-. This indicates that fear conditioning, as measured by startle eyeblink response, did not take place in our sample. As a result of the lack of distinction between startle responses to the two stimuli, we also found that neuroticism was not associated with startle responses to either the CS+ or the CS-, contrary to our predictions and to findings in the extant literature. There are several possible explanations for these findings. Previous studies examining the effects of threat intensity found that a more intense and aversive unconditioned stimulus leads to higher generalization than does an unconditioned stimulus of moderate intensity, both in animal models (Baldi, Lorenzini, & Bucherelli, 2004) and in humans (Dunsmoor, Mitroff, & LaBar, 2009; Dunsmoor, Kroes, Baren, & Phelps, 2017). That is, when an individual is exposed to a high-intensity US, the physiologically-measured fear response develops not only in response to the CS+, but in response to other stimuli and contexts that were not explicitly reinforced. It is possible that the present study utilized a US of too high an intensity to allow for discrimination between the CS+ and CS- at the level of physiological arousal and startle reactivity, resulting in startle responses of similar magnitude in the presence of the two stimulus types.

Though the discrepancy between the subjective data (self-reported fear) and the physiological data (startle response) was unexpected, the pattern of fear conditioning demonstrated by subjective reports of fear aligns closely with our hypotheses. As predicted, subjective fear ratings after the acquisition phase were significantly higher for the CS+ than for

the CS-. The difference in subjective ratings of the two stimulus types following acquisition indicates that fear conditioning did in fact take place, as it demonstrates that participants learned to associate the CS+ with the aversive US, and had consequently acquired a fear response to the CS+. However, the discrepancy between the fear conditioning revealed by subjective and physiological measures in this sample may suggest that physiological and self-report measures do not always effectively capture the same construct. Discrepancies across domains of fear expression have been examined in individuals who often demonstrate low self-reported fear or anxiety, but high physiological arousal (Weinberger, Schwartz, & Davidson, 1979; Derakshan, Eysenck, & Myers, 2007). Although the opposite pattern emerged in our sample (that is, our findings revealed an increase in self-reported fear to the CS+ but no changes in physiological fear response), the discrepancy between subjective and physiological measures of fear has been documented in previous studies and should be investigated further. Subjective fear ratings following extinction also supported our predictions, as subjective fear ratings for the CS+ decreased in extinction and were only slightly higher than fear ratings for the CS-. We can therefore conclude that extinction learning did in fact take place when assessed using subjective data, as participants learned that the CS+ no longer predicted threat, but the previously formed association between the CS+ and the US was not extinguished completely and fear ratings for the CS+ remained slightly higher than fear ratings for the CS-.

Our findings regarding the relationship between neuroticism and fear conditioning were inconsistent across domains, such that no association was found between neuroticism and conditioned fear measured by startle reactivity, but neuroticism was correlated with subjective CS+ fear. Although this may not provide conclusive support for our predictions, it does reflect the varied findings regarding neuroticism and fear conditioning in the current literature. While

some studies report that high neuroticism is associated with increased conditioned fear (Garcia & Zoellner, 2016; Lommen, Engelhard, & van den Hout, 2010), others found no association between neuroticism and fear conditioning (Davidson, Payne, & Sloane, 1964; Otto et al., 2007; Pineles, Vogt, & Orr, 2009). In many cases, studies separating participants into high and low-neuroticism groups are better able to identify significant differences in fear conditioning between the two groups, while correlational studies are unable to detect a significant correlation. Therefore, it is possible that the relationship between neuroticism and fear conditioning is nonlinear. Because neuroticism and aberrant fear conditioning patterns are both vulnerability factors for many anxiety disorders, continued investigation regarding the relationship between the two in nonclinical samples can inform our understanding of anxiety-related psychopathology.

Limitations of the study include a relatively small sample size, and a larger sample may have yielded results showing patterns of startle responses that were more consistent with our predictions. Another potential weakness of the study is the absence of additional physiological measures of fear aside from startle reflex. By analyzing electrodermal activity, for example, in addition to startle reflex, it may be possible to determine whether the insignificant results found in the startle eyeblink data were unique to this particular methodology, or whether other physiological measures would have yielded similar results as well. Future studies aimed at examining fear conditioning and neuroticism may benefit from manipulating the reinforcement rate, as it is possible that more neurotic individuals may be able to acquire fear of conditioned stimuli reinforced at lower rates than is necessary for fear conditioning in less neurotic individuals. Furthermore, it is possible that although the current findings fail to provide evidence of differential fear learning, a more basic form of fear conditioning may have taken place. Thus, further work is also needed comparing startle response in the presence of both CS types in

relation to startle response to probes presented during the ITI, and examining the interaction between neuroticism and these startle responses. Additionally, a direct replication of this study in the future would allow us to determine whether a different sample would produce similar results, and may be useful in providing a better understanding of the unexpected results found in the current sample. It may also be beneficial to replicate the study using a clinically anxious population, as there is considerable overlap between the characteristics of neuroticism and clinical anxiety. Furthermore, there are six facets of neuroticism as defined by the five-factor model of personality: anxiety, angry hostility, depression, self-consciousness, impulsiveness, and vulnerability. It is unclear which of these facets are responsible for the association between neuroticism and increased conditionability, and examining each of these specific traits in a fear conditioning paradigm may provide further understanding of the relationship between neuroticism and fear.

A major goal of the experiment was to determine the extent to which neuroticism was associated with fear conditioning in terms of acquisition, extinction, and the degree of generalization or discrimination between conditioned stimuli. To that end, the experiment was successful in revealing that neuroticism is associated with greater acquisition of fear by subjective, but not physiological measures. The study adds to the existing literature addressing inconsistencies between measures of fear across different modalities, highlighting the need for further studies examining the most effective methodologies in fear conditioning research.

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Variable	N(%)
Gender	
Female	14(70%)
Male	6(30%)
Age (Mean[SD])	18.85(1.04)
Ethnicity	
Hispanic/Latino	1(5%)
Not Hispanic/Latino	19(95%)
Race	
White	16(80%)
Black/African-American	2(10%)
Asian	2(10%)
Yearly Household Income	
\$100,000 and above	13(65%)
\$80,000 to \$99,000	2(10%)
\$60,000 to \$79,000	3(15%)
\$40,000 to \$59,000	2(10%)

Table 1. Sample Demographics

	Eyblink Amplitude (M[SD])	
	Block 1	Block 2
CS+ (Acquisition)	3666.67(2768.19)	2834.96 (2455.80)
CS- (Acquisition)	4204.87 (3278.20)	2942.69 (2429.34)
CS+ (Extinction)	2751.80 (2238.09)	2640.10 (2787.36)
CS- (Extinction)	2948.67(2670.68)	2182.03 (1916.12)

Table 2. Mean amplitude (in microvolts) of eyblink startle responses separated by block and CS type.

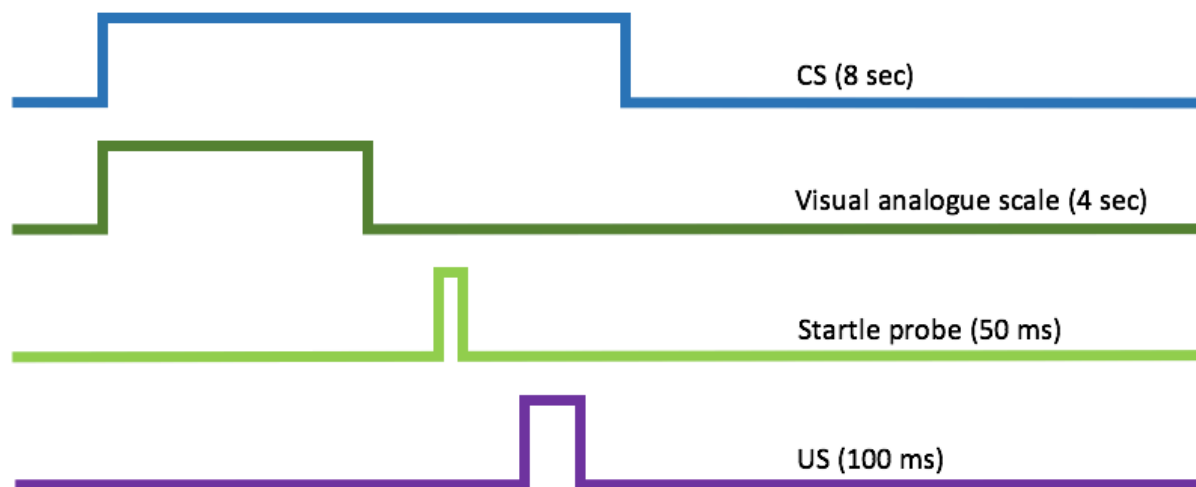


Figure 1. Example sequence of a CS+ trial during the acquisition phase. Each CS presentation lasted a total of 8 seconds. During the first 4 seconds following stimulus onset, a visual analogue scale (VAS) appeared alongside the stimulus, and participants provided ratings of US expectancy. After 4 seconds, the VAS disappeared and the startle probe (when included in the given trial) was presented at a randomized point between 4 and 5 seconds after stimulus onset. The US (when included in the given trial) was presented at a randomized point in the last 3 seconds of the stimulus presentation. Each trial was separated by a 12-second ISI.

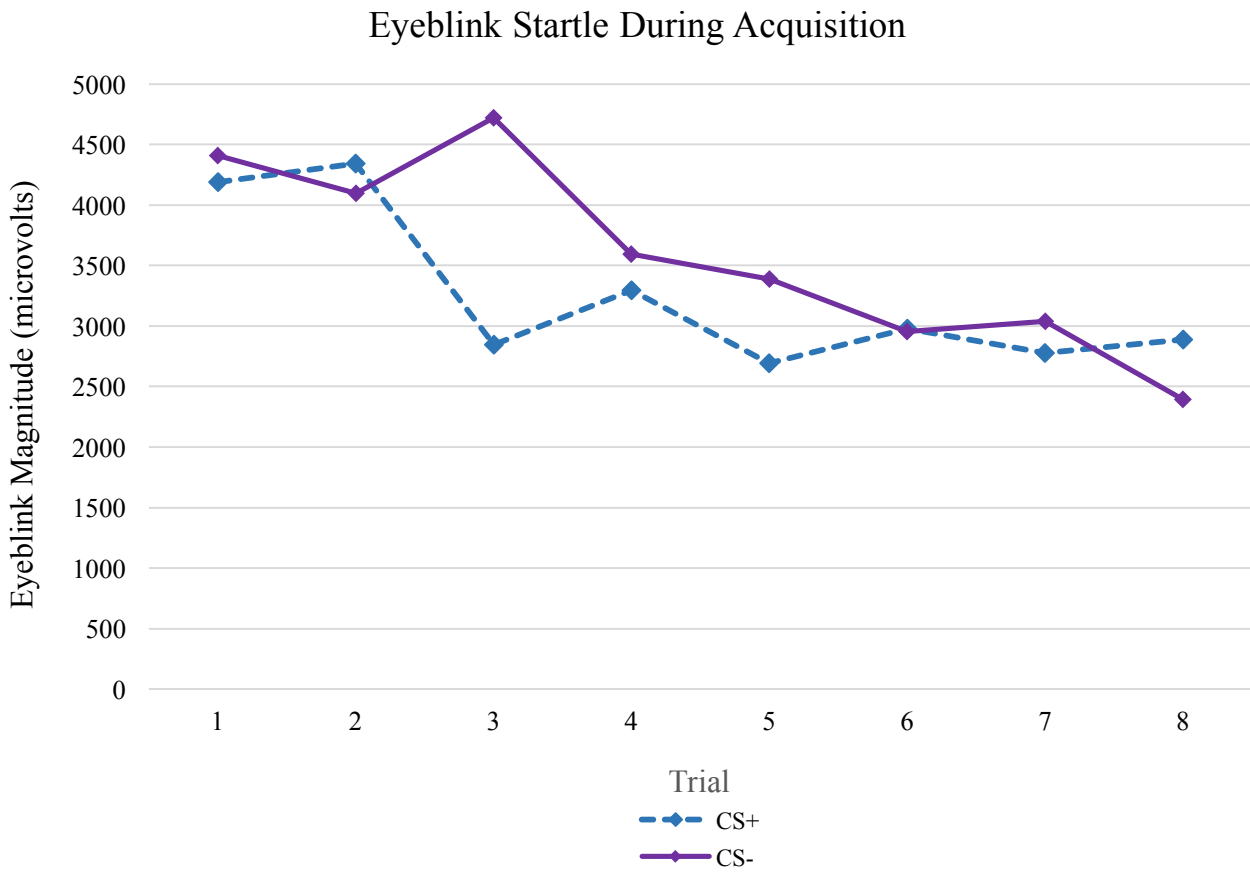


Figure 2. Mean eyblink startle responses by trial during the acquisition phase.

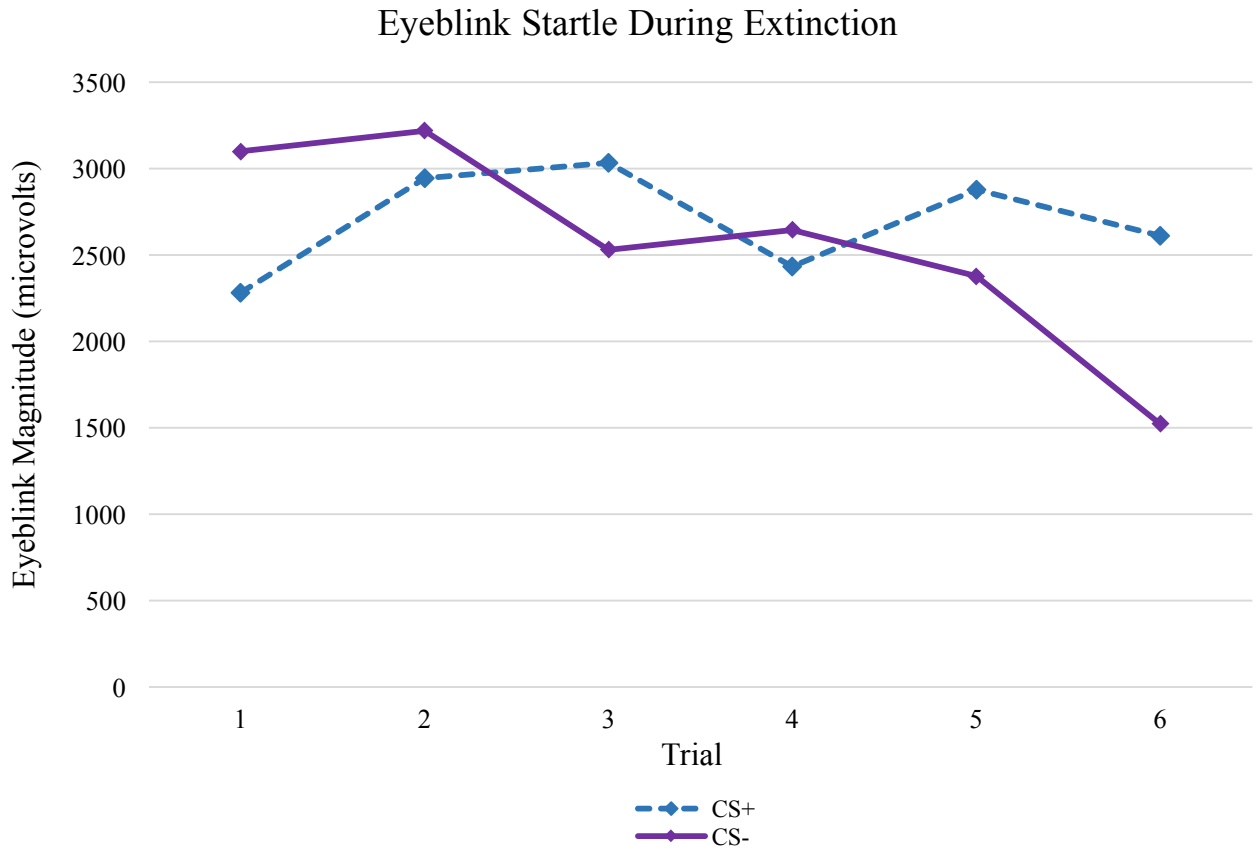


Figure 3. Mean eyeblink startle responses by trial during the extinction phase.

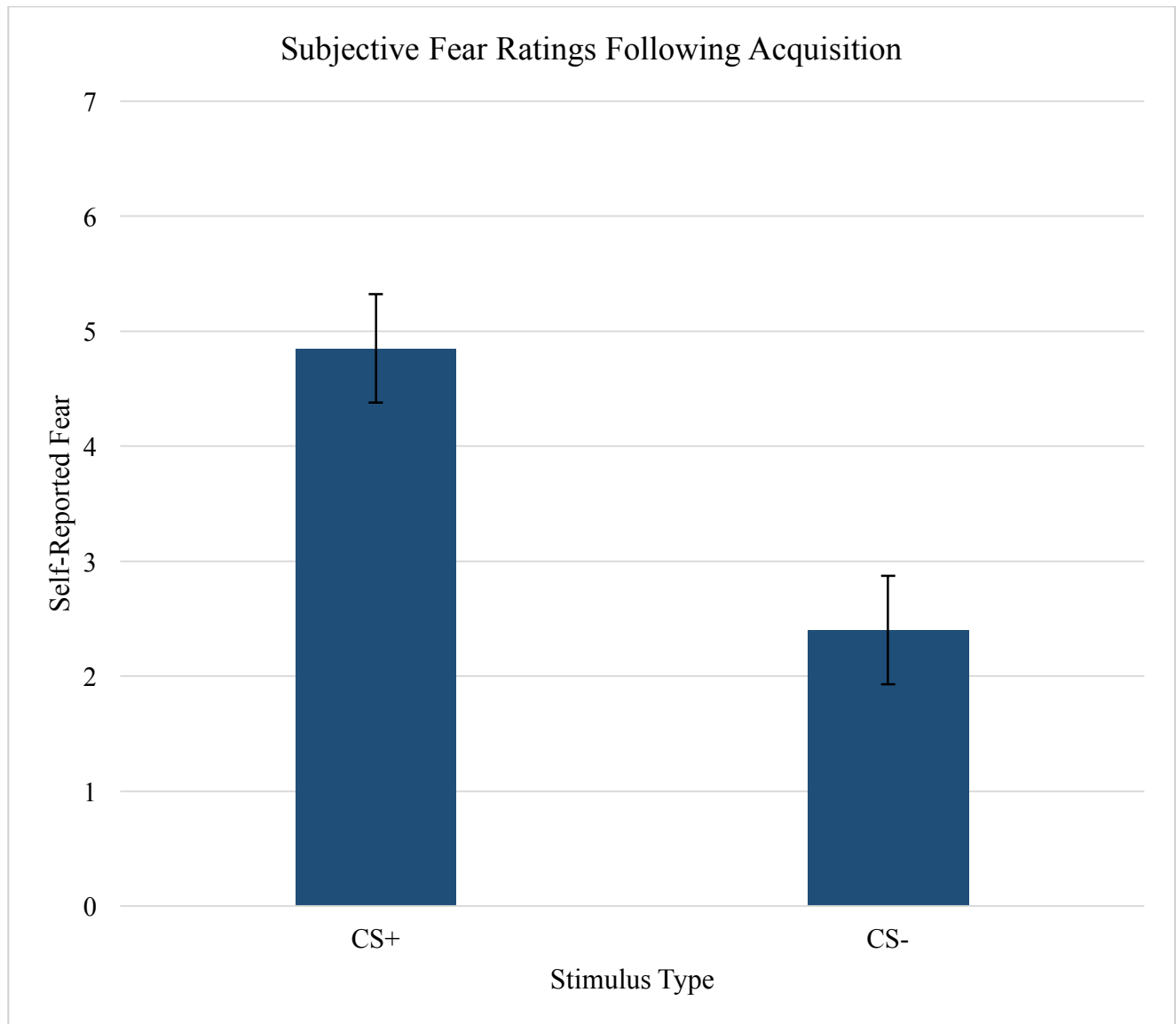


Figure 4. Self-reported fear of each CS immediately following the acquisition phase.

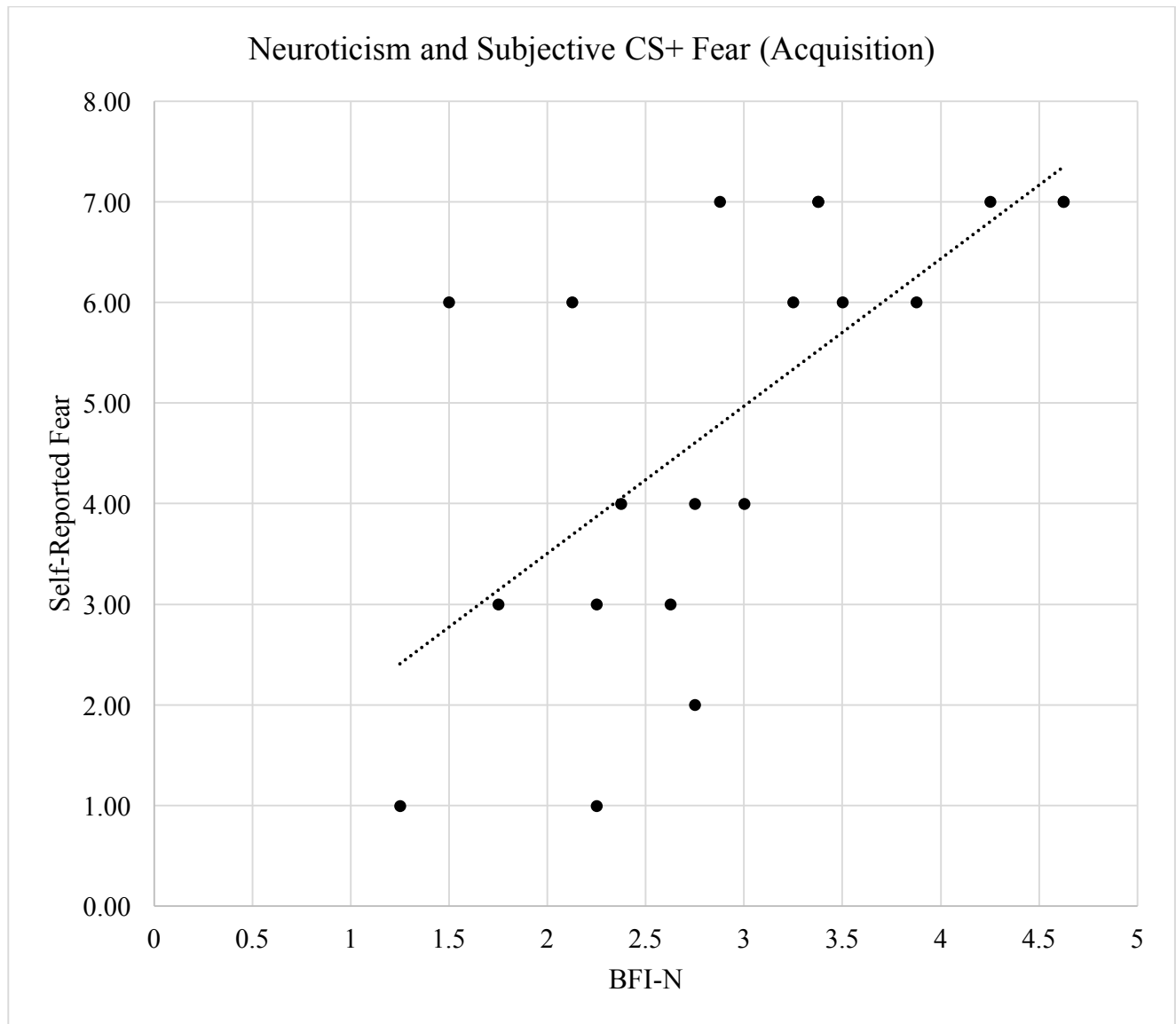


Figure 5. Correlation between neuroticism and subjective fear ratings of the CS+. Ratings were provided immediately following the acquisition phase. $r = .666$.

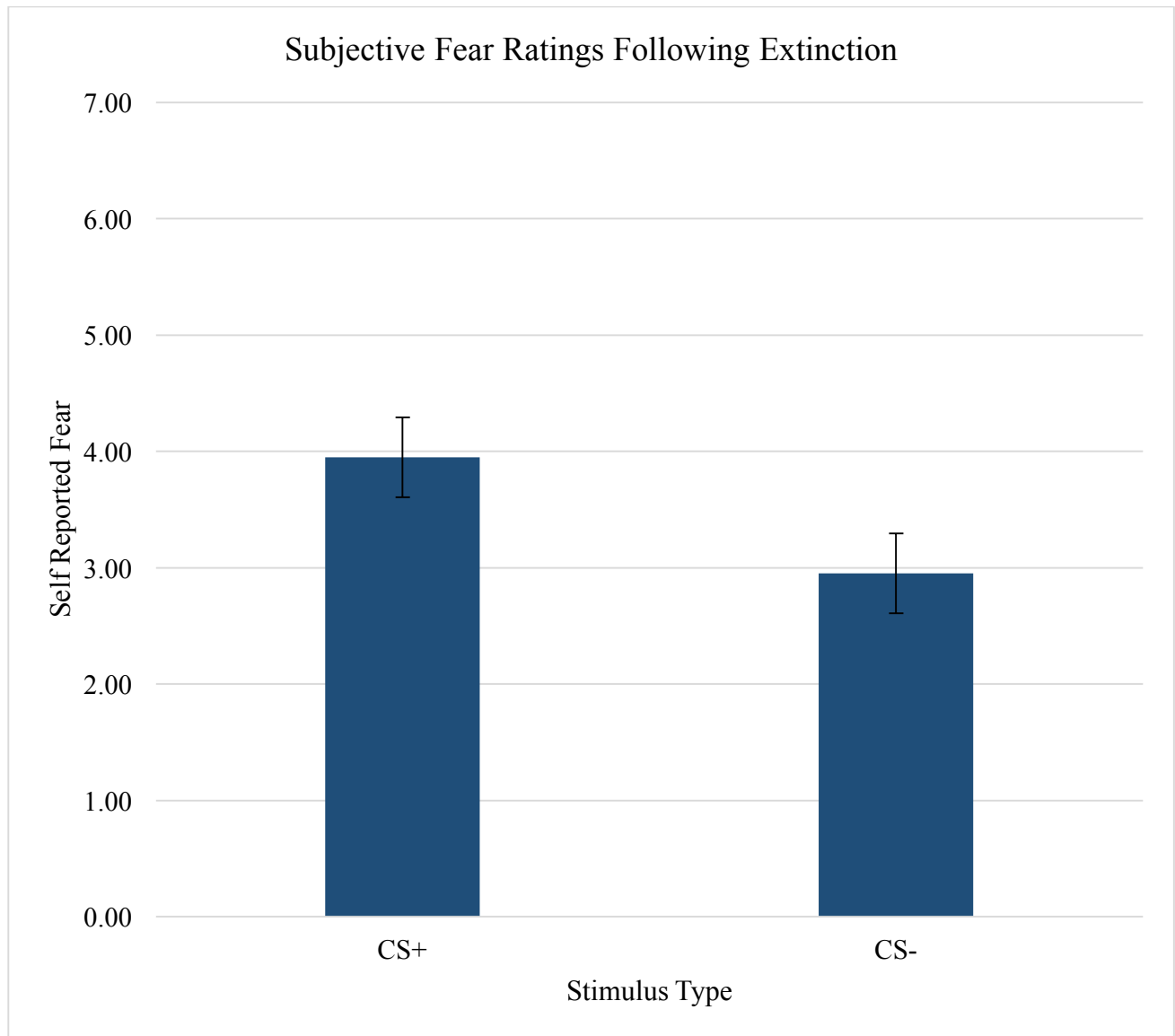


Figure 6. Self-reported fear of each CS immediately following the extinction phase.

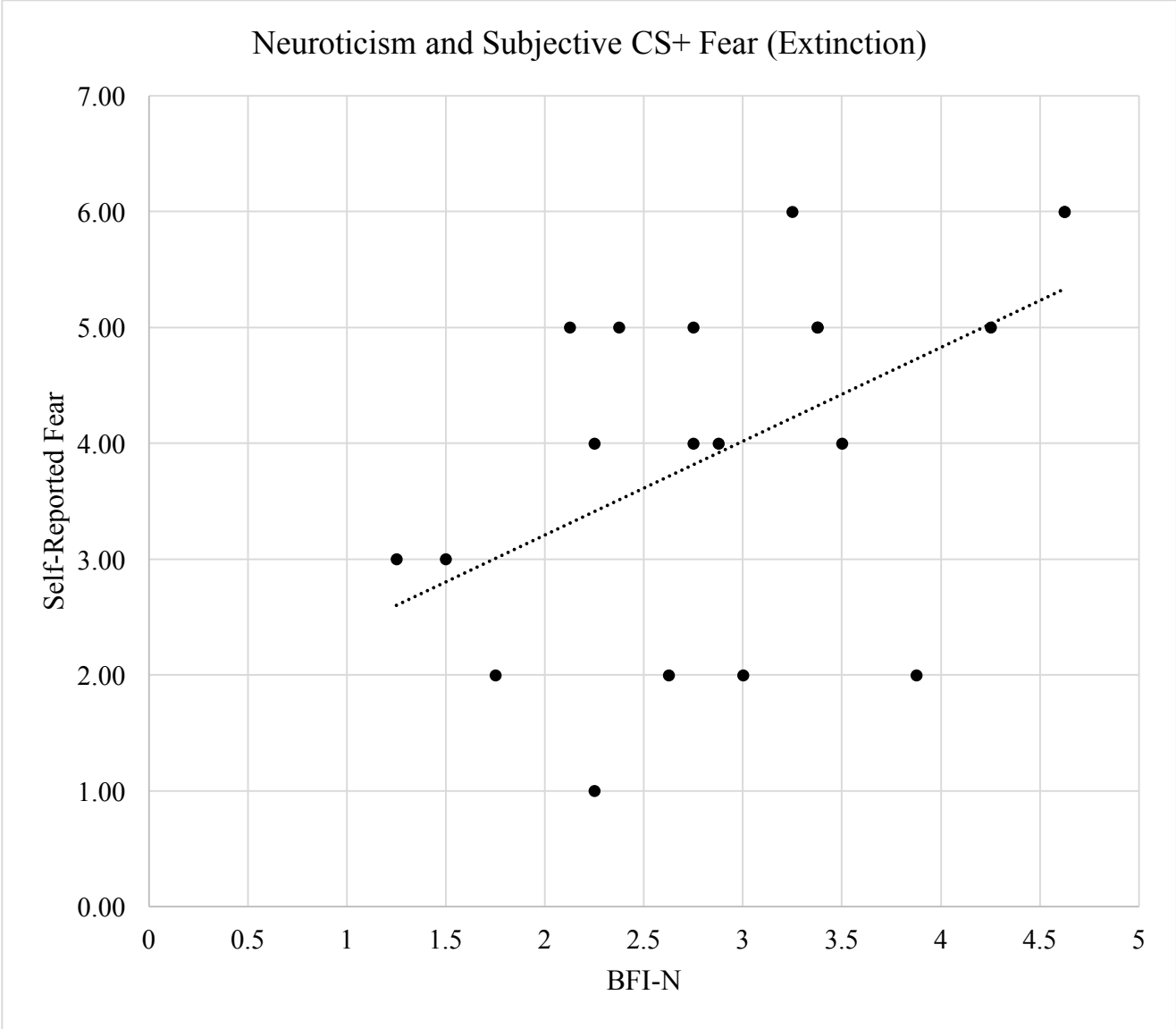


Figure 7. Correlation between neuroticism and self-reported fear of the CS+. Ratings were provided directly following the extinction phase. $r = .505$.