ATTENTION-EMOTION INTERACTIONS IN PSYCHOPATHY

BY

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DISSERTATION

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ABSTRACT

The present study was designed to test an etiological model of psychopathy that re-conceptualizes the attentional and emotional deficits associated with the disorder in an integrative framework. The sample consisted of 63 justice-system involved individuals who were recruited based on their scores on the Psychopathy Checklist-Screening Version (Hart, Cox, Hare, 1999), a widely used and well validated measure of psychopathic traits. Event-related brain potentials and startle reflex magnitude were collected while participants heard blink eliciting noise probes and viewed unpleasant and neutral pictures matched on visual complexity from the International Affective Picture System (Lang et al., 2005). These psychophysiological indices were used to measure basic affective and attentional effects of the stimuli on neural processes. Two dimensions of psychopathic traits were examined, specifically the affective-interpersonal dimension and impulsive-antisociality dimension, given evidence that they index potentially separable sets of risk factors for the manifestation of psychopathy and antisocial behavior. Results indicated the affective-interpersonal dimension is associated with: (1) enhanced sensitivity to attentional load as demonstrated by larger visual N1 to picture onset for high- than low-complexity images, (2) reduced emotional processing of unpleasant compared to neutral pictures as measured by the late positive potential, and (3) an interaction of these two phenomena indexed by reduced fear-potentiated startle during high-complexity pictures. In contrast, the impulsive-antisociality dimension was associated with decreased sensitivity to picture complexity in visual N1 and auditory N1. The findings suggest that psychopathy is a heterogeneous construct that is not characterized solely by an emotional or attentional deficit, as

the literature has historically assumed. Rather, it is characterized by multiple, interactive cognition-emotion deficits that manifest differentially across the psychopathy dimensions.

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CHAPTER 1

INTRODUCTION

In his seminal writings, Cleckley (1941) described the prototypical psychopath as an individual who appears psychologically well adjusted and mentally-healthy, but this apparent sanity masks a long history of social deviance (e.g., inadequately motivated antisocial behavior, unreliability, sexual promiscuity, failure to learn from experience) and emotional disturbance (e.g., remorselessness, shallow emotions, pathological egocentricity, deceitfulness). Unsurprisingly, this collection of traits is associated with repeated engagement in criminal behavior, particularly violent crimes (Hare, Clark, Grann, & Thornton, 2000), and the overrepresentation of psychopathic individuals in the criminal justice system (Louth, Hare, & Linden, 1998; Vitale, Smith, Brinkley, & Newman, 2002). There is increasing interest in clarifying the neurobiological vulnerabilities associated with psychopathy, partly because no efficacious interventions presently exist for treating these functional impairments (Harris & Rice, 2006). Given the financial and emotional burden caused by psychopathy, identifying risk factors and the mechanisms by which they combine is an important research endeavor with potentially critical implications for designing effective treatment interventions.

Although Cleckley (1941) originally conceptualized psychopathy as a unitary disorder, contemporary psychometric research on the structure of psychopathy supports a multidimensional conceptualization of the construct, in that at least two sets of traits vary dimensionally across individuals (e.g., Cooke & Michie, 2001; Edens, Marcus, Lilienfeld, & Poythress, 2006; Harpur, Hare, & Hakstian, 1989). The first dimension describes the affective and interpersonal features of psychopathy (e.g., superficial charm, deceitfulness, grandiosity, remorselessness, shallow affect), and the second dimension describes an impulsive, irresponsible, and antisocial lifestyle (e.g., Harpur et al., 1989). Examination of the external correlates of these dimensions indicates that the variance associated with the affective-interpersonal and impulsive-antisociality dimensions evidence distinct external correlates (e.g., Benning, Patrick, Hicks, Blonigen, & Krueger, 2003; Harpur et al., 1989; Ross, Benning, Patrick, Thompson, & Thurston, 2008; Verona, Patrick, & Joiner, 2001). For instance, the affective-interpersonal dimension is related to low levels of anxiety and fear, resilience against mood disorders, and intact general intelligence (Benning et al., 2003; Harpur et al., 1989; Ross et al., 2008), whereas the impulsive-antisociality dimension is related to high levels of anxiety and distress, a range of comorbid psychopathology (e.g., major depressive disorder, posttraumatic stress disorder, substance dependence), low general intelligence, and elevated rates of psychosocial adversity (e.g., poverty, childhood abuse) (Benning et al., 2003; Harpur et al., 1989; Reardon, Lang, & Patrick, 2002; Smith & Newman, 1990; Verona, et al., 2001). Despite differences in the psychopathological correlates of these dimensions, they do not merely differ in terms of the severity of functional impairments associated with each. Rather, research increasingly suggests that the psychopathy dimensions measure distinct etiological pathways to the manifestation of psychopathic traits and antisocial behavior that are characterized by distinct emotional and cognitive impairments instantiated in separable neurobiological systems (e.g., Fowles & Dindo, 2009; Patrick & Bernat, 2009). To test this hypothesis, the present study investigated whether the psychopathy dimensions exhibit differential cognitive and affective deficits, which would be consistent with the theory that they measure distinct risk processes associated with the development of psychopathic traits.

Etiological Models of Psychopathy

Despite great advances in uncovering psychological, biological, and environmental correlates of psychopathic traits, the etiology of psychopathy remains contested in the literature. The prominent etiological models of psychopathy differ in the emphasis each places on the relevance of emotional versus cognitive deficits, which has led to disagreement in the literature about the extent to which affective and cognitive processes confer risk for psychopathic traits. Furthermore, research has only begun to specify the emotional and cognitive dysfunction associated with each psychopathy dimension, an area of research that requires additional inquiry.

Low-fear model. For decades, researchers have theorized that psychopathy develops as a result of deficits in the emotional circuitry of the brain postulated to modulate the experience of fear, such as the amygdala and paralimbic system (e.g., Kiehl, 2006; Kiehl et al., 2001). Commonly referred to as the low-fear model, this theory emerged from a substantial body of research linking psychopathy to deficits in aversive conditioning (Flor, Birbaumer, Hermann, Ziegler, & Patrick, 2002; Hare, 1965), passive avoidance learning (Lykken, 1995; Newman & Kosson, 1986), and reactivity to threatening cues (Levenston, Patrick, Bradley, & Lang, 2000; Patrick, Bradley, & Lang, 1993). Psychopathic individuals' deficient fear-potentiated startle responses to threatening or unpleasant stimuli are often cited as evidence for the deficient emotional reactivity predicted by the low-fear model (Benning, Patrick, & Iacono, 2005; Levenston et al., 2000; Patrick et al., 1993; Pastor, Molto, Vila, & Lang, 2003). Deficiencies in affect-related neurological systems are theorized to be critical for the inadequate development of a moral conscience and collectively adaptive behavior in psychopathic individuals.

Recent research has begun to examine whether etiological models of psychopathy that were developed to explain psychopathy as a unitary construct also explain variance associated with the distinct psychopathy dimensions. Laboratory research has found that the deficient emotionality described by the low-fear model is specific to the affective-interpersonal dimension (e.g., Benning et al., 2005; Gordon et al., 2004; Patrick et al., 1993; Verona et al., 2001). For example, research has found that fear-potentiated startle reflex, a measure of defensive reactivity of motivational systems to threatening stimuli (Bradley, Cuthbert, & Lang, 1989; Grillon & Baas, 2003; Kim & Davis, 1993), is inversely related to scores on affective-interpersonal measures of psychopathy but remains unchanged as a function of scores on the impulsive-antisociality dimension (Benning et al., 2005; Patrick et al., 1993; Vaidyanathan, Hall, Patrick, & Bernat, 2011). Further, functional magnetic resonance imaging (fMRI) research indicates that the affective-interpersonal dimension is related to decreased activation in the amygdala during the processing of emotional stimuli, whereas the impulsive-antisociality dimension is associated with increased neural activation in brain regions related to emotional processing and reward anticipation, including the amygdala and nucleus accumbens (Buckholtz et al., 2010; Gordon et al., 2004). In combination, these studies suggest that the affective-interpersonal dimension is negatively related to processing of emotional stimuli, particularly deficient defensive activation of motivational systems that are important for responding to threatening stimuli as indexed by the fear-potentiated startle reflex. In contrast, the impulsive-antisociality dimension appears to be related to enhanced processing of emotional and motivationally relevant stimuli and to higher autonomic reactivity to stress (Lorber, 2004), though not necessarily an increased fear response to threatening stimuli.

Attention model. Although compelling, models of affective dysfunction in psychopathy, specifically affective-interpersonal traits, do not explain the "non-emotional" information processing deficits that are also associated with psychopathic traits. A large body of research has found that psychopathic individuals perform abnormally on tasks that involve the processing of neutral stimuli, such as non-affective Stroop tasks and dual attention tasks (Hiatt, Schmitt, & Newman, 2004; Jutai & Hare, 1983; Vitale, Brinkley, Hiatt, & Newman, 2007). The prominent cognitive model of psychopathy, referred to as the response modulation hypothesis (Newman, 1998), posits that psychopathic individuals' poor self-regulation and deficient emotional responses result from the poor integration of bottom-up information (e.g., emotion, contextual information) into conscious awareness when their attention is engaged in goal-directed behavior. Based on evidence that psychopathic individuals screen out distractors when engaged in attentionally demanding tasks (e.g., Jutai & Hare, 1983; Hiatt, Schmitt, & Newman, 2004) and display appropriate emotional responses in certain conditions (Baskin-Sommers, Curtin, & Newman, 2011; Glass & Newman, 2006; Newman, Curtin, Bertsch, & Baskin-Sommers, 2010), a subset of theorists attribute the development of psychopathy to abnormalities in attentional processing, such as reduced attentional capacity (Harpur & Hare, 1990; Kosson, 1996), or over-focused attention (Jutai & Hare, 1983), rather than deficiencies in emotional reactivity per se.

Recent work has also demonstrated that the selective attention deficits observed in psychopathic individuals are specifically related to the affective-interpersonal dimension (Baskin-Sommers et al., 2011; Newman et al., 2010). For instance, Sadeh and Verona (2008) found that the affective-interpersonal dimension was inversely associated with distractor processing on a perceptual load behavioral task (Maylor & Lavie, 1998) but unrelated to performance on a working memory task (Lavie et al., 2004). The findings of this study suggest that the affective-interpersonal dimension is associated with diminished perceptual capacity and intact working memory.

Deficits in working memory function and response inhibition have instead been associated with the impulsive-antisocial dimension in behavioral tasks (Sadeh & Verona, 2008; Sellbom & Verona, 2007). Similarly, psychophysiological research has identified an association between reduced P300 amplitude on visual oddball tasks, an ERP index of working memory processes, and the impulsive-antisociality dimension (Carlson, Thái, & McLarnon, 2009; Venables, Patrick, Hall, & Bernat, 2011). Thus, in contrast to the affective-interpersonal features of psychopathy, impulsive and antisocial traits appear to be characterized by heightened sensitivity to emotional stimuli and emotional dysregulation (Lorber, 2004) as well as deficits in working memory function.

The emotion-based and attention-based models of psychopathy are both supported by decades of laboratory research, making them plausible explanations for the development of psychopathic traits. Given that certain types of data support both etiological models, it is likely that attention and emotional deficits jointly confer risk for the development and maintenance of psychopathic traits. Thus, etiological models of psychopathy that integrate attentional and emotional dysfunction are warranted to advance conceptualizations of the risk factors associated with the psychopathy dimensions.

Attention-Emotion Integration in Psychopathy

Various theorists argue for examining the validity of the distinction between cognition and emotion (Lang, 1979; Miller, 1996). Emerging evidence from psychophysiological research, including functional neuroimaging, indicates that attention and emotion are not mutually exclusive processes but rather are reciprocally interconnected and influential (Blair et al., 2007). Emotional stimulus processing was historically thought to be a largely automatic process, because research shows that motivationally relevant stimuli are processed quickly and interfere with the perception of non-emotional stimuli (e.g., Anderson, 2005).

Other studies, however, have indicated that the processing of emotional information is not entirely automatic and generally does not occur independently of cognitive processes. As an example, Pessoa and colleagues examined the extent to which emotional stimuli located outside the focus of attention are processed under varying attentional loads (Pessoa, McKenna, Gutierrez, & Ungerleider, 2002; Pessoa, Padmala, & Morland, 2005). The theoretical foundation for these studies stemmed from research by Lavie (1995) among others (e.g., Hillyard, Hink, Schwent, & Picton, 1973) who showed that, as the attentional demands of a task increase, fewer resources are available for processing information that is outside the focus of attention. Pessoa et al. (2005) tested Lavie's attentional load theory with emotional stimuli and demonstrated using fMRI that attentional engagement during a demanding cognitive task suppressed activation in limbic regions of the brain, including the amygdala, when exposed to task-irrelevant emotional faces. Thus, the extant literature indicates that, as more attentional resources are allocated to a central task, the processing of unattended or peripheral stimuli decreases, regardless of its affective properties (see also Yates, Ashwin, & Fox, 2010). In other words, cognition is capacity-limited such that stimuli or processes can compete for it, including stimuli commonly judged as emotional.

Additionally, these data suggest that the influence of attention on the processing of emotional stimuli can occur as early in the processing stream as initial perception, in that high cognitive load can suppress activation in the amygdala despite the presence of affective stimuli (Pessoa et al., 2005). Similarly, the processing of emotional stimuli (affective pictures) has been shown to increase activation in the visual cortex (Bradley et al., 2003; Sabatinelli, Bradley, Fitzsimmons, & Lang, 2005), which is consistent with the influence of motivation and emotion on attention and basic perception as proposed by Lang (see Lang, 1979; Lang, Davis, & Ohman, 2000).

Based on these and other programs of research implicating affect-related regions of the brain in the modulation of early attention and vice versa, it is not only plausible but likely that dual emotion-attention deficits are associated with the psychopathy dimensions. Consequently, the present study examined the potential interactive effects of the purported emotional and attentional deficits associated with each psychopathy dimension.

The Startle Reflex Paradigm

As discussed above, the amygdala is likely to play a role in the biological implementation of emotional responses, whether it is the deficient emotional reactivity in individuals high in affective-interpersonal features or the emotional dysregulation in individuals high in impulsive-antisociality. Given that there is no gold standard to measure amygdala activity non-invasively at present, the startle-probe methodology has been widely used to index emotional reactivity in psychopathy (e.g., Patrick et al., 1993). The use of this paradigm is based on human research and animal work that has established the startle reflex as a measure of amygdala function (Bradley, Cuthbert, & Lang, 1989; Grillon & Baas, 2003; Kim & Davis, 1993). For instance, animal research using lesion and neurochemical antagonist methodologies demonstrates that fear conditioning, as indexed by startle reactivity, is mediated by the central nucleus of the amygdala (Hitchcock & Davis, 1986; Walker & Davis, 1997). Research also shows that the magnitude of the startle reflex is potentiated by contexts with unpleasant or fearful stimuli (e.g., scary photographs, potential for electric shocks or air blasts; Bradley, Cuthbert, & Lang, 1989; Curtin, Patrick, Lang, Cacioppo, & Birbaumer, 2001; Verona, Patrick, & Lang, 2002) and varies with individual differences in trait fear (Cook, Davis, Hawk, Spencer, & Gautier, 1992). Thus, the extant literature forges a strong link between fear processing, amygdala activation, and the magnitude of the startle reflex.

In the typical startle reflex paradigm, the processing of threatening stimuli results in an increase in blink amplitude following the presentation of fear-inducing stimuli, termed the fear-potentiated startle effect, and is theorized to reflect activation of a fear response driven by an increase in amygdala activity (Davis & Lee, 1998). A diminished blink magnitude is observed in response to pleasant stimuli, attributed to a desire to approach the appetitive properties of the stimuli (Patrick et al., 1993). Further, the startle reflex is modulated by the interaction of attention and emotion. Cuthbert, Bradley, and Lang (1996) found an initial (300 ms) attenuation of the startle response to arousing emotional stimuli reflective of orienting to the presentation of pleasant and unpleasant stimuli relative to neutral stimuli. This early attentional effect is thought to be overridden by activation of a fear response approximately 800 ms post-slide onset, which results in the differential inhibition and potentiation of the startle reflex to pleasant and unpleasant stimuli, respectively. Thus, startle reflex work in humans has provided considerable information on the time course of attention-emotion interactions.

Several studies have reported deficiencies in the startle reflex in psychopathic offenders (Levenston et al., 2000; Patrick et al., 1993; Pastor et al., 2005) and individuals with subclinical psychopathic traits (Benning et al., 2005). Patrick et al. (1993) conducted the first startle reflex study with psychopathic offenders, which involved presenting pleasant (e.g., erotic females, adventure scenes), neutral (e.g., household objects, inactive people), and unpleasant (e.g., mutilated bodies, attack scenes) pictures from the International Affective Picture System (IAPS) to participants and measuring startle-blink magnitude in response to unexpected noise bursts presented 3-5 s following stimulus onset. Replicating research on the startle reflex in college students (Lang, Bradley, & Cuthbert, 1990), Patrick et al. found a linear effect of emotion modulation on the blink response in non-psychopathic offenders, such that blink magnitude was smaller for pleasant than unpleasant slides. They also documented an aberrant pattern among psychopathic offenders, with the psychopathic group showing attenuation of the startle blink reflex to both positive and negative slides relative to neutral slides. This effect has been replicated several times in psychopathic samples (Benning et al., 2005; Levenston et al., 2000; Pastor et al., 2003) and is typically interpreted as evidence for an intrinsic emotional deficit related to the fear response in psychopathy, implemented in the amygdala. As discussed above, research increasingly indicates that deficient fear-potentiated startle is specific to the affective-interpersonal dimension rather than the impulsive-antisociality dimension (e.g., Benning et al., 2005; Patrick et al., 1993; Vaidyanathan et al., 2011)

Given that attentional and emotional processes are dually engaged in the IAPS startle paradigm and that both are here hypothesized to be dysfunctional in psychopathy, it is necessary to ensure that stimulus properties are matched across conditions along these dimensions.

According to Bradley, Hamby, Low, and Lang (2007), emotion and perceptual complexity are often confounded in IAPS slides, such that pleasant and unpleasant slides are typically more visually-complex (e.g., mutilation scenes) than neutral slides (e.g., a chair). A confound of emotion and perceptual load is problematic for interpreting existing startle reflex data in psychopathy. For instance, the tendency of individuals high in affective-interpersonal traits to screen out peripheral information when engaged in an attentionally demanding task may cause them to be less affected by the noise probes that initiate the startle response during visually-complex, unpleasant slides relative to visually-simple, neutral slides. This would result in smaller startle responses to unpleasant than neutral slides.

Research has begun to explore whether attentional processes influence fear-potentiated startle reflex in individuals with psychopathic traits. For instance, using an attentional-focus task, Newman and colleagues have found that the affective-interpersonal dimension is associated with reduced fear-potentiated startle when attention is directed away from threat-related information, but it is associated with robust fear-potentiated startle when attention is focused on the threatening properties of stimuli (Baskin-Sommers et al., 2011; Dvorak-Bertsch, Curtin, Rubinstein, & Newman, 2009; Newman et al., 2010). These findings suggest that the focus of attention moderates the deficient fear responses associated with the affective-interpersonal dimension. However, the role of perceptual complexity in modulating emotional processing has not been investigated, including in the context of the widely-used IAPS startle reflex paradigm.

Present Study

The goal of the present study was to concurrently test the hypothesis that both attentional and emotional abnormalities are associated with the psychopathy dimensions. This hypothesis was examined using the ERP paradigm employed by Bradley et al. (2007) that disentangles the frequent confound between emotion and picture complexity in the IAPS startle paradigm. In a sample of college students, Bradley et al. examined ERP responses to visually complex scenes and simple figure-ground slides from the IAPS that were matched on valence. They found that pictures high in perceptual complexity, regardless of valence, elicited larger early attentional components (i.e., visual N1). In contrast, pleasant and unpleasant pictures elicited larger later ERP components (i.e., late positive potential). The Bradley et al. study not only helps resolve ambiguity in the effects of emotional and attentional properties of stimuli in the paradigm, this variant of the IAPS paradigm allows for investigation of the neural processes, and their time course, that may be aberrant in the psychopathy dimensions. Further, the excellent temporal resolution makes ERP methodology a very appropriate approach for clarifying processing of the startle probe and IAPS slides, distinctions that cannot be definitively determined solely with startle reflex or behavioral data.

As reviewed above, research suggests the affective-interpersonal dimension is associated with deficits in emotional reactivity, particularly to threatening stimuli, (e.g., Patrick et al., 1993) and abnormal attentional selection (Baskin-Sommers et al., 2011; Newman et al., 2010; Sadeh & Verona, 2008), whereas the impulsive-antisociality dimension is related to emotional dysregulation (e.g., Gordon et al., 2004; Verona et al., 2001) and deficits in working memory (e.g., Carlson et al., 2010; Sadeh & Verona, 2008; Sellbom & Verona, 2007).

To test the potential interactive nature of the emotional and attentional processes associated with the psychopathy dimensions, the present study presented startle probes while participants viewed neutral and unpleasant IAPS slides (emotion manipulation), with an equal number of slides in each emotion category rated high and low in perceptual complexity (complexity manipulation). The experimental paradigm and examples of picture stimuli are presented in Figure 1. ERP data on the visual N1 (VN1) to picture onset was examined, because the N1 is a component that indexes attentional orienting to task stimuli (e.g., Hillyard & Anllo-Vento, 1998; Luck, Heinze, Mangun, & Hillyard, 1990). The late positive potential (LPP) to picture onset was also scored. It is a later P3-like, positive-going waveform that is enhanced by motivationally relevant stimuli, such as arousing relative to neutral pictures, but is relatively unaffected by early attentional processes (Bradley et al., 2007). It provides a valuable measure of engagement of emotional stimuli. Lastly, startle reflex magnitude and auditory N1 (AN1) to the startle probe were measured based on research indicating that these measures are modulated by both attentional manipulations and emotional processing during the IAPS startle paradigm (Cuthbert et al., 1998) and are expected to reflect the interactive effects of attentional and emotional processes.

Hypotheses

The experimental design was developed to test predictions about the affective and cognitive dysfunction theorized to be associated with the psychopathy dimensions. These hypotheses are summarized in Table 1.

Selective attention. Attention models theorize that individuals who display high levels of the affective-interpersonal features of psychopathy are more affected by attentional load than individuals low on these traits (Baskin-Sommers et al., 2011; Newman et al., 2010; Sadeh & Verona, 2008), and there is some behavioral evidence to indicate this abnormal selective attention may occur as early as initial perception (Sadeh & Verona, 2008). Consequently, it was expected that the affective-interpersonal dimension would moderate picture complexity for VN1 amplitude to picture onset. Specifically, it was expected that the affective-interpersonal dimension would be positively associated with sensitivity to picture complexity, which would result in greater VN1 amplitude to high-complexity versus low-complexity pictures, regardless of picture emotion.

*Emotional processing***.** Individuals high in affective-interpersonal traits are less affected by threatening stimuli than are individuals who score low on this dimension (e.g., Benning et al., 2005; Gordon et al., 2004; Patrick et al., 1993; Vaidyanathan et al., 2011), whereas there is some evidence to suggest individuals with elevated levels of impulsive-antisociality show enhanced emotional processing relative to those who score low on this dimension (Davidson, Putnam, & Larson, 2000; Gordon et al., 2004; Joseph, Liu, Jiang, Lynam, & Kelly, 2009; Verona, Sprague, & Sadeh, under review). Thus, it was predicted that the psychopathy dimensions would show differential relationships with emotional processing indexed using the LPP, which measures affective processing of motivationally relevant and arousing stimuli features (Bradley et al., 2007; Schupp et al., 2000). Specifically, it was expected that the affective-interpersonal dimension would correlate negatively and the impulsive-antisociality dimension would correlate positively with picture emotion indexed using the LPP, regardless of picture complexity.

Attention-emotion interactions. Research indicates the AN1 to the startle probe (Cuthbert et al., 1998) and the startle reflex response (Cuthbert et al., 1996) are modulated by both attention and emotion in the IAPS paradigm, which makes these measures appropriate for investigating the hypothesis that the psychopathy dimensions are associated with emotional and cognitive processes that are interactive and mutually influential. It was hypothesized that the attentional and emotional deficits associated with the psychopathy dimensions that were expected to be manifested in the earlier VN1 and LPP components, respectively, would interact to influence AN1 amplitude and startle reflex magnitude. In particular, it was anticipated that visually-complex slides would tax the attentional resources of individuals high in affective-interpersonal traits and consequently reduce their processing of the startle probe. This effect would be reflected in small AN1 amplitude to the startle probe, and ultimately a reduced startle response, during visually-complex slides relative to low-complexity slides. Further, this attentional effect would interact with emotional deficits, such that visual complexity would exacerbate the decreased reactivity of individuals high in affective-interpersonal traits to the unpleasant relative to neutral slides. Thus, a three-way interaction between the affective-interpersonal dimension, picture complexity, and picture emotion was expected for the AN1 to the startle probe and for startle reflex magnitude. In particular, affective-interpersonal traits were anticipated to be negatively associated with the magnitude of the AN1 response and startle reflex during unpleasant relative to neutral pictures but only when the images were also high in visual complexity.

Research indicates that the impulsive-antisociality dimension is not associated with emotional potentiation of the startle reflex (e.g., Benning et al., 2005), and it was not expected to moderate startle reflex magnitude in the present study. Research has not been conducted that examines whether impulsive-antisociality modulates AN1. Thus, no hypotheses were made and examination of this relationship was exploratory.

CHAPTER 2

METHODS

Participants

An ethnically diverse sample of 63 adults (male: *n* = 52, 82.5%) ages 18-50 participated in the present study. The demographic characteristics for the sample are presented in Table 2. Individuals from a separate assessment study were invited to participate based on their psychopathy scores and mental health diagnoses. Specifically, individuals with a lifetime diagnosis of a psychotic (non-substance-induced), or bipolar disorder, determined using the Structured Clinical Interview for DSM-IV-TR (First, Spitzer, Gibbon, & Williams, 2002), were ineligible to participate, because the acute effects of these disorders can artificially inflate scores on measures of psychopathy (e.g., antisocial behavior during mania). When individuals reported a diagnosis of a developmental disorder or when evidence of such a disorder was apparent during the diagnostic interview, participants were also determined to be ineligible to participate. Further, stratified sampling based on the Psychopathy Checklist: Screening Version (PCL: SV; Hart, Cox, & Hare, 1999) was used to ensure that a range of psychopathic traits was present in the sample, and the prevalence rates for low, middle, and high psychopathy scores, and the two dimensions, were comparable to those typically found in forensic samples. The sample was recruited from criminal justice system agencies (e.g., probation, parole, local county jails) and newspaper advertisements targeting individuals with a history of justice system involvement. The proportion of men and women invited to participate was based on the prevalence rates of psychopathy for each gender in forensic settings, which is approximately 30% and 10% for men and women, respectively (Louth et al., 1998; Vitale et al., 2002). Participants were paid $10/

hour for their participation, which lasted two hours on average.

Measures of Psychopathy and Intellectual Abilities

The PCL: SV (Hart, Cox, & Hare, 1995) is a 12-item measure designed to index psychopathic traits in both incarcerated and non-incarcerated samples with high base rates of psychopathic traits. The screening version was used in place of the 20-item Psychopathy Checklist-Revised (Hare, 2003), because research indicates that the shorter version is more appropriate for use in samples where collateral information on criminal and psychosocial history (e.g., prison records) is limited. Data collected from a semi-structured interview (1-2 hours) and a public criminal record search were used to rate participants on 12 psychopathic traits, which were summed to create two dimensions. PCL: SV Affective-Interpersonal consisted of superficial charm, grandiosity, deceitfulness, lack of remorse, shallow affect, and failure to accept responsibility, whereas PCL: SV Impulsive-Antisociality consisted of impulsivity, poor behavioral control, lacks goals, irresponsibility, adolescent antisocial behavior, and adult antisocial behavior (see Table 2 for descriptive statistics). Each trait was rated on a three-point scale ranging from 0 ("Not at all characteristic") to 2 ("Extremely characteristic") by trained graduate students or doctoral-level raters. In the present sample, 29 individuals (46.0%) were classified as low-psychopathy (total score 0-12), 19 individuals (30.2%) were classified as mid-psychopathy (total score 13-17), and 15 individuals (23.8%) were classified as high-psychopathy (total score 18-24). Analysis of skewness and kurtosis indicated that scores on Affective-Interpersonal, Impulsive-Antisociality, and Total Psychopathy were not excessively skewed or kurtotic (values ranged between -1.2 and .31). Inter-rater reliability was evaluated in 25% of interviews conducted in the original assessment sample (N = 465). Average intra-class correlations were calculated separately for the PCL: SV dimensions and total score using a two-way mixed analysis of consistency among raters. Intra-class correlations for Affective-Interpersonal, Impulsive-Antisociality, and Total Psychopathy scores were 0.93, 0.93, and 0.97, respectively, which were consistent with the intra-class correlations obtained for the subsample who participated in the present study (0.97, 0.91, and 0.97, respectively).

Portions of the Wechsler Adult Intelligence Scale-Third Edition (WAIS-III; Wechsler, 1997) were administered to obtain an estimate of each participant's overall intellectual abilities. Participants were asked to define words on the Vocabulary subtest, which provided a measure of verbal comprehension and correlates highly with measures of overall intelligence. The Block Design subtest was also administered to assess perceptual reasoning and required participants to arrange colored blocks according to a pattern as quickly as possible. Each subtest ranged from a low score of 1 to a high score of 19 and can be compared to a normal mean of 10 with a standard deviation of 3. Performance breakdown for the Vocabulary and Block Design subtests, respectively, were: 4.8%/4.8% borderline range, 19.0%/19.1% below average range, 44.4%/53.9% average range, 12.6%/17.4% above average, 11.1%/3.2% superior range, and 5.8%/1.6% very superior range. A composite estimate of intellectual function was created by standardizing and summing the two subtest scores (see Table 2 for descriptive statistics). Given that none of the composite scores fell more than two standard deviations below the mean, all participants were included in analyses. This composite was used as a covariate in analyses to ensure that findings could not be attributed to individual differences in overall intellectual ability.

Picture-Viewing Paradigm

Participants completed a computer task in which they viewed unpleasant and neutral pictures from the International Affective Picture System (IAPS; Lang et al., 1999)[1]. To ensure that the unpleasant and neutral pictures were matched on visual complexity, pictures were selected based on normative ratings of Emotion (unpleasant, neutral) and Complexity (low, high) published in Bradley et al. (2007). Visual complexity determinations were made based on a priori classifications of the images as having either a clear figure-ground composition or a complex scene composition (i.e., defined as images that did not have a constant background or a prominent central figure), and these classifications of low complexity and high-complexity images, respectively, were verified by independent raters (Bradley et al., 2007). High-complexity images were found to have higher spatial frequency, defined as the number of sinusoidal cycles used to generate the pattern in the image (Delplanque, N'diaye. Scherer, & Grandjean, 2007), than low-complexity images, whereas low-complexity images were found to have higher contrast than high-complexity images (Bradley et al., 2007). Spatial frequency is commonly used to measure the processing capacity of the visual system, because research indicates the spatial frequency of images modulates processing in early visual areas (Singh et al., 2000). Given that spatial frequency is associated with the amount of visual detail and complexity in an image, the higher spatial frequency of the high-complexity images confirms that these IAPS stimuli induced more of a perceptual load than the low-complexity images, which is central to the present hypothesis that the affective-interpersonal dimension is sensitive to manipulations of attentional load. The four conditions depicted in Figure 1 (neutral-low, neutral-high, unpleasant-low, and unpleasant-high) were each represented by 32 pictures in the task, resulting in a total of 128

[1] Pleasant slides were not included, because (1) studies of fear-potentiated startle in psychopathy fail to detect differences in reactivity to pleasant stimuli, and (2) the number of trials was limited to reduce the duration of the task to make it appropriate for use with a clinical sample. Based on previous research, emotion modulation of the startle reflex in relation to positive slides would not been expected to vary as a function of either psychopathy dimension (e.g., Vaidyanathan et al., 2011).

pictures[2]. Nine buffer slides (with no acoustic startle probe) were also presented to reduce the predictability of the startle probe. Pictures were presented for 4.75 s followed by an average intertrial interval of 12 s. Participants viewed the pictures in 32 subsets of four pictures (one from each condition) that were organized in one of two presentation orders. Presentation order was counterbalanced across participants.

After each picture presentation, participants were administered a computerized version of the Self-Assessment Manikin (SAM; Bradley & Lang, 1994) and were asked to rate each picture on valence (i.e., attractiveness/pleasantness vs. aversiveness/unpleasantness) and arousal. The SAM is a 9-point, non-verbal scale that assesses the pleasure (1= pleasant to 9= unpleasant) and arousal (1= aroused to 9= calm) experienced by participants while viewing each picture. Three participants were missing SAM ratings due to equipment failure.

Acoustic startle probes (105 dB, 50 ms burst of white noise with an instantaneous rise time) were administered binaurally over earphones to elicit a blink response. The onset of the startle probe varied across three delays from picture onset (2.5 s, 3.0 s, 3.5 s) and also occurred intermittently during the inter-picture interval (1.0 s, 1.5 s, 2.0 s following picture offset).

Prior to task administration, participants were seated in a recliner approximately 1.25 m from a computer monitor and were given a keyboard to enter their SAM responses. They were instructed to view pictures on the monitor for the entirety of their presentation, ignore any noises

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[2] The following IAPS pictures were selected from Bradley et al. (2007) for this study:
Low-Complexity: Neutral: 2190, 2200, 2210, 2214, 2215, 2221, 2230, 2270, 2271, 2280, 2440, 2495, 2516, 2570, 2810, 2830, 6150, 7010, 7100, 7110, 7130, 7140, 7150, 7175, 7190, 7211, 7224, 7233, 7235, 7490, 7705, 7950. Unpleasant: 1050, 1120, 1300, 1930, 2120, 2520, 2800, 3030, 3100, 3168, 3170, 3181, 3266, 3400, 3550, 5970, 6020, 6230, 6250, 6260, 6300, 6370, 9006, 9008, 9010, 9180, 9405, 9432, 9440, 9560, 9561, 9800.
High-Complexity: Neutral: 2206, 2381, 2383, 2410, 2480, 2514, 2518, 2580, 2749, 2752, 2850, 2870, 3210, 5120, 5395, 5455, 5731, 6000, 7180, 7205, 7234, 7495, 7496, 7500, 7510, 7550, 7560, 7590, 7595, 7700, 9210, 9700. Unpleasant: 1051, 1280, 1303, 2205, 2590, 2691, 2730, 3015, 3064, 3500, 3530, 5971, 6211, 6212, 6821, 6830, 6831, 6838, 7380, 9001, 9090, 9102, 9181, 9252, 9290, 9300, 9470, 9480, 9592, 9611, 9912, 9921.

heard over the earphones, and keep their eyes on the fixation point in the middle of the monitor to avoid eye movements. Three practice trials were completed in the presence of an experimenter to ensure participants understood task instructions. The stimuli were presented in four blocks, and participants were given a short break (2 minutes) between each block.

Psychophysiological Measures

Event-related brain potentials. EEG was recorded from the scalp using a lycra stretchable cap (Electrocap International, Eaton, OH) with Ag-AgCl electrodes placed on the head. Each electrode site was mildly abraded and electrode paste applied. The International 10-20 System was used for electrode placement, and electrode impedance for all channels was kept below 20 KΩ. EEG data for one participant were excluded as a result of high electrode impedance. To record eye movements for offline blink correction, two 4 mm Ag-AgCl electrodes were placed above and below the pupil of the right eye, and two electrodes were placed near the right and left outer canthi, measuring vertical and horizontal electrooculogram (EOG), respectively. EEG and EOG were amplified using Neuroscan Synamps2 (Neuroscan Compumedics, Charlotte, NC) and bandpass-filtered from 0.1 to 100 Hz. Analog signals were digitized online at 2000 Hz using a 24-bit A/D converter (a high sampling rate was required to adequately sample the EMG). The left mastoid (A1) served as the reference electrode for all other sites during recording, specifically midline (Fz, FCz, Cz, CPz, Pz, Oz), midfrontal (F4, F3), frontocentral (FC4, FC3), central (C4, C3), centroparietal (CP4, CP3), midparietal (P4, P3), temporal (T5, T6), occipital (O1, O2), right mastoid (A2), and the 4 EOG electrodes.

Auditory N1 (AN1) amplitude, measured over frontocentral midline electrodes (FCz, Cz) (Jutai & Hare, 1983; Luck, 2005), was used to measure attentional allocation to the startle probe

(Luck, 2005). Visual N1 (VN1) was measured over occipital electrodes (O1, Oz, O2) and used to measure attentional allocation to picture onset (Bradley et al., 2007; Hillyard & Anllo-Vento, 1998). Per previous research (Cuthbert et al., 2000; Schupp et al., 2000), the LPP was measured over central and parietal midline sensors (Cz, CPz, Pz) to assess emotional processing of the pictures.

Startle reflex. Two 4 mm Ag-AgCl electrodes were placed on the orbicularis oculi muscle under the left eye to record the startle reflex. Electrode impedance was kept below 10 KΩ, and EMG was digitized online at 2000 Hz using a 24-bit A/D converter.

Data Reduction

ERPs. After data collection, the EEG was visually checked for muscle, movement, and miscellaneous artifacts. Contaminated epochs were removed manually. Eye movements were removed using a regression-based blink-correction procedure in Neuroscan Edit version 4.3 (Compumedics, Charlotte, NC). EEG data was re-referenced off-line using an average mastoid reference derivation so that each channel reflected the voltage between the average activity at the mastoids and an active scalp site. Next, data were digitally bandpass-filtered 0.1 to 30 Hz (half-amplitude cutoff; 12 dB/octave roll-off) (Edgar, Stewart, & Miller, 2005) to reduce the noise in the EEG channels generated by EMG. Artifact-free epochs were extracted from 200 ms before until 1500 ms after picture onset for VN1 and LPP, and from 200 ms before to 500 ms after the startle probe onset for the AN1. Data were baseline-adjusted (200 ms before stimulus onset) prior to averaging and analysis. The average number of usable trials for each condition was as follows (out of 32 possible trials): neutral-low = 31.6, neutral-high = 31.4, unpleasant-low = 30.5, and unpleasant-high = 30.3.

Analyses were conducted with three ERP components: 1) the AN1 response to startle probe onset was scored as the most negative peak 95-145 ms post-probe-onset for each sensor and then averaged over frontocentral and central midline sensors (FCz, Cz), 2) the VN1 response to picture onset was scored as the most negative peak 105-165 ms post-picture-onset for each sensor and then averaged over occipital sensors (O1, Oz, O2), and 3) the LPP response to picture onset was scored as the average amplitude 400-700 ms post-picture-onset for each sensor and then averaged over central, centroparietal, and parietal midline sensors (Cz, CPz, Pz). Peak scoring windows of 50 ms and 60 ms for the AN1 and VN1 components, respectively, were centered on the grand-average peak of the first negative-going waveform that occurred after 100 ms following post-picture-onset (e.g., per previous research; Luck, 2005), which was determined based on visual inspection of the ERP components. The scoring window for the LPP component was based on previous work that used an average amplitude measure (Bradley et al., 2007), and this was consistent with individual-subject average waveforms in the present sample. Average ERP waveforms were calculated separately for each Emotion (neutral, unpleasant) and Complexity (low, high) category by averaging across trials within each category. Participants with amplitude values more than 3 standard deviations from the mean of the sample for a particular component were excluded from analyses including that component (VN1: $n = 2$).

Startle reflex. Epochs from the raw orbicularis oculi EMG signal were extracted from 50 ms before to 100 ms after the startle probe onset. In accordance with the recommendations of Blumenthal et al. (2005), the raw EMG signal was filtered to reduce noise using a high-pass filter at 30 Hz (half-amplitude cutoff; 24 dB roll-off), rectified, and then smoothed using a low-pass filter at 30 Hz (half-amplitude cutoff; 24 dB roll-off). The EMG signal was also baseline-adjusted offline (50 ms before probe onset). Startle responses were scored as the peak magnitude of the eye-blink response 21-120 ms following probe presentation using a computer-scoring program. Nonresponses, defined as peaks less than 1 microvolt, were set to zero. Accurate peak identification was verified by visual inspection. Trials were rejected if the baseline period was contaminated with noise, the blink began before 21 ms, or the eye-blink response was contaminated with noise (Blumenthal et al., 2005). To ensure that individual differences in absolute blink magnitude and response variability could not account for results, blink magnitude was standardized across trials within each participant using a *z* transformation (Blumenthal et al., 2005). Standardized blink magnitudes greater or less than 3 were winsorized to 3 or -3, respectively, to reduce the influence of outliers (Benning et al., 2005; Patrick et al., 1993). The signals for each participant were averaged across trials for each condition. Participant data were included in analyses if less than 30% of trials were rejected due to noise, and there were at least six usable startle responses for each condition. Data for three participants were removed for not meeting the minimum number of acceptable trials.

Data Analytic Strategy

The ERP components (VN1, LPP, AN1), startle reflex magnitude, and SAM ratings were analyzed separately in repeated-measures analysis of variance (ANOVA) with Emotion (neutral, unpleasant) and Complexity (low, high) as the within-subject factors. First, analyses were conducted with only the within-subjects factors to determine whether the picture complexity and picture emotion task manipulations influenced the dependent variables as expected based on previous research. Second, repeated-measures ANOVAs were conducted with scores on the psychopathy dimensions (PCL: SV Affective-Interpersonal and PCL: SV Impulsive-

Antisociality) entered as between-subjects continuous variables, along with the within-subject factors, and gender and the WAIS-III composite variable entered as covariates. The second set of analyses was used to examine whether the psychopathy dimensions moderated the effects of picture emotion and picture complexity on the dependent variables[3]. The covariates were included to account for variance associated with gender and overall intellectual ability and were not correlated with the psychopathy dimensions (Miller & Chapman, 2001). When analyses indicated moderation by a psychopathy dimension, scatter plots were examined to ensure the results were not accounted for by bivariate outliers[4].

For follow-up analyses, a picture emotion index was calculated by subtracting responses to neutral pictures from responses to unpleasant pictures, and a picture complexity index was calculated by subtracting responses to low-complexity pictures from responses to high-complexity pictures. For ease of interpretation, picture emotion effects for negative-going waveforms were calculated by subtracting responses to unpleasant pictures from neutral pictures, and picture complexity effects for negative-going waveforms were calculated by subtracting responses to high-complexity pictures from responses to low-complexity pictures. Differences in neural processing related to picture emotion and picture complexity were inferred to increase as the magnitude of these indices increased.

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[3] Given that the psychopathy dimensions were moderately correlated ($r = .62$), analyses also were conducted separately for each PCL: SV dimension to examine whether results for the psychopathy dimensions reflected suppressor effects. All of the effects reported for analyses conducted with the psychopathy dimensions entered simultaneously were also present when each psychopathy dimension was examined separately, with the exception of the main effects of PCL: SV Affective-Interpersonal and Impulsive-Antisociality reported for VN1 amplitude, which were no longer significant. For the sake of parsimony, results for analyses conducted with the psychopathy dimensions entered simultaneously are reported in the results section.

[4] Analysis of LPP amplitude indicated that three bivariate outliers significantly influenced the relationship of PCL: SV Impulsive-Antisociality to picture complexity. Two bivariate outliers significantly influenced the relationship of PCL: SV Impulsive-Antisociality with SAM valence ratings. Consequently, these values were removed from analysis of these relationships.

CHAPTER 3

RESULTS

A summary of the results for the event-related potential components and startle reflex response are presented in Table 1. To help with interpretation of the findings, the results are listed in relation to each of the hypotheses for the psychopathy dimensions in this table.

Event-Related Brain Potentials

Visual N1. As noted above, VN1 is a negative-going deflection (negative scores signify higher amplitude) that is measured over occipital sensors and assesses the allocation of attention to picture onset. Grand-average waveforms for the VN1 response to picture onset are presented in Figure 2. As expected, VN1 amplitude to picture onset varied as a function of picture complexity, $F(1, 59) = 30.10$, $p < .001$, $\eta_p^2 = .34$. Specifically, VN1 amplitude increased as the picture stimuli became more visually complex, with high-complexity pictures eliciting more negativity ($M = -2.19$, $SD = 2.77$) than low-complexity pictures ($M = -1.16$, $SD = 2.55$). Unexpectedly, VN1 amplitude was also influenced by picture emotion, $F(1, 59) = 4.60$, $p = .036$, $\eta_p^2 = .07$, such that unpleasant images ($M = -1.92$, $SD = 2.65$) elicited more negativity in VN1 amplitude than neutral images ($M = -1.57$, $SD = 2.64$). These findings suggest participants allocated more attention to high- than low-complexity pictures and unpleasant than neutral pictures.

Main effects of the PCL: SV dimensions emerged for VN1 amplitude. PCL: SV Affective-Interpersonal was positively associated with VN1, $r = -.26$ (greater negative deflection), $F(1, 56) = 4.05$, $p = .049$, $\eta_p^2 = .07$, suggesting greater overall attentional allocation to the pictures among individuals high than for those low on this dimension. In contrast, PCL:

SV Impulsive-Antisociality was negatively associated with VN1 amplitude, $r = .30$ (less negative deflection), $F(1, 56) = 5.57$, $p = .022$, $\eta_p{}^2 = .09$, indicating that individuals high in these traits allocated less attention to the pictures overall than did individuals low on this dimension.

Psychopathy interactions with picture emotion and picture complexity were also found. First, a three-way PCL: SV Affective-Interpersonal x Emotion x Complexity interaction emerged for VN1 amplitude, $F(1, 55) = 9.34$, $p = .003$, $\eta_p{}^2 = .15$. Follow-up analyses indicated that PCL: SV Affective-Interpersonal interacted with picture emotion when the images were high in visual complexity, $F(1, 55) = 6.81$, $p = .012$, $\eta_p{}^2 = .11$, but not when they were low in visual complexity ($p > .12$). As depicted in Figure 3 (top), PCL: SV Affective-Interpersonal was associated with less differentiation of unpleasant versus neutral pictures in VN1 amplitude when the images were high-complexity, $r = -.34$, but more differentiation when images were low-complexity, $r = .22$. This interaction suggests that individuals high in affective-interpersonal traits did not preferentially attend to emotion when the pictures were visually-complex relative to individuals low in these traits, although they showed robust attention to unpleasant versus neutral pictures when the pictures were not complex. Second, PCL: SV Impulsive-Antisociality interacted with picture complexity, $F(1, 55) = 4.85$, $p = .032$, $\eta_p{}^2 = .08$, reflecting less differentiation between complex and simple pictures in VN1 amplitude among those scoring high in impulsive-antisociality (Figure 3, bottom). Thus, individuals high on PCL: SV Impulsive-Antisociality appeared to attend less to complex versus simple pictures than individuals low on this psychopathy dimension.

Late Positive Potential. As noted above, LPP is a positive-going deflection (positive scores signify higher amplitude) measured over centroparietal sensors that was used to assess processing of emotional information in the pictures. Grand-average waveforms for the LPP response to picture onset measured over centroparietal midline sensors are presented in Figure 4. As expected, picture emotion affected LPP amplitude, which was larger to unpleasant pictures (M = 1.98, SD = 3.85) than neutral pictures (M = .90, SD = .2.79), $F(1, 61) = 24.37$, $p < .001$, $\eta_p^2 = .29$. Unexpectedly, picture complexity also influenced LPP amplitude, $F(1, 61) = 25.01$, $p < .001$, $\eta_p^2 = .29$, with low-complexity pictures (M = 2.10, SD = 3.55) eliciting larger LPP amplitude than high-complexity pictures (M = 0.78, SD = 3.27). These relationships were qualified, however, by an Emotion x Complexity interaction, $F(1, 61) = 4.47$, $p = .039$, $\eta_p^2 = .07$. Although differences in LPP amplitude emerged for unpleasant versus neutral pictures across all images, the magnitude of the picture emotion effect was larger for pictures that were low-complexity (M = 1.38, SD = 2.20) than those that were high-complexity (M = 0.78, SD = 1.88), which is consistent with previous work (Bradley et al., 2007). Thus, LPP amplitude was larger when participants viewed unpleasant pictures in simple figure-ground images (e.g., gun) than in complex scenes (e.g., angry mob), suggesting that the unpleasantness depicted was more salient to participants during low-complexity pictures.

As hypothesized, a PCL: SV Affective-Interpersonal x Emotion interaction emerged for LPP amplitude, $F(1, 57) = 5.17$, $p = .027$, $\eta_p^2 = .08$. This interaction reflected a negative association between this psychopathy dimension and the magnitude of the LPP emotion effect (see Figure 5), which is consistent with work suggesting the interpersonal-affective features of psychopathy are associated with diminished emotional processing. No other main or interactive effects, including effects of PCL: SV Impulsive-Antisociality, emerged for LPP amplitude (ps > .10).

Auditory N1. As noted above, AN1 is a negative-going deflection (negative scores signify higher amplitude) measured over frontocentral sensors that assess attentional allocation to startle probe onset. Grand-average waveforms for the AN1 response to startle probe onset are presented in Figure 6. An AN1 response was generated to the startle probe that varied as a function of picture emotion, $F(1, 61) = 7.54$, $p = .008$, $\eta_p^2 = .11$. The effect of picture emotion reflected the tendency for participants to allocate less attention to processing the startle probe when they viewed unpleasant pictures ($M = -14.88$, $SD = 7.14$) then when they viewed neutral pictures ($M = -15.35$, $SD = 7.47$), presumably because the unpleasant pictures were more engaging and attentionally taxing than the neutral pictures, and fewer resources remained to attend to the startle probe. This effect was qualified, however, by picture complexity, such that an Emotion x Complexity interaction emerged, $F(1, 61) = 5.86$, $p = .019$, $\eta_p^2 = .09$. As predicted, the effect of picture emotion on AN1 amplitude was present when the images were also low in visual complexity, $F(1, 61) = 10.86$, $p = .002$, $\eta_p^2 = .15$, but not when they were high in visual complexity ($p > .59$). Thus, the interaction indicates that decreased processing of the startle probe during unpleasant images was evident when the images were low in complexity (presumably because picture unpleasantness was more salient under low complexity - see LPP results above). However, when the images were high in complexity, there was no difference between unpleasant and neutral images in allocation of attention to the startle probe.

Contrary to predictions, PCL: SV Affective-Interpersonal did not moderate the effects of picture emotion or complexity. However, a PCL: SV Impulsive-Antisociality x Complexity interaction did emerge, $F(1, 57) = 4.00$, $p = .05$, $\eta_p^2 = .07$, reflecting less differentiation of high vs. low complexity pictures according to AN1 amplitude, $r = -.26$. That is, consistent with results for VN1, individuals high in impulsive-antisociality showed less of a difference in attention to the probe as a function of picture complexity than individuals low on this dimension (Figure 7). No other main or interactive effects were found for AN1 amplitude (*p*s > .21)[5].

Startle Reflex Response

Average startle reflex magnitude across participants for each condition is presented at the top of Figure 8 (top). Replicating previous work, startle magnitude varied as a function of picture emotion, $F(1, 59) = 4.14$, $p = .046$, $\eta_p^2 = .07$, with unpleasant pictures ($M = .01$, $SD = .09$) eliciting greater startle reflex responses on average than neutral pictures ($M = -.05$, $SD = .09$). Consistent with research demonstrating the startle reflex is affected by attentional load, startle magnitude was also affected by picture complexity, $F(1, 59) = 16.42$, $p < .001$, $\eta_p^2 = .22$, with low-complexity images ($M = .02$, $SD = .08$) eliciting greater startle responses on average than high-complexity images ($M = -.06$, $SD = .08$).

The predicted PCL: SV Affective-Interpersonal x Emotion x Complexity three-way interaction was found, $F(1, 55) = 4.29$, $p = .043$, $\eta_p^2 = .07$. Further analysis revealed that PCL: SV Affective-Interpersonal dimension interacted with picture emotion for high-complexity, $F(1, 55) = 4.06$, $p = .049$, $\eta_p^2 = .07$, but not low-complexity pictures ($p > .84$). As illustrated in Figure 8 (bottom), PCL: SV Affective-Interpersonal scores were associated with less emotion modulation of the startle reflex to high-complexity pictures, $r = -.26$, but not low-complexity pictures, $r = .03$. Similar to results for VN1, individuals high in affective-interpersonal traits

[5] Given the temporal proximity of the startle blink peak and the AN1 peak, analyses were conducted with waveforms that were not corrected for ocular artifact to ensure that results for AN1 were not a result of blink correction procedure. In this analysis, the AN1 emotion effect was no longer significant, though the Emotion x Complexity interaction remained significant, $F(1, 61) = 7.78$, $p = .007$. The psychopathy dimensions did not moderate these findings.

were less affected by picture emotion when the pictures were also high in visual complexity. No other main or interactive effects emerged in the analysis of the startle reflex response (ps > .16).

Subjective Ratings

To aid in the interpretation of the psychophysiological findings, SAM ratings of the images were analyzed for picture emotion and complexity effects.

Valence ratings. Analyses revealed an effect of picture emotion on SAM valence ratings, $F(1, 58) = 116.99$, $p < .001$, $\eta_p^2 = .67$, such that participants rated unpleasant pictures as more aversive ($M = 6.59$, $SD = 1.45$) than neutral pictures ($M = 4.82$, $SD = 1.26$). Picture complexity also influenced the valence ratings, $F(1, 58) = 6.14$, $p = .016$, $\eta_p^2 = .10$, with participants rating low-complexity pictures ($M = 5.75$, $SD = 1.21$) as slightly more aversive on average than high-complexity pictures ($M = 5.67$, $SD = 1.20$). These results for self-report ratings parallel the finding that both picture emotion and picture complexity affected the ERP components and startle reflex.

Picture emotion interacted with PCL: SV Impulsive-Antisociality to affect valence ratings, $F(1, 52) = 5.35$, $p = .025$, $\eta_p^2 = .09$, such that PCL: SV Impulsive-Antisociality was associated with lower ratings of aversiveness for unpleasant pictures, $r = -.31$, but had no relationship with ratings of aversiveness for neutral pictures, $r = .01$. This interaction suggests that individuals high on PCL: SV Impulsive-Antisociality considered the unpleasant pictures to be less aversive than neutral pictures than individuals low in these traits. No other main or interactive effects were present in the analysis of SAM valence ratings (ps > .10).

Arousal ratings. Similar to the findings for valence ratings, picture emotion influenced SAM arousal ratings, $F(1, 59) = 33.64$, $p < .001$, $\eta_p^2 = .36$, which reflects participants rating unpleasant pictures (*M* = 6.07, *SD* = 2.31) as more arousing on average than neutral pictures (*M* = 7.43, *SD* = 1.72). Unlike the valence ratings, an Emotion x Complexity interaction was present for SAM arousal ratings, $F(1, 59) = 36.80$, $p < .001$, $\eta_p^2 = .38$. Consistent with results for LPP, the interaction was driven by participants rating unpleasant pictures as more arousing in the low-complexity (*M* = 1.58, *SD* = 1.95) than high-complexity condition (*M* = 1.15, *SD* = 1.72). The psychopathy dimensions did not moderate these effects, and no other main or interactive effects were found for the SAM arousal ratings (*p*s > .20).

CHAPTER 4

DISCUSSION

A central goal of psychopathy research has been to explicate dysfunction in emotional processing systems associated with psychopathic traits. However, this research has largely been conducted without attending to how these emotional deficits may contribute to or interact with cognitive processing deficits, despite research to suggest the presence of such deficits (c.f., Newman, 1998). In addition, more recent work has reduced emphasis on psychopathy as a unitary dimension and shifted to focusing on distinct dimensions or vulnerabilities that relate to psychopathic behavior, specifically affective-interpersonal traits versus impulsive-antisociality traits. The present study tested the hypothesis that, in addition to abnormal emotional reactivity, the psychopathy dimensions are differentially related to early attentional deficits. As expected, the findings indicate that the psychopathy dimensions display distinct, and at times opposing, patterns of deficits that include attention and emotion, which is consistent with the theory that they represent separable pathways to antisocial behavior and violence.

In conjunction with emerging research that implicates the psychopathy dimensions are associated with distinct endophenotypes (for a review, see Patrick & Bernat, 2009), the present findings suggest the affective-interpersonal and impulsive-antisocial dimensions represent separable disorders that can appear phenotypically similar in terms of antisocial and violent outcomes. Despite efforts to create assessment instruments that index a homogenous disorder (e.g., Psychopathy Checklist-Revised; Hare, 2003), research increasingly suggests that measures of psychopathy do not assess a unitary construct, with individuals diagnosed as “psychopathic” evidencing diversity in terms of their personality profiles, comorbid psychopathology, and developmental risk factors (e.g., Hicks, Markon, Patrick, Krueger, & Newman, 2004; Skeem, Johansson, Andershed, Kerr, M., & Eno Louden, 2007). As data on the distinct neural processes associated with each dimension continue to grow, it would be useful to use this information to inform diagnostic instruments of antisocial syndromes as a means of adding etiological specificity to the currently heterogeneous diagnostic categories used in the literature, particularly psychopathy.

Task Effects

In addition to psychopathy-related findings, analyses revealed interesting results regarding the effects of picture emotion and complexity on ERP components and startle reflex in the oft-used IAPS paradigm. These findings extend previous research conducted with undergraduate samples by informing emotional and cognitive processing of images in a clinical-forensic sample.

Visual N1. Consistent with research by Bradley et al. (2007) that examined the effects of perceptual complexity in the IAPS slides on early attentional processes, VN1 amplitude varied as a function of picture complexity in the present study, with the high-complexity images eliciting greater VN1 amplitude than the low-complexity images. This finding suggests that the picture complexity manipulation successfully induced an attentional load effect manifested in VN1, such that participants allocated more attentional resources to processing the high- than the low-complexity images. Contrary to the findings of Bradley et al., however, an effect of picture emotion also emerged that indicated that participants allocated more attention to processing unpleasant than neutral pictures. Thus, VN1 amplitude was moderated by both picture complexity and picture emotion in the present results, indicating early attentional processes were influenced by both perceptual complexity and image unpleasantness.

Although unexpected given the Bradley et al. study, the modulation of VN1 by picture emotionality is consistent with research in the neuroscience literature demonstrating that motivationally relevant stimuli are perceived very early in the processing stream. For example, prior work has found that VN1 amplitude is greater for pleasant and unpleasant IAPS pictures than for neutral images (Foti, Hajcak, & Dien, 2009; Keil et al., 2002), which is consistent with the effect of picture emotion on VN1 amplitude in the present study. Additionally, research using hemodynamic neuroimaging has found that activation in visual areas increased as participants viewed emotionally arousing than neutral images (Lang et al., 1998). This early modulation of visual perception by emotionally arousing stimuli suggests sensory processing of motivationally relevant information is typically prioritized or amplified, including in the IAPS picture-viewing paradigm.

Late positive potential. Present LPP results indicate that this component was affected by both picture emotion and picture complexity, and these effects were qualified by a cognition-emotion interaction, which is consistent with the findings of Bradley et al. (2007). In particular, LPP amplitude was greater to unpleasant than neutral images, an effect of picture emotion that decreased when participants viewed high-complexity than low-complexity pictures. Based on research that finds that the LPP is consistently modulated by emotionally-arousing stimuli (e.g., Schupp et al., 2000), it can be inferred from this finding that the unpleasantness of pictures was more salient to participants when they viewed the simple figure-ground images than the high-complexity scenes (an interpretation that is consistent with the effect of picture complexity seen in the SAM valence ratings).

Auditory N1. The AN1 was used to examine how picture complexity and emotion in the IAPS images affects attention to the startle probe. Results were consistent with research that indicates that processing of the startle probe in the IAPS picture-viewing paradigm is influenced by emotional and attentional manipulations (Keil et al., 2007). Specifically, analysis of AN1 amplitude revealed decreased processing of the startle probe when participants viewed unpleasant images, suggesting that these pictures engaged visual attention more than neutral pictures. The influence of picture emotion on AN1 amplitude is consistent with a series of studies that have found reduced processing manifested in the P3 component to startle-probe onset when participants viewed emotional than neutral IAPS images (Cuthbert et al., 1998; Keil et al., 2007; Schupp, Cuthbert, Bradley, Birbaumer, & Lang, 1997). This effect of picture emotion also suggests that processing of the startle probe does not necessarily influence the magnitude of the fear-potentiated startle response, because participants startled more on average to unpleasant than neutral images despite processing the probe less.

A cognition-by-emotion interaction also emerged for AN1, such that the effect of picture emotion on processing of the startle probe was diminished to high-complexity slides. This interaction can be interpreted within the context of the results for LPP, which suggested that the emotion of the slides was most salient when the images were low in perceptual complexity, and thus attention to the startle probe was only affected by picture emotion when the slides were also low-complexity. As seen in Figure 6, AN1 amplitude was also smallest in the unpleasant, low-complexity condition, which suggests these slides were the most visually engaging and resulted in the greatest decrease in processing of the startle probe in favor of attention to the visual images.

Startle reflex. Research examining emotion modulation of the startle reflex has consistently shown that blink magnitude is larger when individuals encounter unpleasant, threatening, or aversive stimuli than neutral stimuli (Bradley et al., 1989; Curtin et al., 2001; Verona et al., 2002). The present results replicate this emotion modulation of the startle reflex with the IAPS slides and show for the first time a picture complexity effect on startle reflex magnitude, with low-complexity images eliciting larger blink responses on average than high-complexity images. Although no published research to date has specifically investigated the effects of perceptual complexity of IAPS slides on the startle reflex, there are data to suggest that perceptual load manipulations moderate startle-blink magnitude. For instance, research indicates that high perceptual load (e.g., degraded visual stimuli, continuous performance tasks) inhibits blink magnitude to startle probes in normative samples (Lipp & Neuman, 2004; Rissling, Dawson, Schell, & Nuechterlein, 2005). This effect of perceptual load on blink magnitude can be understood in terms of research that shows that directing attention away from the modality that elicits the startle response, which in the present study was the auditory noise probe, decreases the magnitude of the startle response (Lipp & Neuman, 2004), presumably because attentional resources are capacity-limited. The effect of picture complexity observed in the present task may be a consequence of more attentional resources being directed toward processing the visual stimuli in the high- than low-complexity conditions and away from processing the auditory startle probe, which would be consistent with the picture complexity effect that emerged for VN1 to picture onset.

In summary, analysis of the main and interactive effects of picture emotion and picture complexity indicates that these task manipulations induced changes in emotional and attentional processing in expected ways. These data are some of the first to test the hypothesis of interactive effects of early attentional and emotional processing using event-related potentials in a forensic sample, including with the widely utilized IAPS picture-viewing paradigm. Overall, the results largely replicate the effects of perceptual complexity and picture emotionality on neural processes reported in normative samples (e.g., Bradley et al., 2007; Bradley et al., 1989; Foti, Hajcak, & Dien, 2009; Keil et al., 2002).

Moderation of Emotional & Cognitive Processes by the Psychopathy Dimensions

Affective-interpersonal dimension. Research on the affective-interpersonal features of psychopathy finds evidence that this dimension is associated with deficits in emotional processing, particularly a weak fear response to unpleasant stimuli (Benning et al., 2005; Patrick et al., 1993; Vaidyanathan, et al., 2011), as well as an increased sensitivity to stimuli that tax attentional resources (Baskin-Sommers et al., 2011; Newman et al., 2010; Sadeh & Verona, 2008). Consistent with theories of affective and attentional dysfunction in psychopathy, the affective-interpersonal dimension moderated attentional and emotional processing in VN1, LPP, and fear-potentiated startle reflex in the present study. Importantly, present results advance etiological theories of the affective-interpersonal dimension that have foregrounded either deficient emotionality or selective attention deficits by providing new evidence that these proposed mechanisms for the development of psychopathic traits are not only dually operational but also interactive in nature.

Evidence that the affective-interpersonal dimension moderated the interactive effects of attentional and emotional processing emerged rapidly within 100-200 ms of picture onset in VN1. As predicted, the affective-interpersonal dimension was associated with picture complexity manifested in VN1, though the relationship that emerged was unexpectedly a cognition-emotion interaction rather than a simple effect of picture complexity. In particular, the prioritization of attention to emotional stimuli that was seen in the sample as a whole diminished for pictures that were high in visual complexity as scores on the affective-interpersonal dimension increased. Attention to unpleasant versus neutral images when picture complexity was low, in contrast, was unchanged as a function of the affective-interpersonal dimension.

Consistent with study hypotheses, differentiation between the processing of neutral and unpleasant pictures manifested in LPP was diminished as a function of affective-interpersonal traits, though this effect did not vary as a function of picture complexity as it did in the VN1. The findings that the affective-interpersonal dimension was inversely related to LPP amplitude to unpleasant stimuli and that this effect was not modulated by picture complexity suggest that unpleasant stimuli held less intrinsic motivational significance for individuals high on the affective-interpersonal dimension than those low on the affective-interpersonal dimension, regardless of picture complexity. Although research has found that LPP amplitude correlates positively with self-report ratings of arousal (Cuthbert et al., 2000), individuals high on the affective-interpersonal dimension reported similar experiences of aversiveness and arousal when viewing unpleasant pictures as individuals low on this dimension. Inconsistencies between self-report ratings of valence and arousal and physiological reactivity among individuals high in affective-interpersonal traits are not atypical (e.g., Patrick et al., 1993).

Of note is the differential influence of the affective-interpersonal dimension on picture complexity in the LPP and VN1 components. In particular, affective-interpersonal traits did not moderate attention to emotion in low-complexity images as manifested in VN1 but were associated with decreased emotional processing across both low- and high-complexity pictures manifested in LPP. These differential results suggest that, even though emotion appears to be attended to in low-complexity images in VN1, it was less motivationally relevant for individuals high in affective-interpersonal traits than individuals low on this dimension (e.g., Schupp et al., 2000).

The attentional and emotional effects revealed in VN1 and LPP persisted for several seconds and were evident in the eventual fear response measured by the startle reflex. However, contrary to predictions, this effect was not due to reduced processing of the startle probe, as the affective-interpersonal dimension did not moderate AN1 amplitude. The diminished attention to emotion observed in VN1 amplitude paralleled the diminished effect of picture emotion on startle reflex magnitude for high-complexity pictures. In conjunction, the AN1 results suggest that individuals high on affective-interpersonal traits did not screen out the startle probe in high-complexity images, as originally anticipated, but rather failed to process emotional information from the onset of the high-complexity pictures.

This type of multilevel assessment to unpack the mechanisms promoting psychopathic deficits in emotional reactivity has never been conducted in terms of IAPS images, the seminal paradigm which established psychopathic deficits in fear responses. These data add specificity to the understanding of emotional deficits attributed to psychopathy and signify that individuals high in affective-interpersonal traits are most likely to show a fear deficit when attention is loaded. Although results for both VN1 and startle reflex are indicative of cognition-emotion interactions, there are multiple causal explanations for these findings. First, there is research to suggest that taxing perceptual resources with a secondary task reduces differentiation between emotional and neutral IAPS pictures as manifested in VN1 (e.g., perceptual load task; Doallo, Holguín, & Cadaveira, 2006) and emotion modulation of the startle reflex (e.g., working-memory task; King & Schaefer, 2010), which suggests that the prioritization of emotional information is dependent upon the availability of capacity-limited attentional resources. Based on this research, present results could be interpreted as evidence for the high-complexity scenes sufficiently taxing the attentional resources of individuals high in affective-interpersonal traits to suppress the prioritization of motivationally relevant information. Thus, moderation of VN1 amplitude and fear-potentiated startle reflex by the affective-interpersonal dimension suggest that individuals high in these traits are more sensitive to the effects of perceptual complexity on early selective attention than individuals low in these traits. This interpretation would give primacy to cognitive deficits in explaining reduced affective processing in psychopathy.

Second, an explanation for the cognition-emotion interaction observed for VN1 and startle reflex is that the reduced attention to emotion in visually complex images by individuals high compared to those low in affective-interpersonal traits results from deficits in bottom-up amplification or prioritization of motivationally relevant stimuli by emotional systems. That is, present findings suggest that emotional content was less salient in the high- than low-complexity images on average (e.g., LPP) and that failure by individuals high in affective-interpersonal traits to differentiate emotion in the complex images relative to those low in affective-interpersonal traits may be caused by a weakened affective response (Levenston et al., 2000). This interpretation gives primacy to bottom-up emotional deficits.

Third, it is possible that deficits in both perceptual selection and emotional enhancement contribute to the moderation of VN1 and fear-potentiated startle reflex by the affective-interpersonal dimension. In fact, this interpretation of present findings is most compelling when the data are considered within the context of the broader literature on affective-interpersonal traits. Extensive data support both the low-fear and attention-deficit models of psychopathy, including research that shows that individuals high in affective-interpersonal traits display impairments on cognitive tasks using non-emotional stimuli (e.g., Sadeh & Verona, 2008) as well as affective tasks using emotional stimuli (e.g., Gordon et al., 2004). Thus, it is likely that attentional and emotional deficits interactively contribute to deficits associated with affective-interpersonal traits in the present study. It is important for future research to determine whether the attention-specific emotional processing deficits observed relate to observable behavioral impairments, such as psychopathic individuals' tendency to myopically focus on obtaining a goal or reward without attention to the distress of their victims or the legal deterrents.

Impulsive-antisociality dimension. In contrast to the affective-interpersonal dimension, research suggests the impulsive-antisocial dimension is related to enhanced emotional processing (e.g., Gordon et al., 2004) and deficits in processes that depend on working memory, including response inhibition and context-updating (Carlson et al., 2009; Sadeh &Verona, 2008; Sellbom & Verona, 2007; Venables et al., 2011). The present study tested the hypothesis that the impulsive-antisociality dimension would be positively associated with emotional processing manifested in LPP, which would be consistent with previous research (e.g., Gordon et al., 2004).

The relationship between impulsive-antisociality and perceptual complexity was also explored, given that previous research has not examined whether this psychopathy dimension influences neural processes associated with early attentional processes.

First, results indicated that the impulsive-antisociality dimension did in fact moderate the effect of picture complexity in VN1, which was an unanticipated finding but one that expands our understanding of this dimension of psychopathy. Specifically, impulsive-antisociality correlated negatively with the effect of picture complexity in the VN1. Research suggests the amplitude of this component is influenced by the amount of attention that is allocated to processing a stimulus (Bradley et al., 2007; Cuthbert et al., 1998, Luck, 2005), which in the present study was the onset of the IAPS images. Moderation of this component by impulsive-antisociality suggests that individuals high in impulsive-antisociality showed less differential processing of high- versus low-complexity pictures than individuals low in these traits. Although a novel finding regarding the impulsive-antisociality dimension, research has found that individuals with a history of alcohol dependence, a disorder related to the impulsive-antisociality dimension via the externalizing spectrum of psychopathology (Krueger et al., 2002), is associated with reduced visual N1 amplitude to non-target stimuli as well as reduced P3 amplitude to target stimuli on oddball paradigms (Glenn, Parsons, & Smith, 1996; Olbrich, Maes, Gann, Hagenbuch, & Feige, 2000; Patterson, Williams, McLean, Smith, & Schaeffer, 1987). Thus, the smaller picture complexity effect in the VN1 observed in individuals high than low on the impulsive-antisociality dimension, although unexpected, is consistent with findings in the broader literature on the cognitive deficits related to externalizing traits.

It is possible that the negative association of impulsive-antisociality with processing of picture complexity reflects an early selective attention process that contributes to or parallels the executive function deficits found in individuals with externalizing tendencies. For example, this result could reflect insensitivity to perceptual complexity in individuals high vs. low in impulsive-antisociality, which may indicate that they have a higher capacity for perceiving visual information than individuals low on this dimension (at least in this sample). Enhanced perceptual capacity among individuals high in impulsive-antisociality could overload later information processing systems with stimuli to process, including those important for problem-solving, such as working memory. Taxing working memory processes could, in turn, contribute to deficits maintaining cognitive control in everyday situations and explain the tendency of individuals high in impulsive-antisociality to become easily frustrated and have difficulty with anger regulation. The reduced picture complexity effect in VN1 among individuals high relative to those low in impulsive-antisociality could also reflect the tendency for these individuals to attend less to contextual information at perception than those low on impulsive-antisociality, which would be consistent with the diminished attention to novel and unexpected information observed in measures of the oddball P3 in individuals with high levels of externalizing traits (e.g., Bauer, O'Connor, & Hesselbrock, 1994; Costa et al., 2000; Iacono et al., 2002). This interpretation suggests that individuals high in impulsive-antisocial traits differentiate less among the non-emotional properties of stimuli during selection and are less likely to processes non-emotional contextual changes as novel or important relative to individuals low in impulsive-antisocial traits (see Patrick & Bernat, 2009, for a review of this finding in relation to externalizing), which might contribute to, or reflect, the tendency of individuals high in impulsive and antisocial traits to act without full consideration of changing situational demands. Given the exploratory nature of this finding, these interpretations are speculative. They do suggest, however, that the impulsive-antisociality dimension is associated with abnormal early visual attention processes that parallel those observed for other types of externalizing disorders (e.g., alcohol dependence). Additional research is needed to explicate early selective attention processes associated with impulsive-antisociality and how abnormalities in these processes may relate to the documented deficits in later working memory processes associated with this psychopathy dimension.

Second, based on research indicating that the impulsive-antisociality dimension is potentially related to heightened emotional processing, it was expected that these traits would be positively associated with picture emotion manifested in LPP. However, a relationship between this psychopathy dimension and LPP picture emotion did not emerge. The impulsive-antisociality dimension was inversely related to ratings of picture aversiveness, with individuals high in impulsive-antisociality rating unpleasant pictures as less aversive than individuals low in impulsive-antisociality. These self-report data suggest reduced perceptions of distress to picture emotion for individuals high than those low in impulsive-antisociality, which may explain why this psychopathy dimension did not moderate picture emotion in the LPP as expected. The impulsive-antisocial dimension includes items that measure lifetime engagement in violent and antisocial behavior and is associated with a history of environmental adversity and victimization (Verona, Hicks, & Patrick, 2005). It is possible that individuals high on this dimension reported less aversion to the unpleasant images on average compared to those low on this dimension, because they are more desensitized to violent images than individuals low on this dimension.

Finally, the impulsive-antisociality dimension moderated picture complexity manifested in AN1 to startle probe onset. Similar to its association with VN1, the impulsive-antisociality dimension was negatively associated with picture complexity manifested in AN1, which indicates attention to startle-probe onset among individuals high in impulsive-antisociality varied less as a function of image complexity than in individuals low in impulsive-antisociality. Given that both VN1 and AN1 index the allocation of attentional resources to stimulus processing (e.g., Luck, 2005), specifically picture onset and startle probe onset in the present task, the diminished effect of picture complexity associated with impulsive-antisociality likely reflects a similar aberrant early selection process across both components. Given that this is the first study to examine whether attention to the startle probe in picture-viewing paradigms is moderated by the psychopathy dimensions, replication and further investigation of how the reduced sensitivity to perceptual load observed in relation to the impulsive-antisociality dimension is needed to adequately interpret this finding.

Implications for Etiological Models of the Psychopathy Dimensions

The present findings for the affective-interpersonal dimension help advance etiological models of psychopathy by providing specificity to model predictions that can drive research incorporating analyses of emotional and cognitive deficits associated with these traits. First, present results are consistent with recent research indicating that the deficient emotionality and attentional deficits documented in psychopathy are selectively associated with the affective-interpersonal dimension. Second, the finding of reduced attention to emotional stimuli (VN1), diminished emotional processing (LPP), and decreased fear reactivity (startle response) are consistent with etiological theories that centralize the influence of deficient emotional reactivity and attention to motivationally relevant stimuli in psychopathy (e.g., Hare, 1965; Kiehl et al., 2001; Patrick, Bradley, & Lang, 1993). At the same time, reduced attention to emotion was specific to high-complexity pictures, which adds contextual specificity to the emotional processing deficits theorized to be associated with the affective-interpersonal dimension and provides evidence consistent with etiological models that emphasize the role of attention in the development of psychopathic traits (c.f., Newman, 1998). Of critical importance for present hypotheses, the interactions of emotional and cognitive processes that emerged in relation to the affective-interpersonal dimension signify that, not only are both types of processes abnormal in psychopathy, they are bidirectionally influential and operate as early as initial perception. There is enough empirical evidence to suggest that attentional and emotional processing is abnormal in psychopathic individuals to assume these deficits jointly contribute to the maintenance of these traits in adulthood, regardless of whether or not one type of deficit (emotional or attentional) was instrumental in causing the other form of impairment during development.

The present findings also extend etiological theories of the impulsive-antisociality psychopathy dimension. In particular, results suggest that the working memory deficits attributed to impulsive and antisocial traits may be preceded in certain conditions by abnormal early selective attention processes. Understanding the reduced sensitivity to perceptual complexity that emerged in the VN1 and AN1 measures may help elucidate the range of processing deficits associated with the impulsive-antisociality dimension. Indeed, the present findings call into question the selective emphasis in the literature on information processing deficits related to working memory in relation to the impulsive-antisociality dimension and externalizing psychopathology more broadly. The finding that impulsive-antisociality was associated with intact differentiation of emotion manifested in VN1 and AN1 indicates that early selection processes in relation to affective stimulus properties function normally. It may also be indicative of the prioritization of processing emotional over non-emotional stimulus properties among individuals high compared to those low in impulsive-antisociality. However, reduced VN1 to target stimuli has been observed in oddball tasks using non-affective stimuli among individuals with externalizing traits (e.g., Patterson et al., 1987), which suggests that distraction by and/or prioritization of emotion does not fully account for these findings. These findings may also point to ways to address attentional processing deficits in externalizing. That is, the tendency of these individuals to prioritize emotional over non-emotional stimulus processing may serve to develop interventions in which emotional information is used to enhance attention and working memory, without emotion overwhelming their processing capacity.

Despite evidence that the impulsive-antisociality dimension is associated with heightened emotional reactivity (e.g., Gordon et al., 2004), the present results indicated that these features of psychopathy did not moderate emotional processing reflected in LPP or startle reflex. There are a few possible reasons for this. First, psychophysiological studies that measure emotional processing using fMRI measures of amygdala have reported increased emotional reactivity among individuals high in impulsive and antisocial traits (e.g., Davidson et al., 2000; Gordon et al., 2004; Joseph et al., 2009), whereas those that have used fear-potentiated startle reflex typically do not find that this dimension moderates processing of emotional stimuli (e.g., Benning et al., 2005; Patrick et al., 1993). Thus, it may be that the ERP and startle reflex measures used in the present study were not sensitive enough to detect differences in emotional processing related to the impulsive-antisociality dimension. Second, the emotional reactivity theorized to be associated with this psychopathy dimension may not be induced by mere exposure to fearful or generally unpleasant stimuli. Rather, individuals high in impulsive-antisociality might show emotional dysregulation only in certain contexts with particular types of affective stimuli, such as in stimuli or contexts that induce feelings of anger or reward (e.g., reward; Buckholtz et al., 2010). Finally, research on the etiology of the impulsive-antisocial dimension might benefit from further parsing this dimension into multiple facets. It is possible that the heightened emotional reactivity attributed to this dimension is largely driven by a subset of traits, which could be tested by separating and comparing the aggressive and antisocial tendencies represented on this dimension from the impulsive, sensation-seeking, and irresponsible tendencies.

Strengths, Limitations, & Future Directions

The present study benefited from a relatively large sample for a study of event-related brain potentials, particularly in a clinical-forensic sample of individuals with psychopathic traits. Psychopathic traits were assessed using a well-validated assessment tool, and the picture-viewing paradigm has been widely used to investigate the interplay of emotional and attentional processes, which increases the generalizability of the results and reliability of the constructs assessed. Moreover, this study is one of the first to investigate the hypothesis that affect-based and attention-based etiological models of psychopathy should be integrated by testing the interactive effects of emotional and cognitive deficits associated with the psychopathy dimensions.

As with any investigation, however, this study has limitations that should be considered when interpreting the findings. First, the proportion of women included in the present study was chosen to reflect the proportion of women represented in forensic populations (Federal Bureau of Investigation, 2007). Thus, the study was underpowered to investigate the potential moderating effects of gender. Existing research suggests that the abnormal selective attention and deficient fear-potentiated startle effects documented in psychopathic men generalize to psychopathic women (Sutton, Vitale, & Newman, 2002; Vitale et al., 2007). However, research on the construct of psychopathy in women and relations of the psychopathy dimensions with the hypothesized cognitive and affective deficits is in its infancy. Given emerging evidence that the construct of psychopathy, particularly the two dimensions, may operate differently in women than men (Sprague, Javdani, Sadeh, Newman, & Verona, under review), additional research is needed to explicate whether the nature of the psychological and supporting brain mechanisms associated with the affective-interpersonal and impulsive-antisociality dimensions vary as a function of gender.

Second, the present study was designed to examine how perceptual complexity influences the deficient fear-potentiated startle reflex associated specifically with the affective-interpersonal dimension but not the impulsive-antisociality dimension. The picture-viewing paradigm did not allow for a thorough investigation of the executive-function deficits theorized to be associated with the impulsive-antisociality dimension and how these cognitive deficits may interact to influence emotional processing in impulsive-antisociality. Research on cognition-emotion interactions associated with antisocial traits is beginning to emerge that suggests that, unlike individuals high in affective-interpersonal traits, those high in impulsive and antisocial traits prioritize the processing of emotional information over inhibitory control processes (Verona et al., under review). Identification of the distinct cognitive and emotional deficits associated with the psychopathy dimensions and the interactive effects of these processes could help elucidate distinct pathways or sets of risk factors that lead to engagement in severe and persistent antisocial behavior.

Third, the cross-sectional nature of the data does not permit causal inferences to be made about the etiological underpinnings of the psychopathy dimensions. Longitudinal research is needed to explicate how the cognitive and emotional deficits associated with the psychopathy dimensions develop and to what extent they are mutually influential and reinforcing across development. Moreover, the use of a longitudinal design is needed to parse confounds associated with use of a forensic sample, including histories of violence-related head trauma, heavy illegal substance consumption, and long-term incarceration[6].

Fourth, although the present study included an emotion manipulation, it should be noted that only a subset of emotions were investigated using the IAPS stimuli. Specifically, the unpleasant images used were limited to those that induce feelings of disgust and fear. Thus, the conclusions that can be drawn regarding emotional processing associated with the psychopathy dimensions are restricted to emotional experiences related to these subsets of emotions. Future research would need to include other types of unpleasant emotions (guilt, sadness) as well as

[6] Analyses were also conducted with a composite of lifetime symptoms (current and past) of alcohol dependence and substance use dependence, which were conducted to examine whether the present findings could be attributed to the long-term effects of these substances on neural functioning. The dependence symptom composite was uncorrelated with PCL: SV Affective-Interpersonal, $r = .08$, and positively correlated with PCL: SV Impulsive-Antisociality, $r = .39$, which is consistent with the relationship of the latter psychopathy dimension with externalizing psychopathology. Repeated-measures ANOVAs with the dependence symptom composite entered as the between-subjects factor indicated lifetime dependence symptoms interacted with picture complexity for VN1 amplitude, $F(1,55) = 11.1$, $p = .027$. The dependence symptom composite was inversely correlated with picture complexity for the VN1, $r = -.29$, which paralleled the finding for the PCL: SV Impulsive-Antisociality dimension. No effects of dependence symptoms were found for LPP amplitude, AN1 amplitude, or startle reflex magnitude. When the dependence symptom composite was entered as a covariate in analyses with the psychopathy dimensions, the main and interactive effects of the affective-interpersonal dimension did not change. However, the picture complexity interactions with PCL: SV Impulsive-Antisociality for VN1 and AN1 were reduced to non-significance (*p*s < .13).

pleasant stimuli to determine whether cognitive processes interact with emotional processing more broadly in relation to the psychopathy dimensions.

Fifth, the purpose of this study was to examine the cognitive and affective correlates of the psychopathy dimensions in a clinical-forensic sample where the prevalence rates of these traits are high and result in severe functional impairments. Consequently, the range of psychopathic traits in the sample was restricted and did not capture variance at lower levels of the constructs, including those that occur in normative samples. The size of the sample was also modest for a dimensional investigation of personality traits, though it is comparable to other psychophysiological studies of psychopathic traits (e.g., Baskin-Sommers et al., 2011). These sample characteristics limit the interpretation of the findings, because null results could be driven by restriction in the range of psychopathic traits sampled or a lack of power to detect relationships with small effect sizes. Thus, research should attempt to replicate these findings in larger samples of individuals that represent a wider range of psychopathic traits than the present study.

Despite these limitations, the present study advances the literature on information processing deficits in psychopathy by showing how selective attention and emotional reactivity may contribute to the development and maintenance of behaviors associated with distinct psychopathy dimensions. The findings suggest that psychopathy is a heterogeneous construct that is not characterized solely by an emotional or attentional deficit, as the literature has historically assumed. Rather, present results indicate that psychopathy is characterized by multiple, interactive cognition-emotion deficits that manifest differentially across the psychopathy dimensions.

TABLES

Table 1: Study Hypotheses & Results.

Affective-Interpersonal	**Hypotheses**	**Results**
Visual N1	Positive relationship w/ picture complexity	Negative relationship w/ picture emotion in high-complexity condition
Late Positive Potential	Negative relationship w/ picture emotion	Negative relationship w/ picture emotion
Auditory N1	Negative relationship w/ picture emotion in high-complexity condition	No relationship
Startle Reflex	Negative relationship w/ picture emotion in high-complexity condition	Negative relationship w/ picture emotion in high-complexity condition
Impulsive-Antisociality	**Hypotheses**	**Results**
Visual N1	Exploratory	Negative relationship w/ picture complexity
Late Positive Potential	Positive relationship w/ picture emotion	No relationship
Auditory N1	Exploratory	Negative relationship w/ picture complexity
Startle Reflex	No relationship	No relationship

Note. Picture complexity = High-complexity condition - Low-complexity condition. Picture emotion = Unpleasant condition – Neutral condition.

Table 2: Descriptive Statistics (*N* = 63).

Age	**M *(SD)***	**Min/Max**
	33.2 *(8.4)*	18 / 50
Gender	**Frequency**	**%**
Men	52	82.5
Women	11	17.5
Ethnicity	**Frequency**	**%**
African-American	31	49.2
Caucasian	25	39.7
Biracial	3	4.8
Hispanic	2	3.2
Native-American	2	3.2
Education	**Frequency**	**%**
Less than HS	10	15.9
HS Diploma	16	25.4
Technical School/Some College	32	50.8
Bachelor's Degree	4	6.3
WAIS-III	**M *(SD)***	**Min/Max**
Vocabulary	10.0 *(3.3)*	4 / 18
Block Design	9.5 *(2.7)*	4 / 18
WAIS-Composite	0 *(0.8)*	-1.2 / 2.5
PCL: SV	**M *(SD)***	**Min/Max**
Affective-Interpersonal	5.3 *(3.1)*	0 / 11
Impulsive-Antisociality	7.4 *(2.7)*	1 / 12
Total Score	12.6 *(5.3)*	2 / 23

Note. WAIS-III = Wechsler Adult Intelligence Scale-Third Edition (Wechsler, 1997), possible scores for Vocabulary and Block Design range from 1 to 19. WAIS-Composite = standardized and summed scaled scores for Vocabulary and Block Design subtests. PCL: SV = Psychopathy Checklist: Screening Version (Hart, Cox, & Hare, 1995), possible scores range from 0-12 and 0-24 for dimension scores and total score, respectively.

FIGURES

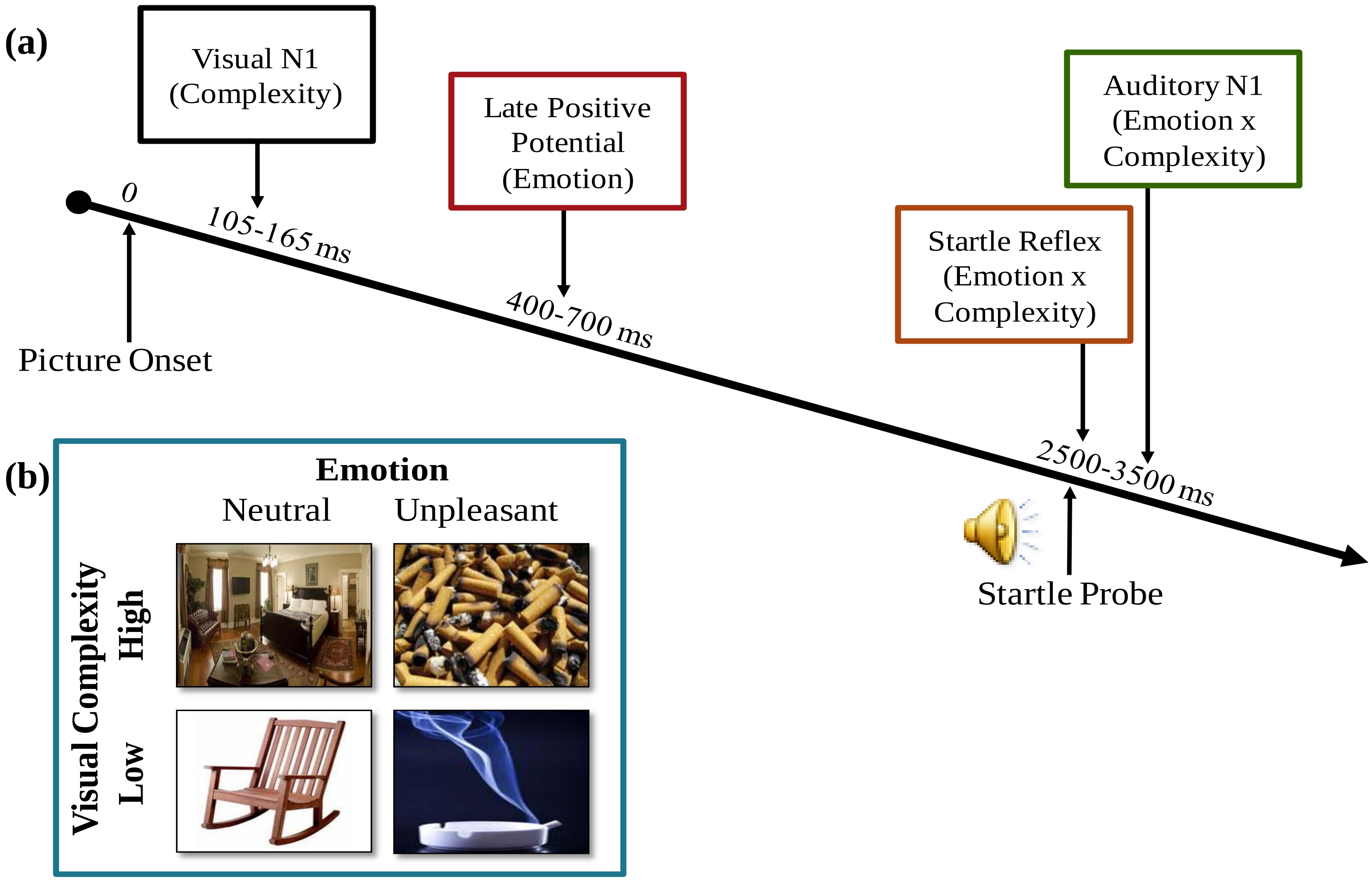


Figure 1: Experimental Design

Note. (a) = Time course of dependent variables in each trial. (b) = Example stimuli for each condition.

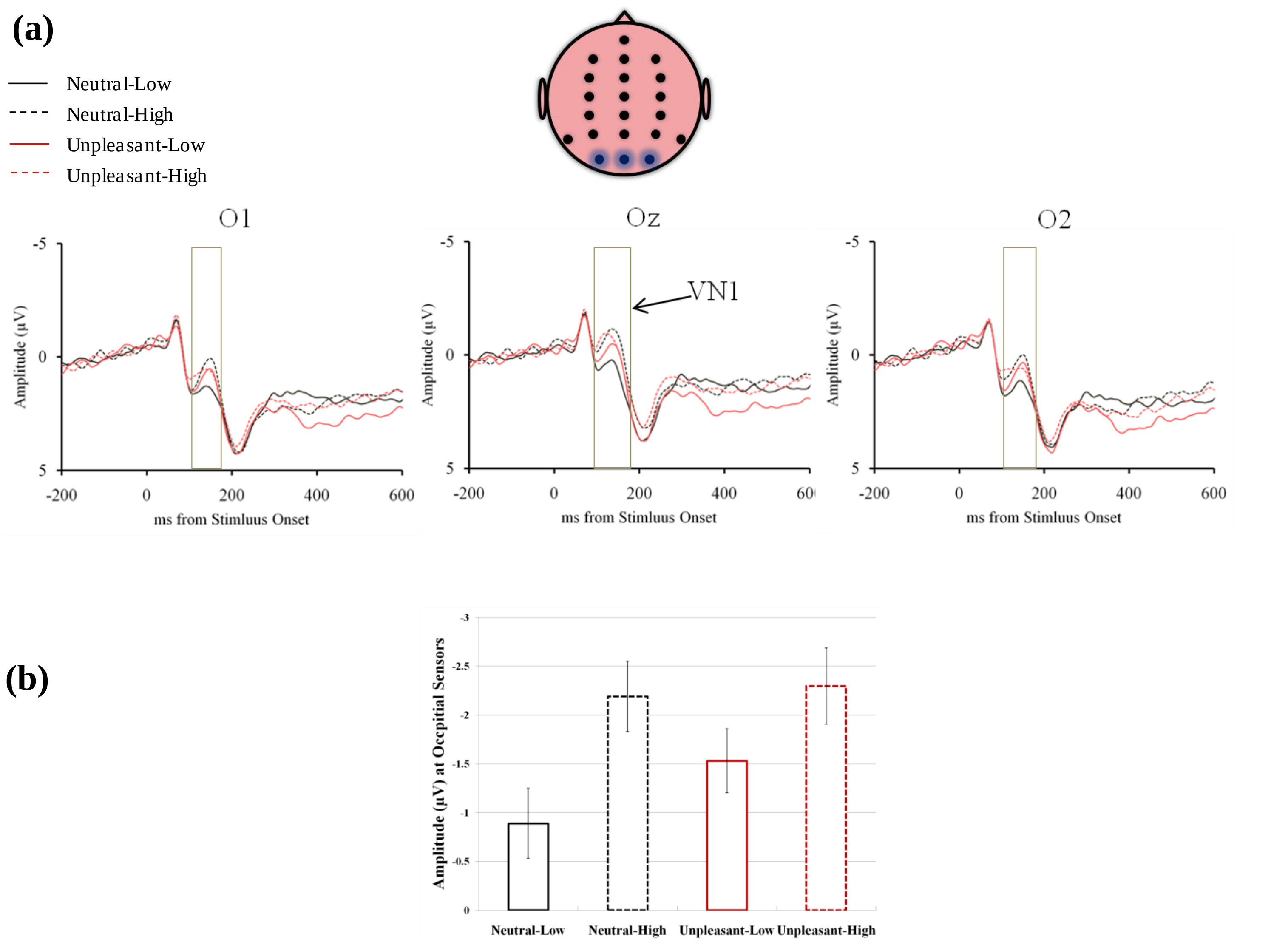


Figure 2: Visual N1 (VN1) to Picture Onset by Picture Complexity & Picture Emotion

Note. (a) = Grand-average waveforms over occipital sensors. Boxes denote scoring window. (b) = Average peak amplitude across occipital sensors.

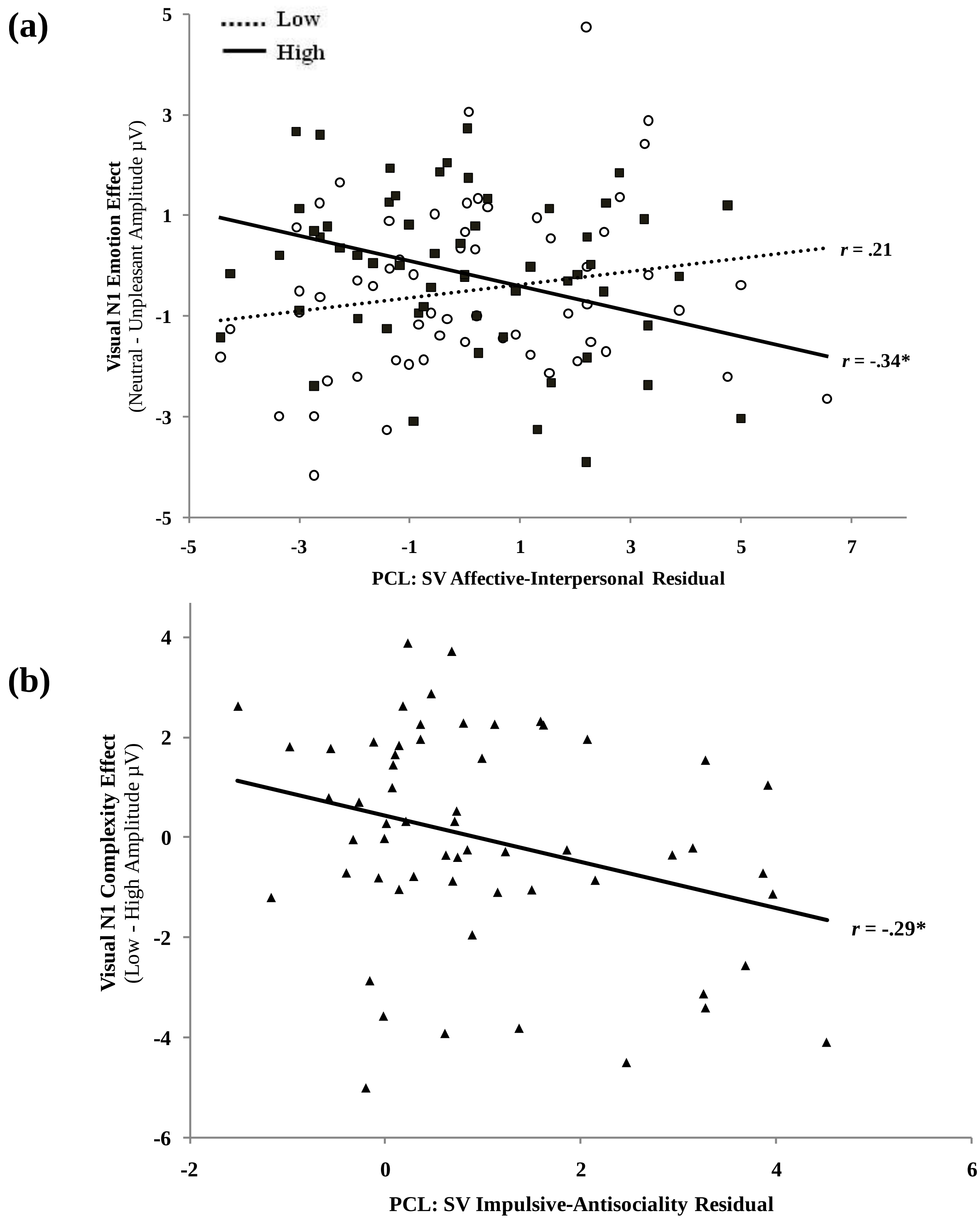


Figure 3: Moderation of Visual N1 (VN1) Amplitude by the Psychopathy Dimensions

Note. (a) = Relationship of PCL: SV Affective-Interpersonal with picture emotion effect as a function of picture complexity. (b) = Relationship of PCL: SV Impulsive-Antisociality with picture complexity effect. * $p < .05$.

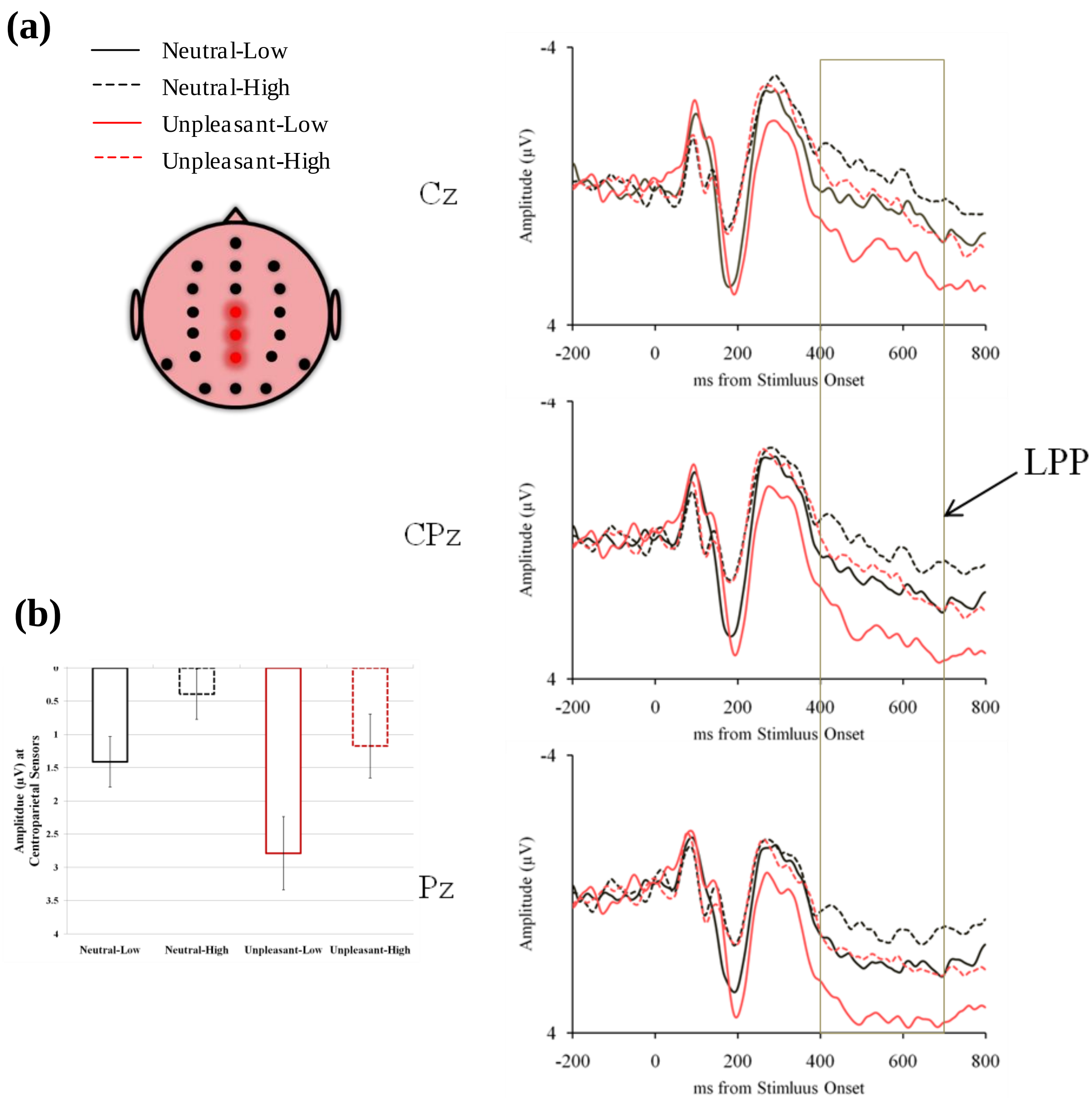


Figure 4: Late Positive Potential (LPP) to Picture Onset by Picture Complexity & Picture Emotion

Note. (a) = Grand-average waveforms over centroparietal midline sensors. Boxes denote scoring window. (b) = Average amplitude across centroparietal midline sensors.

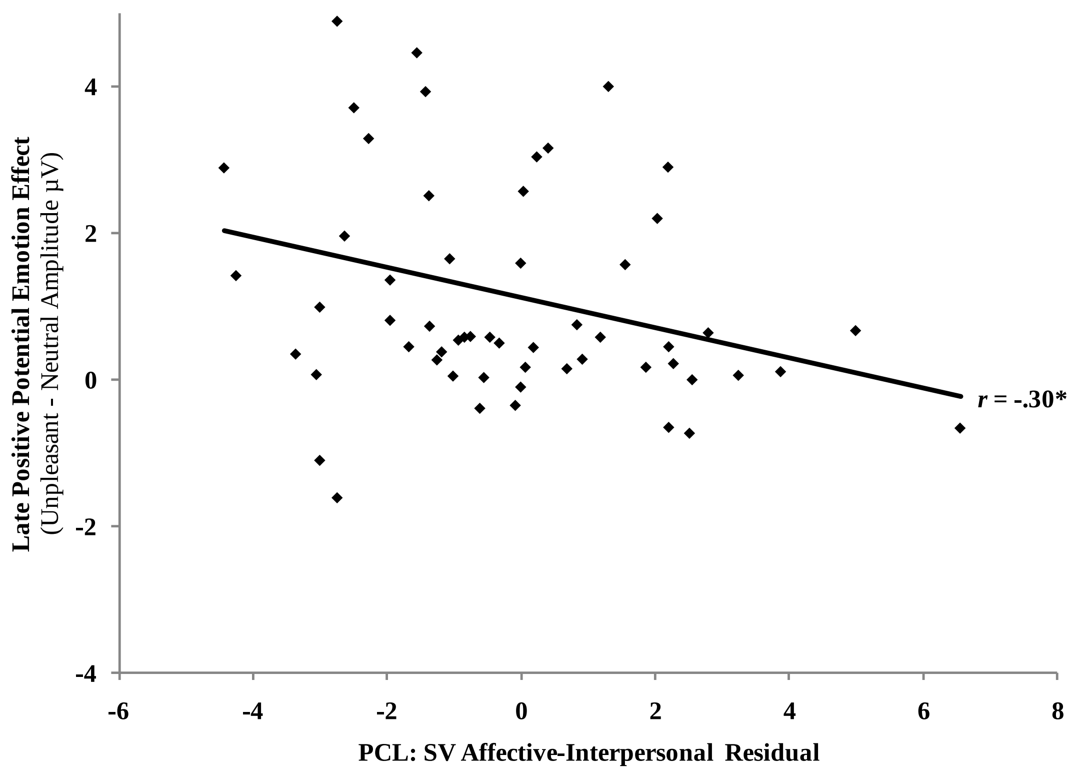


Figure 5*:* Relationship of PCL: SV Affective-Interpersonal with Picture Emotion in the Late Positive Potential (LPP). * *p* < .05.

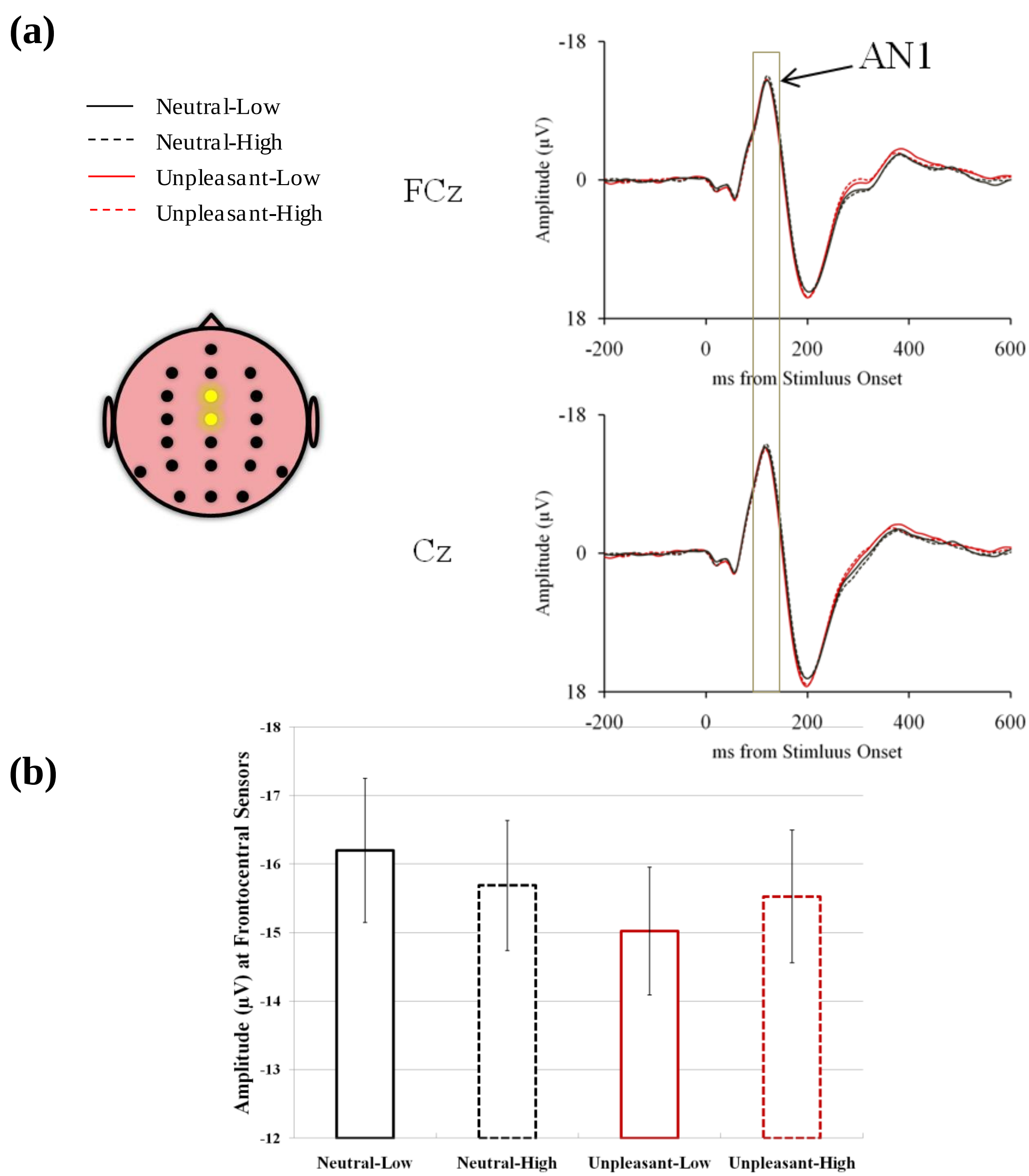


Figure 6: Auditory N1 (AN1) to Startle Probe Onset by Picture Complexity & Picture Emotion

Note. (a) = Grand-average waveforms over frontocentral midline sensors. Boxes denote scoring window. (b) = Average peak amplitude across frontocentral midline sensors.

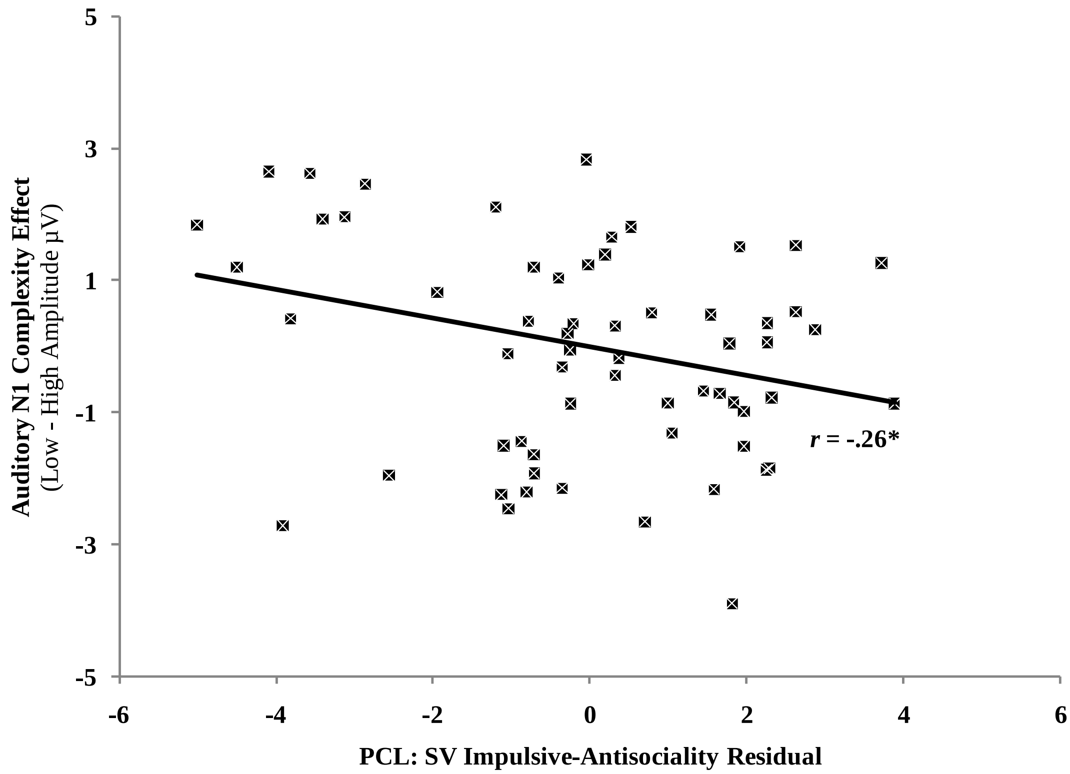
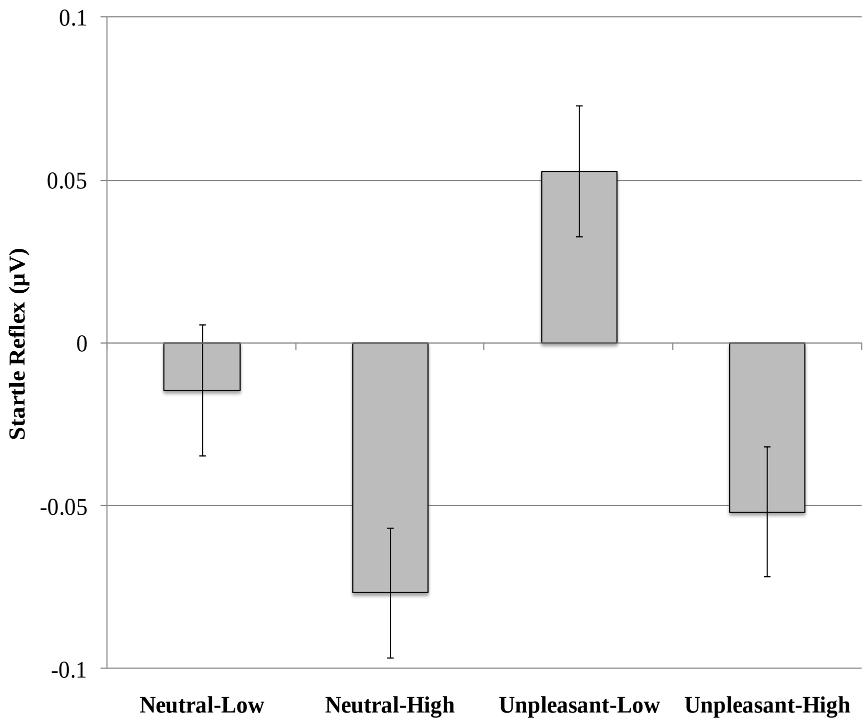


Figure 7: Relationship of PCL: SV Impulsive-Antisociality with Picture Complexity in the Auditory N1 (AN1) to Startle Probe Onset. * $p < .05$.

(a)



(b)

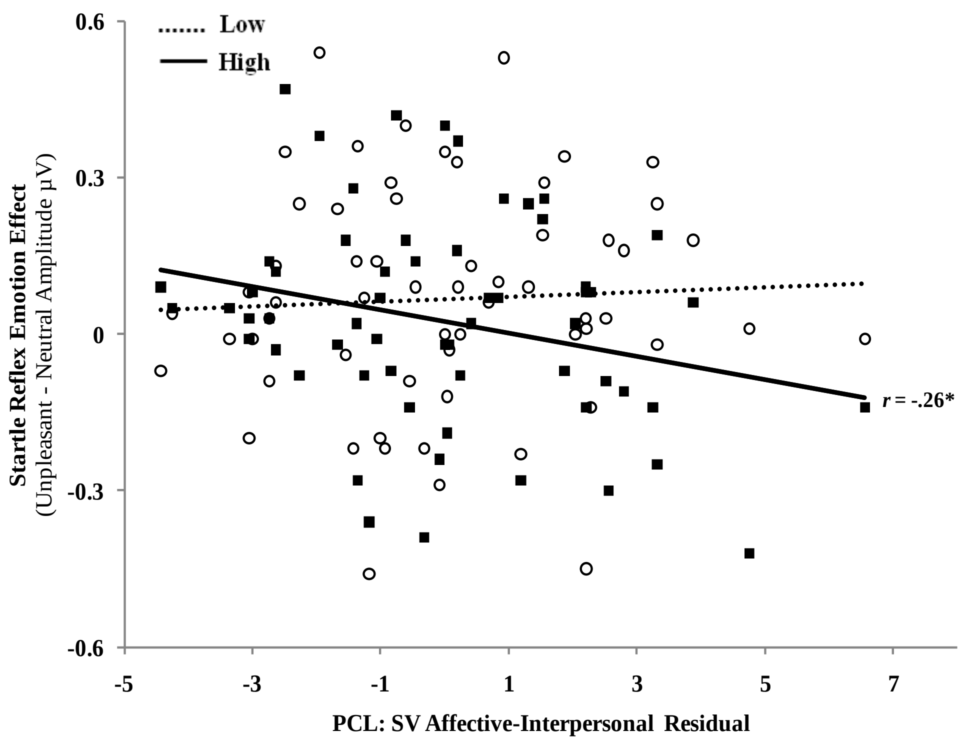


Figure 8: (a) Startle Reflex Magnitude by Condition and (b) Moderation of Fear-Potentiated Startle by PCL: SV Affective-Interpersonal. * $p < .05$.

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