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Psychopathic Traits and P3 Modulation During Simple and Complex Target Detection Tasks

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Abstract

Psychopathy is notable for traits of impulsivity, irresponsibility, and proneness to boredom, characteristics that are all substrates of executive function. However, event-related potential (ERP) P3 studies of attention-related abnormalities in the context of psychopathic traits have yielded inconsistent results (Gao & Raine, 2009). The current study attempted to address these discrepancies by investigating the effects of psychopathic traits on P3s during two attentional tasks. Two groups of ERP participants (n = 28) who had high ($T \geq 50$) or low ($T \leq 40$) Psychopathic Personality Inventory – Revised (PPI-R; Lilienfeld & Widows, 2005) total scores were recruited from a larger sample (n = 181) of undergraduate students. ERP participants completed a standard oddball (SDO) task and a continuous performance task (CPT) during which they responded to target stimuli while their EEG was recorded. Contrary to my hypotheses, individuals with high PPI-R total scores performed significantly less accurately on both tasks compared to those with low PPI-R total scores, yet, total PPI-R scores were not related to P3 amplitude. High TriPM Disinhibition scores were associated with decreased P3 amplitudes during the complex CPT task, but not the simple SDO task. My results suggest that impulsive-externalizing traits that are often a hallmark of psychopathy, are associated with an attentional deficiency.

Keywords: event related potential, P300, psychopathy, successful psychopathy

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The psychopathic personality is characterized by interpersonal traits of callousness, superficial charm, and exploitativeness paired with impulsivity, irresponsibility, and proneness to boredom (Hare, 1996). Psychopathy was originally conceptualized by Cleckley (1941/1988) as a unitary construct defined by a constellation of personality traits like egocentricity and superficial charm paired with frequent deceit and antisocial motivations. The externalizing traits of psychopathy are associated with reduced neural activity in brain networks underlying attention and working memory (Blair, 2005; Kiehl, 2006). The current study used electroencephalographic (EEG) recording to measure brain responses during attentional tasks, in order to elucidate the cognitive deficits that may be associated with the externalizing aspects of the psychopathic personality.

Psychopathy measures

The current gold standard in the clinical assessment of psychopathy is the Hare Psychopathy Checklist Revised (PCL-R; Hare, 1991, 2003). Both the original (PCL; Hare, 1980) and revised versions of this scale were intended to measure psychopathy as a unitary construct reflective of Cleckley's conceptualization of psychopathy (Hare 1980). However, Patrick, Fowles, & Krueger (2009) argued that the PCL and PCL-R fail to acknowledge some of the adaptive aspects of psychopathy mentioned by Cleckley. Patrick, Fowles, and Krueger (2009) pointed out that the item discrimination analyses for the PCL, which drew from only criminal populations, resulted in a predominance of items relating to the deviant and antisocial aspects in the final scales.

Subsequent factor analyses of the PCL-R have inspired a two-factor model of psychopathy (e.g., Harpur, Hakstian, & Hare, 1988; for a three-factor solution see Cooke & Michie, 2001). Factor 1 reflects the affective-interpersonal qualities of the disorder, such as deceitfulness, lack of empathy, and failure to accept responsibility, while Factor 2 encapsulates the impulsive-antisocial traits which typically present as a need for stimulation and poor behavioral control (Harpur et al., 1988; Harpur, Hare, & Hakstian, 1989). More recently, Hare and Neumann (2006) have argued for a four-factor model for the PCL-R, in which the higher-order Factor 1 is broken down into distinct facets; the Interpersonal domain (Facet 1) which includes items measuring glibness and pathological lying and is highly correlated (r = .70) with the Affective domain (Facet 2) onto which items such as lack of remorse/guilt and shallow affect load (Hare & Neumann, 2008). Similarly, the higher-order Factor 2 was deconstructed into a Lifestyle domain (Facet 3) which measures traits of impulsivity and stimulation seeking and is highly correlated (r =.73) with the Antisocial domain which is supported by items measuring juvenile delinquency and criminal versatility (Hare & Neumann, 2006).

The Psychopathic Personality Inventory – Revised (PPI-R; Lilienfeld & Widows, 2005), an updated version of the PPI (Lilienfeld & Andrews, 1996), is a self-report measure designed to better reflect Cleckley's criteria of the psychopathic personality and is suitable for use with community and offender populations. The PPI-R is made up of the same eight subscales as used in the PPI. Factor analyses of the PPI showed that three of the subscales load onto the factor of Fearless Dominance (FD; also known as PPI-I; Benning, Patrick, Blonigen Hick, & Iacono, 2005) and four load onto the factor of Self Centered Impulsivity (SCI; also known as Impulsive Antisociality or PPI-II; Benning et al., 2005) the subscale of Coldheartedness (C) does not load onto either factor (Benning et al., 2005, Lilienfeld & Widows, 2005). Further, the FD and SCI

scales have been found to be orthogonal (Benning et al., 2003; Patrick, Edens, Poythress, Lilienfeld & Benning, 2006) or weakly correlated (Marcus, Fulton & Edens, 2013). Much research with the PPI and PPI-R have adhered to using this two-factor model. However, the authors, Lilienfeld and Widows (2005) argued for a three-factor solution for the PPI-R in which Self-Centered Impulsivity and Fearless Dominance are joined by the Coldheartedness subscale. Miller and Lynam (2012) also favored this three-factor solution with the argument that the Coldheartedness subscale captures core features of psychopathy that are otherwise neglected by the two factor solution. However, Uzieblo, Verschuere, Van den Bussche, and Crombez (2010), using a large mixed gender community sample, did not find statistical support for a two-factor (FD and SCI) model for the PPI-R. Similarly, Anetis, Caron, and Carbonell (2011) found no support for one (total score), two (FD and SCI), or three-factor models (FD, SCI, and C) when mixed gender undergraduate samples were used, but found support for one and two-factor models when model comparison criteria was used to control for gender. A meta-analysis that collapsed PPI and PPI-R studies into a single category provided evidence that Factor 2 of the PCL-R correlates better (r = .41) with the SCI factor of the PPI and PPI-R than Factor 1 of the PCL-R correlates with the FD factor of the PPI and PPI-R (r = .21; Marcus, Fulton, & Edens, 2013). The two-factor model of psychopathy identified in the PCL-R and PPI-R has resulted in an accumulation of research on whether the etiologies of these distinct factors are shared or divergent.

Theories of psychopathy

Patrick and Bernat (2009b) proposed a Two Process Theory of psychopathy which argued for etiologically distinct underpinnings of the two factors that aligned with Cleckley's (1941/1988) conceptualization of psychopathy. The authors argued that the affective traits of

psychopathy, which they broadly labeled as "trait fearlessness", are driven by the inhibition of autonomic responses to threat, whereas "externalizing vulnerability" is related to the deficits observed in frontocortical systems involved in behavioral inhibition. The authors further argue that these two systems manifest themselves in the symptomatology described in Factor 1 and Factor 2, respectively, in the PCL-R. However, due to the emphasis on characteristics of antisociality in the PCL-R, they assert that this model is better reflected by the Fearless Dominance and Self-Centered Impulsivity scales of the PPI and PPI-R (Patrick & Bernat, 2009b).

Patrick and Bernat (2009b) proposed that "trait fearlessness" was similar to Lykken's conceptualization of psychopathy, which suggested that primary (innate) psychopaths had low levels of fear, as evidenced by low skin conductance and lack of avoidance learning during fear conditioning (Lykken, 1957; 1995). Other studies have also found reduced levels of fear-conditioning in psychopathic samples (Birbaumer et al., 2005; Flor, Birbaumer, Hermann, Ziegler, & Patrick, 2002). Blair (2008) developed a neuroanatomical theory that attributed deficits in fear conditioning in psychopathy to amygdala dysfunction, whereas deficits in emotional learning deficits more broadly were attributed to disruptions in circuits between the limbic region (including, but not limited to the amygdala) and the prefrontal cortex.

The concept of "trait fearlessness" is also consistent with the literature demonstrating that negative images do not potentiate the startle reflex in individuals with psychopathic traits (Patrick & Bernat, 2009a). A deficient startle reflex has been associated with Factor 1 traits (as measured by both the PCL-R and PPI) in community samples (Benning, Patrick & Iacono, 2005; Vanman, Mejia, Dawson, Schell, & Raine, 2003) and incarcerated samples (Levenston, Patrick, Bradley & Lang, 200; Patrick, Bradley, & Lang, 1993). High PCL-R Factor 1 traits in offenders

have also been associated with a reduced skin conductance response (SCR), a measure of autonomic reactivity partially mediated by the amygdala (Mangina & Beuzeron-Mangina, 1996), in response to both pleasurable and aversive stimuli (Verona, Patrick, Curtin, Bradley, & Lang, 2004).

The "externalizing vulnerability" aspect of the Two-Process Theory addresses a predisposition to a broad spectrum of externalizing behaviors. Factor analytic studies have found externalizing to be common across a number of Diagnostic Statistical Manual (DSM) disorders, including Antisocial Personality Disorder (APSD) as well as alcohol and drug dependence (Krueger, 1999). A biometric analysis of 1,048 twins found that a highly heritable (81%) latent factor, "externalizing", explained significant covariance across measures of disinhibition, conduct disorder (CD), alcohol dependence, and adolescent antisocial behavior (Krueger et al., 2002). Patrick, Hicks, Krueger and Lang (2005) used structural equation modeling to evaluate the correlation between an externalizing dimension of symptoms from CD, APSD, alcohol dependence, drug dependence, and disinhibitory personality traits with the two PCL-R factors. After controlling for shared variance between the two factors, the externalizing dimension demonstrated an extremely strong correlation (r = .94) with Factor 2 and a negligible negative correlation (r = -.16) with Factor 1. Similarly, in a meta-analysis that collapsed 49 studies that used the PPI or PPI-R into a single category, Miller and Lynam (2012) found the PPI/R SCI to be associated with broad externalizing traits (d = .454), including impulsivity (d =.540), aggression (d =.420) and antisocial behavior (d =.359) specifically. Conversely, PPI/R FD demonstrated negligible relationships with broad externalizing traits (d = .060), impulsivity (d =.023), aggression (d = -.040), and antisocial behavior (d = .117).

Notably, Fowles and Dindo (2006, 2009), proposed the Dual-Pathway Model of Psychopathy, which is similar to the Two Process Theory of Psychopathy (Patrick & Bernat, 2009b), but includes a developmental perspective supported by evidence in the child psychology literature (see Frick & Morris, 2004; Moffit & Lynam, 1994). The Dual-Pathway model argues that temperamental predispositions of fearlessness and high externalization paired with an absence of effective parenting and early positive social environments could lead to psychopathy in adulthood. More specifically, Fowles and Dindo (2006) suggested that PCL-R Factor 1 traits of psychopathy are the result of low reactivity to fear (cf., Lykken's low-fear hypothesis; Lykken, 1957, 1995). Citing evidence that temperamental traits of anxiety are negatively associated with PCL-R Factor 1 scores and positively associated with Factor 2 scores (Benning et al., 2005), Fowles and Dindo (2006) considered fear and anxiety to be clinically and neurobiologically similar (Barlow, 2002). Thus, deficits in both anxiety and fear during development may lead to PCL-R Factor 1 traits. This theory is bolstered by evidence from the developmental literature. Kochanska (2002) discovered that the interaction between fearful temperament in children between the ages of 4 and 5 and maternal parenting style predicted internalization of conscience. Specifically, internalization of conscience was predicted by an environment of gentle maternal discipline for fearful children, but a mutually responsive (reward-based) maternal relationship for fearless children. Frick and Morris (2004) also purported that a low-fear temperament in early childhood could result in callous-unemotional traits which in turn leads to poor socialization, impaired conscience development, and heightened likelihood of a subsequent diagnosis of conduct disorder. Taken together, these results suggest that trait fearlessness and environment may interact to result in reduced conscience and PCL-R

Factor 1 traits (pathological lying, lack of remorse or guilt, failure to accept responsibility; Hare, 2003) in adulthood (Fowles & Dindo, 2006).

The Dual-Pathway Model of psychopathy also states that traits associated with PCL-R Factor 2 are due to temperamental deficits in emotional and behavioral control which interact with poor parenting or inadequate social environment (Fowles & Dindo, 2006). The authors reference evidence that infants with hyperactive temperaments who receive inadequate or coercive infant-parent interactions are more likely to receive childhood diagnoses of externalizing pathologies, such as attention deficit hyperactivity disorder (ADHD), oppositional-defiant disorder (ODD), and CD (Patterson et al., 1992; Patterson et al., 2000). Moffit and Lynam (1994) argued that impaired executive functioning, evidenced by an early diagnosis of ADHD, is also likely to put children and adolescents at risk for the development of CD and antisocial behaviors. They reasoned that this might occur because ADHD often impairs socialization and school performance, and may also cause stigmatizing effects by imposing negative labels early in life. These externalizing pathologies may potentially develop into adult antisocial behaviors and other PCL-R Factor 2 traits (impulsivity, irresponsibility, proneness to boredom; Hare, 2003; Fowles & Dindo, 2006).

The Dual Model of psychopathy aligns with earlier arguments for psychopathic subtypes (Karpman, 1941, 1948a, 1948b, 1955). Karpman (1941, 1948a) argued for two subtypes of the psychopathic personality, which differed not in their outward behaviors but in the etiology and degree of moral development which drove those behaviors. The primary subtype is associated with a poverty of emotion and asocial motivations due to an inherent temperamental and affective deficit (Karpman, 1941). Conversely, the secondary subtype describes individuals whose symptoms are the result of an affective disturbance resulting from adverse childhood

events (i.e., child abuse or neglect). As this latter disturbance is not the result of an innate deficit, Karpman (1941, 1948b) purported that secondary subtypes are more likely to be responsive to treatment. Karpman (1955) later argued that these two subtypes also differ in their capacity for goal-oriented behaviors; while the primary subtype is capable of planning and inhibiting their behaviors to achieve antisocially driven goals, such as crime, the secondary subtype is prone to impulsive and reactive behaviors, suggesting a likelihood of higher impulsive-antisocial traits.

Patrick, Fowles, and Krueger (2009) provided a subsequent conceptualization of the psychopathic personality in their aptly named triarchic theory. The authors identified three personality constructs that they argued interplay to contribute to the psychopathic personality. The Disinhibition component encapsulates many of the negative traits of psychopathy already noted in the literature such as impulsivity and irresponsibility, as well as reactive aggression and negative affectivity. Patrick (2010) later suggested that this component is driven by dysfunction in the prefrontal cortex and anterior cingulate cortex, which modulate behavioral and emotional regulation (Patrick, 2008; Patrick 2009b). Boldness and Meanness are identified as manifestations of a shared genotypic proneness to fearlessness. While Boldness includes many of the socially adaptive traits noted in Cleckley's (1941) patients (i.e., interpersonal efficacy, imperturbability, low anxiety and low suicidality), the Meanness concept summarizes asocial traits typically identified, such as exploitativeness and interpersonal callousness (Patrick et al., 2009). This Meanness domain was found to be correlated with the Interpersonal (r = .20) and Affective (r = .25) facets, as well as the Antisocial facet (r = .20) of PCL-R (Patrick, 2010). This suggests that the Meanness concept is represented in both of the traditional psychopathy factors, yet it appears to align more strongly with Factor 1 than Factor 2. While Patrick (2010) cites evidence for aberrant amygdala functioning as a source of Boldness traits, he emphasizes the role

of temperament and aversive environmental factors (i.e., poor parenting [Patrick et al., 2009], early physical and sexual abuse [Caspi et al., 2002]) in the development of Meanness characteristics.

Patrick (2010) created the Triarchic Personality Measure (TriPM) as a self-report questionnaire designed to measure psychopathic traits according to the triarchic theory, in both community and incarcerated populations (Patrick et al., 2009). Subsequent research has supported its use in these populations; TriPM scales accounted for over 60% of the variance in total PPI scores in samples of undergraduates (Drislane, Patrick, & Arsal, 2014) and incarcerated female offenders (Sellbom & Phillips, 2013). Sellbom and Phillips (2013) found the Disinhibition scale of the TriPM was strongly associated with the PPI-R SCI (r = 0.74) in both undergraduates and incarcerated offenders. The Boldness scale of the TriPM demonstrated a similarly strong correlation (r = .84) with the PPI-R FD factor, and the Meanness scale correlated (r = .67) moderately well with the C subfactor. A similar pattern of relationships was found with the PPI-R's predecessor, the PPI, in an undergraduate sample (Drislane et al., 2014).

Externalizing psychopathology

Externalizing traits associated with the Disinhibition component of the triarchic model of psychopathy have received specific attention in the psychophysiological literature, which is the focus of this thesis. It is argued that the externalizing traits often present in psychopathy are associated with a reduction in neural activity in brain networks associated with attention and working memory (Kiehl, 2006; Blair, 2005). This has been demonstrated using event-related potentials (ERPs; Patrick & Bernat, 2009b). ERPs are electrical neural responses to an event (such as a stimulus or a decision) that can be measured on the scalp using electroencephalographic (EEG) recordings (Luck, 2014). ERPs provide researchers with the

ability to assess neurocognitive processes related to different psychopathologies (Luck, 2014).

More specifically, externalizing traits have been associated with a reduced amplitude in an ERP component known as the P3 (Iacono, Malone, & McGue, 2003; Gottesman & Gould, 2003; Yoon, Malone, & Iacono, 2015). The P3 (or P300) occurs approximately 300ms after a salient stimulus (or decision) and results in a positive-going slow wave on the scalp (Polich, 2007). Depending on the paradigm and where on the scalp it is measured the amplitude of the P3 reflects both automatic orientation to a stimulus and more conscious task-relevant attentional processes (Ferrari, Bradley, Codispoti & Lang, 2010; Polich, 2007). Thus, the P3 can be divided into P3a (automatic) and P3b (conscious) waveforms (Polich, 2007; Snyder & Hillyard, 1976). The P3a wave appears approximately 60-80 ms before the P3b response (Smith et al., 1990), and is most clearly seen in response to a distractor or novel stimulus (Polich, 2007), while the P3b is produced by a response to a target stimulus (Snyder & Hillyard, 1976). The two waves have different topographic distributions, P3a is maximal around frontal sites and the P3b maximal over more posterior centroparietal sites (Conroy & Polich, 2007). These components have been hypothesized to reflect monitoring and inhibition of extraneous stimuli in the frontal cortex (P3a), in order to enhance working memory storage to salient stimuli (P3b; for a summary of this theory see Polich, 2007). In the literature I review below, the P3 waveform references the P3b component, which is the component measured in the current study.

The amplitude of the P3 is inversely related to stimulus probability, therefore, it is studied by looking at the response to an infrequent stimulus within an oddball paradigm (Polich, 2007). Oddball paradigms occur in three variants: in the first, participants respond to infrequently presented targets in the absence of any other stimuli, in a traditional oddball, participants respond to targets presented among with more frequent nontargets, in a three-

stimulus oddball participants respond to infrequent targets embedded among frequent nontargets and less frequent novel stimuli to which participants do not respond but are also presented to elicit a clear P3a (Polich, 2007). Continuous performance tasks (CPTs), are oddball-like paradigms that have also been used to study the P3 response; participants respond to infrequent targets, but there is a greater variety in the non-targets, or 'distractors' and so they are often considered to be more difficult than a standard oddball (Riccio, Reynolds, Lowe, & Moore, 2002). The size of the P3 response elicited in either task is proportional to the neural resources recruited to process the stimuli; therefore smaller P3s index reduced working memory updating (Polich, 2007).

P3 amplitude has been used as a biomarker of attention-monitoring capacities and executive functioning aptitude (Herrmann & Knight, 2001; Walhovd & Fjell, 2003). For this reason, P3 recording has often been used as a research tool to investigate externalizing maladaptive behaviors, which are theoretically associated with executive dysfunction (e.g., Diamond, 2013; Iacono, Malone & McGue, 2003; Iacono & McGue, 2006; Schoemaker Mulder, Dekovic, & Matthys, 2013; Young et al., 2009). Evidence from a sample of 598 twin participants suggested that covariance between P3 amplitude and vulnerability to externalizing disorders was attributable to predominantly genetic factors (Hicks et al., 2007). A reduced P3 response has been observed in numerous syndromes that involve externalizing maladaptive behaviors, such as alcoholism (Porjesz, Begleiter, & Garozzo, 1980), drug dependence (Attou, Figiel, & Timsit-Berthier, 2001), violent crime (Bernat, Hall, Steffen, & Patrick, 2007), domestic abuse (Stanford, Conklin, Helfrtiz, & Kockler, 2007), attention deficit hyperactivity disorder (ADHD; Szuromi, Czobar, Komlósi, & Bitter, 2011), Conduct Disorder (Iacono, Carlson, Malone, & McGue, 2002), and Antisocial Personality Disorder (Costa et al., 2000).

P3 amplitude in psychopathy

The research investigating the relationship between P3 amplitude and psychopathic traits has been inconsistent in its findings (for review see Gao & Raine, 2009). Some studies have shown that psychopathy, measured as a unitary construct (i.e., looking at PCL-R total scores), is related to smaller P3 amplitudes (Kiehl, Hare, Liddle & McDonald, 1999; Kiehl, Smith, Hare & Liddle, 2000, Kiehl et al., 2006), which fits with the prediction of an attentional and inhibitory deficit. Some researchers have offered evidence for an enhancement of P3 in the presence of psychopathic traits (Anderson, Stanford, Wan & Young, 2011; Raine & Venables, 1987, 1988), while others have found a lack of association between P3 amplitude and psychopathy (Jutai, Hare, & Connolly, 1987; Syndulko et al., 1975).

To help clarify these disparate results, Gao and Raine (2009) conducted a meta-analysis of the literature pertaining to how antisocial behavior and psychopathy modulate the P3. The authors addressed pertinent differences across the studies by delineating the operationalization of the disorder used (i.e., conduct disorder, aggression, psychopathy [measured with PCL-R], etc.), whether the P3 was measured using amplitude (size) or peak latency (timing), the type of task used during EEG recording (standard oddball [SDO], CPT, Go/No-Go, etc.) and the sensory modality of the stimuli (auditory or visual). Antisocial individuals were found to have significantly smaller and later peaking P3 waves than controls, with the notable exception that individuals identified as psychopathic showed a less prominent P3 reduction. Additionally, psychopathic samples showed reduced P3 amplitude in only SDO tasks, but not more complex tasks (i.e., CPT, Go/No-Go, Stroop, S1-S2 tasks, conditioning tasks[1]) and did not exhibit a P3

[1] The authors defined a Go/No-Go paradigm as any two-stimuli task in which participants were responded to a target stimuli and did not response to a non-target. A Stroop task is generally one in which participants are asked to name the color that a word is printed in instead of the meaning of word (i.e., "red" is printed in blue colored text and subjects must say "blue" to be correct). During a S1-S2 task, the S1 stimulus prepares participants for the

latency delay. Two theories were provided as possible explanations for this discovery. Although the meta-analysis only used studies that operationalized psychopathy on the basis of total PCL-R scores, the authors suggested that reduced P3 amplitudes may be more directly associated with the externalizing features of antisocial behaviors, which are captured most directly by Factor 2 in the PCL-R. Therefore the inconsistency across studies investigating P3 in psychopathic groups may have been due to sampling differences in individuals high on Factor 2 scores, who may have driven the P3 reduction.

Subsequent studies have shown more explicit support for the theory that reduced P3 amplitudes (reflecting attentional deficits) are driven by Factor 2 traits, in undergraduate (Carlson, Thái, & McLarnon, 2009) and forensic offender (Venables, Hall, Yancey, & Patrick, 2015; Venables & Patrick, 2014). Carlson et al. (2009) found that SCI scores on the PPI (Lilienfeld & Andrews, 1996) were significantly negatively correlated with P3 amplitude to targets at frontal scalp sites in undergraduate students during a CPT-like task (the "rotated heads" task developed by Begleiter et al., 1984). The SCI scale mirrors many of the qualities of the Disinhibition component of the TriPM (Patrick & Drislane, 2015). Impulsive Nonconformity, a subscale of SCI that reflects qualities of antisocially motivated perceptions, was found to drive the relationship between P3 amplitude and SCI. P3 amplitude was not associated with any other measured psychopathic traits, however, after controlling for SCI, FD became predictive of an enhanced P3 response. Venables and Patrick (2014) found similar results in a sample of incarcerated offenders for whom psychopathy was measured using the PCL-R. These authors also used a modified version of the Begleiter et al. (1984) task noted above. During this task,

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presentation of the S2 stimulus to which they must provide a behavioral response. During conditioning tasks, a neutral stimulus is paired with an unconditioned stimulus until the neutral stimuli produce the same response as the unconditioned stimulus (Gao & Raine, 2009).

reduced P3 amplitudes to targets at anterior electrode sites were found to be associated with only Factor 2. This association was noted to be stronger at frontocentral sites rather than parietal sites, particularly for the association with the antisocial behavior facet of Factor 2. Venables and Patrick (2014) failed to find any association between the P3 and PCL-R Factor 1 scores, and so suggested that the strongest relationship between P3 and psychopathic traits lies in the cognitive deficits related to the antisocial aspects of psychopathic personality. A subsequent study by Venables et al. (2015) also found reduced amplitude P3 ERP waves in 179 offenders using a very different paradigm. Participants passively viewed complex emotional and neutral images from the International Affective Picture System (IAPS; Lang, Bradley, & Cuthbert, 2008) which are known to elicit a P3, even in the absence of a participant response. The authors again found, regardless of picture valence, there was a negative correlation between PCL-R Factor 2 scores (driven by Antisocial Facet 4) and P3 amplitude. Venables et al. (2015) suggested that those with high externalizing features in their offender sample showed reduced sustained attention to all stimuli. Further, they found no relationship between P3 amplitude and PCL-R Factor 1 scores. However, a later ERP, the late positive potential, showed a negative relationship with Factor 1 scores for aversive pictures only, which the authors argued suggested a specific deficit in affective processing.

Despite evidence for an association between the antisocial aspects of psychopathy and a reduction in P3 amplitude across undergraduate and forensic samples, there remain some inconsistencies in the literature. Anderson, Steele, Maurer, Bernat and Kiehl (2015) recently investigated a range of ERPs in forensic psychopathic and nonpsychopathic offenders (identified using the PCL-R) during a three-stimulus auditory oddball target detection task. While the authors found a psychopathy-related P3 reduction associated with target stimuli, analyses

suggested that this was related to the interpersonal Facet 1 (items include glibness/superficial charm, grandiose sense of self-worth, pathological lying, conning/manipulative) but not with antisocial Facet 4 (items include poor behavioral controls, early behavior problems, juvenile delinquency, revocation of conditional release, criminal versatility; Hare, 2003). This suggests there may be other factors influencing the complex relationship between the P3 response and psychopathic traits.

An alternative explanation offered by Gao and Raine (2009) regarding the lack of agreement about psychopathy-related reductions in P3 amplitudes in the broader literature focused on the variability in paradigm use. Their meta-analysis showed that antisocial individuals had reductions in P3 amplitudes across all task types, yet, psychopathic offenders only showed this pattern of results when participating in a simplistic standard oddball task. The authors suggested that psychopaths may show normal or even enhanced capacity for attentional direction during more interesting or engaging paradigm designs. This ability would suggest a potential protective factor provided by psychopathic traits and that could possibly contribute to the manifestation of "successful psychopathy" (Lilienfeld, Watts, & Smith, 2015). The fact that enhanced executive functioning on neuropsychological tests has been found to be exclusively associated with PPI-R FD traits might help to explain this relationship (Sellbom & Verona, 2007). As noted earlier, when statistical models used by Carlson et al. (2009) controlled for the relationship between SCI and the P3, FD traits began to show a positive relationship with P3 responses. This relationship provides some insight into a possible protective mechanism, where FD characteristics may convey neurocognitive advantages in attentional capacity. In light of the lack of consensus in the literature involving the association between P3 amplitude and the subsets of psychopathic traits, an alternative investigation into the influence of paradigm type

and psychopathic traits is warranted.

The Present Study

The present study employed a within-subjects design to compare the P3 amplitude for targets during a simple oddball task and a more complex CPT, in undergraduates classified as having either high or low global psychopathic traits. In the simple oddball task there were two visual stimuli; frequent standard items to which participants did not provide a response and infrequent target items which required a response. The CPT had eleven distinct types of non-targets, and one type of target that required a response. Given that psychopathy has been related to stimulation seeking (Hare, 2006), participants with high psychopathic traits may have an advantage during the CPT because it requires higher levels of attention and response monitoring compared to the oddball task. I hypothesized that individuals high in global psychopathic traits, as measured by total scores on the PPI-R, would show reduced P3 amplitudes to targets during the standard oddball task but disproportionately larger P3 amplitudes in the CPT, relative to participants with low PPI-R scores, thus replicating the meta-analytic findings of Gao and Raine (2009). It was further hypothesized that I would similarly replicate the finding that PPI-R SCI scores would be negatively associated with the amplitude of the P3 (Carlson et al., 2009) however, I proposed that this reduction would be accentuated in the SDO task. Further, I hypothesized that the P3 response would also be negatively related to the impulsive behavioral traits measured by the TriPM Disinhibition scale, but would show no relationship with the affective-interpersonal scales (i.e., PPI-R FD, PPI-R C, TriPM Meanness, TriPM Boldness). Although, it is possible that there would be an enhanced P3 response associated with PPI-R FD and/or TriPM Boldness, given that Carlson and Thái (2010) and Anderson, Wan, Stanford and Young (2011) found this pattern in undergraduate participants.

A task-dependent differential P3 response may provide insight into the attentional capacities associated with some psychopathic traits and help explain the functional and cognitive preservation apparent in some psychopathic traits but not others. Hare (1996) predicted that 1% of the population and nearly 25% of incarcerated individuals could clinically qualify as psychopaths. The antisocial behaviors associated with this relatively large psychopathological subpopulation results in a significant amount of social distress and economic strain on the justice system (Kiehl & Hoffman, 2011). Therefore, better understanding of this disorder could lead to more effective treatment.

Relatedly, Iacono, Malone, and McGue (2002) have argued for the use of P3 as a potential index of genetic predisposition for externalizing psychopathology. Therefore, I cautiously suggest that better elucidating the relationship between this neurophysiological correlate of attention and the impulsive-behavioral traits of the psychopathic personality may provide some insight into early markers of vulnerability towards antisocial or maladaptive behaviors in psychopathy.

Methods

Participants

181 undergraduate and graduate students between the ages of 18 and 29 (M = 20.73, SD = 2.69, 62% female) were recruited from an urban college campus in the Northeast to participate in part 1 of this study. 51.9% of participants identified as Hispanic, 45% identified as Non-Hispanic, and .02% declined to report their ethnicity; when asked about their race 25.5% identified as Caucasian, 23.8% Black, 18.8% Hispanic, 13.3% Asian/Southeast Asian, 4.44% mixed race, 1.11% American Indian, 2.22% other, and 8.33% declined to self-identify. Exclusion

criteria included: uncorrected vision problems, recent neurological impairment (i.e., concussion, seizure), or current psychiatric treatment.

Most participants were recruited from an online posting on the John Jay College of Criminal Justice SONA Research Experience site which is available to all students enrolled in introductory psychology courses. Participants were also referred by word of mouth. A description of the procedure for Part 1 noted the potential for enrollment in Part 2 based on eligibility. Participants provided written informed consent before completing the PPI-R (Lilienfeld & Widows, 2005), the TriPM (Patrick, 2010), and a demographic questionnaire. The PPI-R and TriPM scales were both used in order to measure psychopathic traits using two slightly different theoretical models with somewhat different scales. However, PPI-R total scores were used to designate initial group membership as this measure was intended for use with community samples and has been better validated in the field than the TriPM (Uzieblo, Verschuere, Van Den Bussche, & Crombez, 2010). I chose to use PPI-R total scores to operationalize psychopathy for ease of recruitment for the ERP study; the assumption being that individuals with high psychopathic traits would be more likely to score high on the various subscales of interest (i.e., PPI-R SCI and TriPM Disinhibition) as well as other psychopathy indices (i.e., PPI-R FD, TriPM Boldness, and/or Meanness). If I had tried to be more selective, e.g., picking participants with only high PPI-R SCI *and* FD scores for the high scores for the high group and only low PPI-R and FD scores for the low group, there would have been very few eligible participants. Participants whose total PPI-R *T*-score was 50 ($\geq 53^{rd}$ percentile for males, $\geq 51^{st}$ percentile for females) or higher were considered eligible for recruitment into the high psychopathy group. Individuals whose total PPI-R *T*-score was 40 or lower ($\leq 17^{th}$ percentile for males, $\leq 18^{th}$ percentile for females) were placed in the low psychopathy group.

Upon completion of Part 1, participants were debriefed concerning the questionnaires and were informed that they may be contacted for later enrollment in Part 2.

Participants with *T*-scores that fell within the desired ranges defined above were notified via email and invited to complete part two of the study, i.e., the ERP study, on a later day. All 34 participants from Part 1 who were eligible for Part 2 were contacted; 32 participants responded with interest in the study, however, 2 were unable to complete the ERP portion due to scheduling conflicts. 28 participants (female = 13) participated in the two-task ERP paradigm; 15 participants ranked in the high psychopathy range (M = 57.23, SD = 10.814, 79th percentile[2]) and 13 scored in the low psychopathy range (M = 36.54, SD = 10.814, 9th percentile). The high psychopathy group scored significantly higher than the low group on the PPI-R, $t(24) = 5.017$, $p < 0.001$. The data of two participants were excluded from subsequent analyses due to technical errors with the E-Prime system during task administration (n =1) and excessive artifacts in the EEG recording (n = 1). Of those who completed the second part of the study, 60.71% identified as Hispanic/Latino/Latina, 32.14% not Hispanic/Latino/Latina and 7.14% did not identify their ethnicity. 42.8% of Part 2 participants identified as White, 32.14% Black, 10.70% Hispanic, 7.14% Asian/Southeast Asian, and 7.14% other.

Prior to the initiation of EEG recording, subjects provided written informed consent for the second part of the study. At the conclusion of Part 2 participants were debriefed regarding the intention of the ERP portion of the study. Subjects were awarded points for their participation in Part 1, Part 2, or both, that contributed to their final grade in a psychology course. Participants who were not currently enrolled in undergraduate courses were given monetary compensation of

[2] This percentile has been averaged across males and females.

$10.00 for Part 1 and an additional $30.00 for the completion of Part 2. All procedures were approved by the City University of New York IRB Board, protocol #599521.

Materials

Psychopathic Personality Inventory – Revised (PPI-R; Lilienfeld & Widows, 2005).

Psychopathic traits were measured using the PPI-R, which is a 154-item questionnaire answered using a 4-point Likert scale (Lilienfeld & Widows, 2005). The items include statements that address behaviors and cognitions typically associated with the psychopathic personality, such as "I get mad if I don't receive special favors I deserve" and "I enjoy seeing someone I don't like get into trouble". Individuals recorded whether they feel each statement was *false*, *mostly false*, *mostly true*, or *true* as it pertained to their character or beliefs. The instrument measures different traits of the psychopathic personality using eight subscales; Social Influence (SOI), Fearlessness (F), Stress Immunity (STI; which together make up a higher-order factor, FD as well as Machiavellian Egocentricity (ME), Rebellious Nonconformity (RN), Blame Externalization (BE), and Carefree Nonplanfulness (CN), which sum to create the higher-order factor of SCI. One subscale, Coldheartedness (C), does not load onto either FD or SCI scales and is frequently treated as a standalone trait, yet has been found to have small (r =.15) to moderate (r = .30) correlations with FD and SCI, respectively (Berg, Hecht, Latzman, & Lilienfeld, 2015; Benning et al., 2003). Lilienfeld and Widows (2005) have reported adequate internal reliability (Cronbach's αs between 0.78 and 0.92) and validity. PPI-R total scores and factor scores are significantly correlated with the total scores and factor scores of Hare's Self-Report Psychopathy Scale-II (SRP-II; Hare, 1991), another well accepted self-report assessment of psychopathic traits (Lilienfeld & Widows, 2005). In the current sample, internal consistency was good for the total score (α = .894), FD (α =.891), and C (α =.825), with excellent consistency for the SCI subscale (α =.907).

The PPI-R includes three validity scales, Deviant Responding (DV), Virtuous Responding (VR), and Inconsistent Responding (IR), each of which identify individuals with unreliable reporting styles. The Inconsistent Responding scale (IR-40) is drawn from a subset of 40 items. Individuals who scored in the atypical range on this scale (n = 7) were excluded from Part 1 analyses and Part 2 eligibility. Based on recommendations made by Lilienfeld and Widows (2005), the VR scale was not used to exclude participants because individuals with high psychopathic traits may respond in this manner to appear more socially conforming, similarly, the DV scale was also not used to exclude participants as "faking bad" traits measured by this scale may reflect genuinely elevated pathological traits of the psychopathic personality (Lilienfeld & Widows, 2005).

Triarchic Psychopathy Measure (TriPM; Patrick, 2010). An additional self-report tool was utilized to assess an alternative conceptualization of psychopathic traits. The TriPM is a 58-item measure where participants respond to each item on a four point Likert scale (true = 1, somewhat true = 2, somewhat false = 3, false = 4). Items include statements like, "My impulsive decisions have caused problems with loved ones" and "I can convince people to do what I want" (Patrick, 2010). This tool reflects the triarchic conceptualization of psychopathy developed by Patrick, Fowles, and Krueger (2009), which argued for three main components of the psychopathic personality: meanness, boldness, and disinhibition. These domains are represented in three synonymous scales in the TriPM measure. The Meanness (19 items) and Disinhibition (20 items) scales are both derived from similar scales in the Externalizing Spectrum Inventory (ESI; Krueger, Markon, Patrick, Benning, & Kramer, 2007), while the Boldness scale (19 items) is made from novel items modeled after the FD scale of the PPI-R, detailed above (Evans & Tully, 2016). Sellbom and Phillips (2013) reported acceptable internal reliability for these scales

with a college sample of 627 undergraduates with Cronbach alphas of .88 for Meanness, .84 for Disinhibition and .89 for Boldness. In the current sample, internal consistency was found to be similarly good: α = .857 for the total score, .890 for the Meanness scale, and .837 for the Disinhibition Scale. Internal consistency was acceptable for the Boldness scale (.755). Given that the PCL-R emphasizes traits of criminality, it is not surprising that the TriPM factor scores show only weak to moderate correlations with PCL-R total scores and factor scores (Patrick, 2010). Of particular relevance to the current study, the strongest correlations were found between the TriPM Disinhibition subscale and PCL-R total scores (*r* =. 53) and PCL-R Lifestyle facet scores (*r* = .48; Patrick, 2010). Venables, Hall, and Patrick (2014) found that only the TriPM disinhibition scale correlated with a PCL-R facet, the Lifestyle facet (Venables, Hall, & Patrick, 2014). The TriPM shows stronger overall correlations with the PPI-R than the PCL-R (Evans & Tully, 2016).

Procedure

ERP study procedure. The EEG data were collected in a quiet and darkened room that is reserved for EEG recording. After participants provided informed consent for Part 2, an electrode cap was put on their head. Gel was inserted under the electrodes on the cap to improve the impedance between the electrodes and the scalp. Participants were instructed to remain still during the EEG recording and to limit eye blinks during the presentation of task stimuli. The standard oddball task and the continuous performance test were administered on the same day and were counterbalanced across participants to account for effects of fatigue. The two tasks were separated by a ten-minute break and were completed in approximately 3 hours, including cap preparation, clean-up, and educational debriefing.

Participants sat approximately 72 cm away from a Dell 1908 flat panel LCD monitor screen on which the stimuli were displayed. The stimuli for both tasks were letters presented on a

gray background and measured (9cm x 6cm), i.e., they subtended a visual angle of 7.1 degrees by 4.7 degrees. Stimuli were presented in the same order to all participants. Each letter was shown on the screen for 100 ms with an inter-stimulus interval of 2000 ms. The stimuli were presented pseudorandomly such that no more than two targets were shown consecutively. E-Prime Version 2.0 software was used to present the stimuli and record both accuracy and reaction time. Instructions appeared on the screen prior to each task informing the participants which stimulus was the target. The subjects were instructed to click the mouse as quickly as possible with their right hand whenever they saw the target on the screen but to refrain from responding to nontargets. A brief practice period was completed prior to each trial administration to ensure instruction comprehension.

Standard oddball stimuli. The standard (nontarget) stimuli were yellow "As" in Calibri 80-point font and the target stimulus was a blue letter "B" in the same font. The standard nontarget "A" stimulus appeared 160 times (80% of trials) and target "B" stimulus was presented a total of 40 times (20% of trials).

Continuous performance stimuli. Twelve distinct non-target stimuli (O, C, D, G, Q, R) shown in both blue and yellow font were presented on a gray background. The target letter was a blue "O", thus participants had to pay attention to both color and shape of the letters. The non-targets were shown a total of 160 times (80% of trials) and the target was shown 40 times (20% of trials). These probabilities were intentionally kept the same as the standard oddball task.

ERP recording

During the ERP tasks, EEG was recorded using a 64-channel electrode Quikcap, referenced to a midline electrode between Cz and CPz. Signals were recorded using a Neuroscan Synamps RT amplifier and a Neuroscan 4.4. Acquire software (Compumedics, El Paso, TX).

Electrode impedances were kept below 5 kΩ and EEG was recorded continuously with a bandpass of 0.01 – 1000 Hz and digitized at 1000 Hz.

ERP analysis

ERPs were analyzed offline using Neuroscan Version 4.4 Edit software. Recordings were re-referenced to averaged activity from the mastoid electrodes. Data were epoched from 200ms prior to stimulus onset to 2000ms after it and band-pass filtered from 0.1 to 30 Hz. Automatic artifact rejection was used to exclude any epochs in which amplitudes exceeded ±50 μV. Averages were created for both the target and nontarget for each participant. In accordance with past research, difference waveforms were also created for each participant by subtracting the averaged non-target waveforms from the averaged target waveforms for each paradigm. Grand averages for the ERPs to the target, nontarget, and difference waves were created. Based on the visual inspection of these waves, P3b amplitude was measured as the mean amplitude at F1, Fz, F2, FC1, FCz, FC2, C1, Cz, C2, CP1, CPz, CP2, P1, Pz, P2, PO3, POz, and PO4 in the following windows: 400-500 ms for all SDO stimuli, and between 410-510 ms for CPT targets and nontargets, and between 450-550 ms for the CPT subtraction waves.

Behavioral data, as measured by correct hits, misses, and false alarms, were collected by the E-Prime software and reviewed before a participant's ERP data was included in analysis, as reduced response accuracy may indicate poor effort. No participants were excluded based on this criteria. ANOVAs with within-subjects factor of Task and between-subjects factor of Group were conducted to compare behavioral performance for each of the dependent behavioral measures for various psychopathy-related groups based on PPI-R total scores, as well as median splits of TriPM total scores, and the PPI-R SCI, FD, C, CN, TriPM Disinhibition, Meanness, and Boldness scores. A repeated measures ANOVA was also conducted with P3 amplitude as the

dependent variable, and Task (SDO, CPT), Stimulus (target, non-target), and Electrode (18) as the within-subjects factors and PPI-R Total Group as the between-subjects factor. Additional repeated measures ANOVAs were performed to explore alternative psychopathy-related groups created using a median split as noted above. Significant interactions were explored using post-hoc Bonferroni *t*-tests. Greenhouse Geisser corrections were applied where necessary and corrected *p* values are reported, however, uncorrected degrees of freedom are reported for ease of interpretation.

Results

Correlations among personality measures

Zero-order correlations between PPI-R and TriPM total scores and their factors are shown in Table 1, for all part 1 participants (n = 172). Total PPI-R *T*-scores were strongly associated with PPI-R SCI *T*-scores and moderately correlated with PPI-R FD and C *T*-scores as well as TriPM total score and the three TriPM factors, Boldness, Meanness, and Disinhibition. SCI *T*-scores were not correlated with any other PPI-R factors, yet were found to be moderately positively correlated with TriPM total scores and TriPM Meanness and Disinhibition. Conversely, the PPI-R FD factor was weakly positively correlated with the PPI-R C subscale. The FD factor was also moderately positively correlated with TriPM total score and weakly negatively correlated with TriPM Disinhibition. FD was strongly positively correlated with the TriPM Boldness factor. The PPI-R C subscale was moderately correlated with the TriPM total score and the TriPM Meanness factor, yet weakly correlated with the TriPM Boldness factor.

Table 1

Zero-order correlations between PPI-R T-scores and TriPM raw scores

Measure	1	2	3	4	5	6	7
1. Total PPI-R *T*-score	—						
2. SCI *T*-score	.787**	—					
3. FD *T*-score	.629**	0.068	—				
4. C *T*-score	.417**	0.141	.179*	—			
5. TriPM Boldness	.373**	-0.132	.779**	.204**	—		
6. TriPM Meanness	.591**	.582**	0.107	.500**	0.092	—	
7. TriPM Disinhibition	.428**	.717**	-.178*	0.026	-.245**	.553**	—
8. TriPM Total	.711**	.612**	.339**	.378**	.403**	.859**	.686**

Note: ** $p < 0.01$ (2-tailed). * $p < 0.05$ level (2-tailed). PPI-R = Psychopathic Personality Inventory -Revised; SCI = Self-Centered Impulsivity; FD = Fearless Dominance; C = Coldheartedness; CN = Carefree Nonplanfulness; TriPM = Triarchic Personality Measure.

ERP task behavioral results

Participants showed good behavioral performance across both tasks, mean and standard errors for correct hits and false alarms are shown in Tables 2 and 3, respectively. The mean number of false alarms (see Table 3) was very low and across both paradigms, and there was no effect of Task ($F < 1.6$, $p < .23$), Group, or interaction with Group ($F < 1.1$, $p < .27$). A mixed ANOVA with correct hits as the dependent variable and a between-subjects factor of Total PPI-R Group (high, low) and within-subjects factor of Task (SDO, CPT) revealed no main effect of Task ($F < 1$) but there was a main effect of Total PPI-R Group; the low group made more correct responses than the high group, $F(1, 24) = 7.493$, $p = .011$, $\eta_p^2 = .238$. Similarly, participants in the low TriPM Meanness group made more correct responses than those in the high TriPM Meanness group, $F(1, 24) = 5.345$, $p = .030$, $\eta_p^2 = .182$. Those in the low PPI-R C group made marginally more accurate responses than those in the high C group, $F(1, 24) = 3.960$, $p = .058$,

η_p^2 = .058. Similar relationships were found for members of the PPI-R SCI groups, $F(1, 24)$ = 3.708, p =.066, η_p^2 = .134 and TriPM Disinhibition groups, $F(1, 24)$ = 3.798, p = .066, η_p^2 = .134. Those with higher scores on these scales performed less accurately on the tasks than those who had lower scores. However, there was no main effect of Group for PPI-R FD, Carefree Nonplanfulness (CN), TriPM total score, or TriPM Boldness, ($F < 1.01$, $p < .326$). Also, there were no significant interactions between Task and Group in any of the correct hit analyses ($F < 2.02$, $p < 1.70$).

Table 2

Mean and (standard error) for number of correct hits in the standard oddball and continuous performance tasks for individuals categorized into various high and low groups based on psychopathic personality scales

	Standard Oddball		Continuous Performance Task	
	High	Low	High	Low
PPI-R Total	38.15 (1.144)	38.92 (.277)	39.38 (1.044)	39.85 (.376)
PPI-R SCI	38.154 (.231)	38.923 (.231)	39.538 (.226)	39.692 (.226)
PPI-R FD	38.357 (.241)	38.750 (.260)	39.643 (.219)	39.583 (.237)
PPI-R C	38.286 (.235)	38.833 (.254)	39.429 (.212)	39.833 (.229)
PPI-R CN	38.368 (.207)	39.00 (.331)	39.632 (.188)	39.571 (.310)
TriPM Total	38.286 (.235)	38.833 (.254)	39.643 (.219)	39.583 (.237)
TriPM Disinhibition	38.154 (.231)	38.923 (.231)	39.538 (.226)	39.692 (.226)
TriPM Boldness	38.500 (.247)	38.583 (.266)	39.714 (.217)	39.500 (.235)
TriPM Meanness	38.231 (.240)	38.846 (.240)	39.385 (.218)	39.846 (.218)

Note: PPI-R = Psychopathic Personality Inventory -Revised; SCI = Self-Centered Impulsivity; FD = Fearless Dominance; C = Coldheartedness; CN = Carefree Nonplanfulness; TriPM = Triarchic Personality Measure.

Table 3

Mean and (standard error) for number of false alarms in the standard oddball and continuous performance tasks for individuals categorized into various high and low groups based on psychopathic personality scales

	Standard Oddball		Continuous Performance Task	
	High	Low	High	Low
PPI-R Total	.692 (.205)	.231 (.205)	1.00 (1.091)	1.846 (1.091)
PPI-R SCI	.692 (.205)	.231 (.205)	.923 (1.089)	1.923 (1.089)
PPI-R FD	.643 (.200)	.250 (.216)	.714 (1.037)	2.250 (1.120)
PPI-R C	.571 (.205)	.333 (.221)	.857 (1.045)	2.083 (1.128)
PPI-R CN	.632 (.165)	< .001 (.272)	1.737 (.900)	.571 (1.483)
TriPM Total	.643 (.200)	.250 (.216)	.714 (1.037)	2.250 (1.120)
TriPM Disinhibition	.462 (.215)	.462 (.215)	2.308 (1.068)	.538 (1.068)
TriPM Boldness	.643 (.200)	.250 (.216)	.714 (1.037)	2.250 (1.120)
TriPM Meanness	.615 (.211)	.308 (.211)	.923 (1.089)	1.923 (1.089)

Note: PPI-R = Psychopathic Personality Inventory -Revised; SCI = Self-Centered Impulsivity; FD = Fearless Dominance; C = Coldheartedness; CN = Carefree Nonplanfulness; TriPM = Triarchic Personality Measure.

P300 amplitude

The mean and standard errors of P3 amplitudes for targets and nontargets are shown in Table 4. Contrary to my hypotheses, the repeated measures ANOVA using PPI-R Total score Group (high, low) as the between-subjects factor, did not find a significant effect of PPI-R Total score Group, $F(1, 24) = 0.005$, $p = .946$, $\eta_p^2 < .001$, nor any interactions with PPI-R Total score Group. The lack of interaction between Group and Task indicated that the hypothesis that participants with high PPI-R total scores would have relatively smaller P3s in the SDO than CPT in comparison to participants with low PPI-R total scores was not supported. There was, however, a main effect of Task, $F(1, 24) = 14.01$, $p = .001$, $\eta_p^2 = .369$; the P3 amplitude was larger in the standard oddball task ($M = 7.213$ μV, $SEM = .636$) than in the CPT ($M = 6.120$ μV, $SEM = .662$). There was also a main effect of Stimulus, $F(1, 24) = 46.014$, $p < .001$, $\eta_p^2 = .657$, the amplitude of the P3 response to targets ($M = 9.243$, $SEM = .846$) was significantly larger than

to nontargets (*M* = 4.090, *SEM* = .610). A significant interaction effect between Task x Stimulus was also present, $F(1, 24) = 13.120$, $p = .001$, $\eta_p^2 = .353$.

An inspection of the means indicated there was a greater difference in P3 amplitude between the SDO target (*M* = 10.464 μV; *SEM* = 0.843) and nontarget (*M* = 3.963 μV; *SEM* = .642) than between the CPT target (*M* = 8.022 μV, *SEM* = .935) and nontarget (*M* = 4.218 μV; *SEM* = .636). In order to confirm this statistically, a new dependent variable, "P3 Subtraction", was created for each task by collapsing P3 amplitudes across electrodes and subtracting amplitude of the P3 for nontargets from the targets. An ANOVA with this new variable as the dependent measure, and a within subjects factor of Task confirmed that the P3 Subtraction amplitude was significantly greater for the SDO task (*M* = 6.501, *SEM* = 0.782) than the CPT (*M* = 3.804, *SEM* = 0.886), $F(1, 25) = 13.627$, $p = .001$, $\eta_p^2 = .353$.

Table 4

P3 amplitude means and (standard errors) for targets and nontargets in the standard oddball and continuous performance tasks for individuals categorized into various high and low groups based on psychopathic personality scales

	Standard Oddball				Continuous Performance Task			
	High		Low		High		Low	
	Target	Nontarget	Target	Nontarget	Target	Nontarget	Target	Nontarget
PPI-R Total	10.30 (1.19)	4.23 (.91)	10.63 (1.19)	3.69 (.91)	7.74 (1.32)	3.87 (.90)	8.30 (1.32)	3.86 (.89)
PPI-R SCI	10.47 (1.19)	3.81 (.91)	10.45 (1.19)	4.11 (.91)	7.95 (1.32)	4.16 (.91)	8.09 (1.32)	4.27 (.91)
PPI-R FD	10.33 (1.15)	4.19 (.88)	10.62 (1.24)	3.69 (.95)	7.53 (1.27)	4.48 (.87)	8.60 (1.37)	3.91 (.94)
PPI-R C	10.08 (1.15)	2.96 (.83)	10.91 (1.24)	5.13 (.89)	8.31 (1.27)	3.51 (.85)	7.69 (1.38)	5.04 (.91)
PPI-R CN	10.66 (.98)	4.37 (.74)	9.93 (1.62)	2.86 (1.21)	7.39 (1.07)	4.62 (.73)	9.74 (1.76)	3.13 (1.20)
TriPM Total	10.96 (1.14)	4.28 (.87)	9.88 (1.23)	3.50 (.94)	8.14 (1.28)	3.75 (.93)	7.88 (1.37)	3.75 (.93)
TriPM Disinhibition	10.91 (1.19)	3.56 (.91)	10.02 (1.19)	4.34 (.91)	7.23 (1.30)	4.48 (.90)	8.18 (1.30)	3.96 (.90)
TriPM Boldness	11.01 (1.14)	4.43 (.87)	9.83 (1.23)	3.42 (.94)	8.08 (1.28)	4.55 (.87)	7.95 (1.38)	3.83 (.94)
TriPM Meanness	11.54 (1.15)	4.08 (.91)	9.36 (1.15)	3.85 (.91)	8.96 (1.30)	4.79 (.89)	7.08 (1.30)	3.65 (.89)

Note: PPI-R = Psychopathic Personality Inventory -Revised; SCI = Self-Centered Impulsivity; FD = Fearless Dominance; C = Coldheartedness; CN = Carefree Nonplanfulness; TriPM = Triarchic Personality Measure.

P3 response and psychopathic subscales

In order to investigate the hypothesis that traits related to the PPI-R Self-Centered Impulsivity (SCI) factor may be modulating the P3 response across task type, subjects were categorized into two groups based on their PPI-R SCI *T*-scores using a median split. The high SCI group (M = 57.46, SD = 8.838) had significantly higher SCI *T*-scores than participants in the low SCI group (M = 36.00, SD = 5.68), $t(24) = 7.363$, $p < 0.001$. A MANOVA with a between-subjects factor of SCI Group (high, low) and within-subjects factors of Task (CPT, SDO), Stimulus (target, nontarget), and Electrode (18) determined that there was no significant main effect of SCI Group, $F(1, 24) = 0.011$, $p = .917$, $\eta_p^2 = .000$, nor an interaction between Task and SCI group, $F(1, 24) = 0.001$, $p = .976$, $\eta_p^2 = .000$.

Due to the conceptual similarities between the SCI factor of the PPI-R and the Disinhibition factor of the TriPM, grouping by this factor was also explored. A median split was used to categorize participants into high (M = 20.85, SD = 8.678) and low (M = 6.31, SD = 2.213) groups based on their TriPM Disinhibition raw scores, $t(24) = 5.853$, $p < .001$. These groups did not significantly differ on their PPI-R FD (High M = 52.85, SD = 8.48; Low M = 45.15 SD = 14.97; $t(24) = 1.612$, $p = .120$), PPI-R C (High M = 50.54, SD = 12.41; Low M = 45.69, SD = 10.67; $t(24) = 1.067$, $p = .296$) or TriPM Boldness scores (High M = 35.08, SD = 6.30 ; Low M = 31.77, SD = 7.28; $t(24) = 1.238$, $p = .228$). These two groups were statistically different on their TriPM Meanness scores (High M = 15.92, SD = 9.23, Low M = 8.23, SD = 5.62); $t(24) = 2.567$, $p = .017$). A repeated measures ANOVA with P3 amplitude as the dependent measure again compared Task (CPT, SDO), Stimulus (target, nontarget) and Electrode (18), using TriPM Disinhibition Group (high, low) as the between-subjects factor.

While no main effect of TriPM Disinhibition Group was found, $F(1, 24) = 0.035$, $p = .835$, $\eta_p^2 = .001$, there was a Task x Stimulus x Group interaction, $F(1, 24) = 8.566$, $p = .007$, $\eta_p^2 = .263$.

To explore this interaction further, two follow-up ANOVAs were conducted for the target and non-target stimuli separately each using within-subjects factors of Task (CPT, SDO) and Electrode (18) with TriPM Disinhibition Group (high, low) as the between-subject factor. There was a significant interaction between Task x Group for targets, $F(1, 24) = 6.344$, $p = .019$, $\eta_p^2 = .209$, but not for nontargets, $F(1,24) = 3.201$, $p = .086$, $\eta_p^2 = .118$, suggesting that the interaction was driven by the P3 to targets.

Follow-up ANOVAs were then conducted for the P3 amplitude to targets for each task separately, using within-subjects factors of Electrode (18) and TriPM Disinhibition Group (high, low). For the CPT, individuals in the low TriPM Disinhibition group, had larger P3 amplitudes ($M = 8.818$, $SEM = 1.304$) to targets than those in the high group ($M = 7.227$, $SEM = 1.304$). This pattern flipped during the SDO task, where individuals in the low TriPM Disinhibition group produced smaller P3 amplitudes ($M = 10.022$, $SEM = 1.187$) than the high TriPM Disinhibition group ($M = 10.906$, $SEM = 1.187$).

This pattern of results can also be seen in the grand averaged waveforms for the TriPM Disinhibition groups for the target and nontarget responses in Figure 1a in the standard oddball paradigm and Figure 1b in the CPT. Figure 2 shows the P3 to the targets for each TriPM Disinhibition Group for each task. The scalp topography of the P3 to targets (which elicited the largest amplitude P3) is shown in the head maps in Figure 3 for each task and TriPM Disinhibition Group. The amplitude of the P3 to targets in the CPT is clearly larger for participants in the low TriPM Disinhibition group than in the high group for targets, but not non-

targets. However, the topography across the figures is very similar, in all cases the P3 is maximal centroparietally.

To confirm that the traits measured by the TriPM Disinhibition scale were exclusively associated with the differential P3 response, MANOVAs were also conducted after categorizing participants into high and low groups on the PPI-R FD and C as well as TriPM total scores and Boldness and Meanness factors. There were no significant main effects of Group ($F < 1.6$, $p > .23$) nor any significant interactions with Group ($F < 1.4$, $p > .26$) for any of these scores. However, there was a marginally significant interaction between PPI-R C x Task, $F(1, 24) = 3.684$, $p = .067$, $\eta_p^2 = .133$. An inspection of the means showed little PPI-R C Group difference in the amplitude of the P3 during the CPT (High C $M = 5.911$, $SEM = .900$, Low C $M = 6.364$, $SEM = .978$), however, the high C group ($M = 6.521$, $SEM = .841$) had smaller P3s than the low C group ($M = 8.021$, $SEM = .909$) during the SDO.

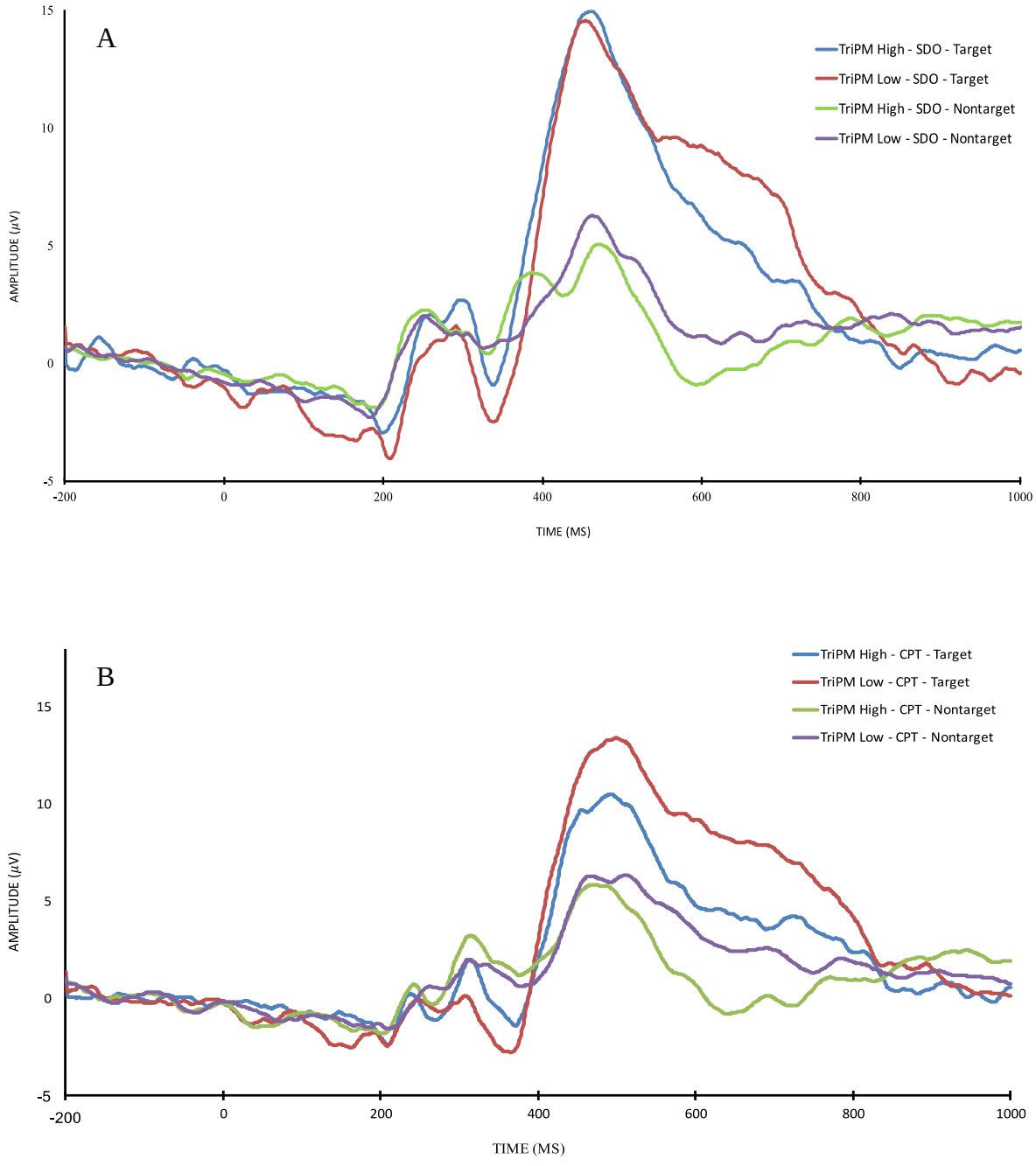

Figure 1. Grand averaged P3 response at CPz to the targets and nontarget P3 responses for high and low TriPM Disinhibition groups for the standard oddball (A) and continuous performance task (B). TriPM = Triarchic Personality Measure.

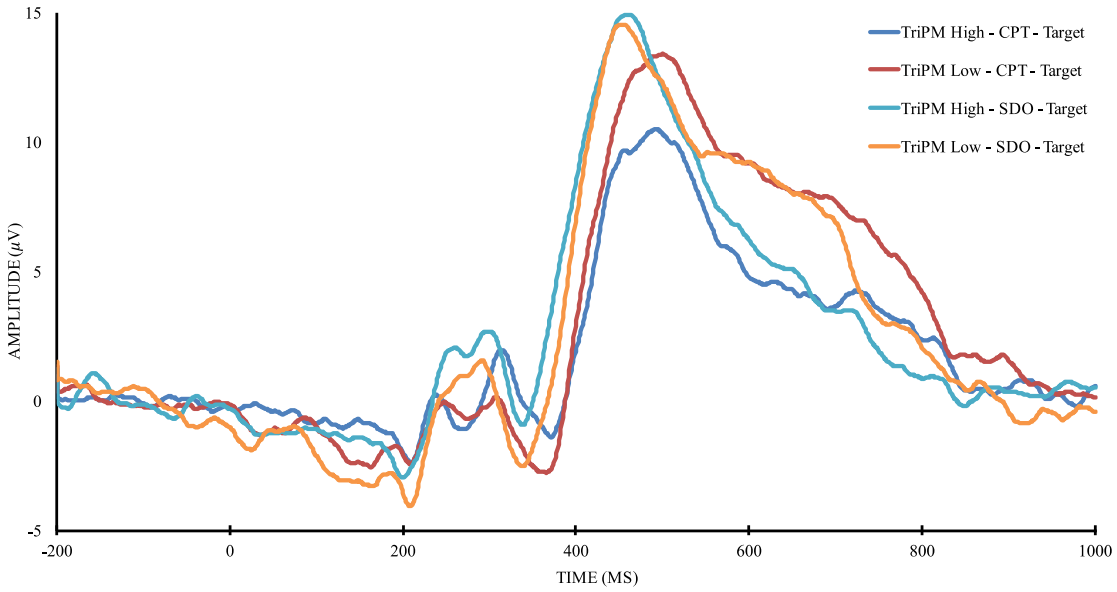

Figure 2. Grand average P3 at CPz to targets for the standard oddball and continuous performance task for high and low TriPM Disinhibition groups. TriPM = Triarchic Personality Measure.

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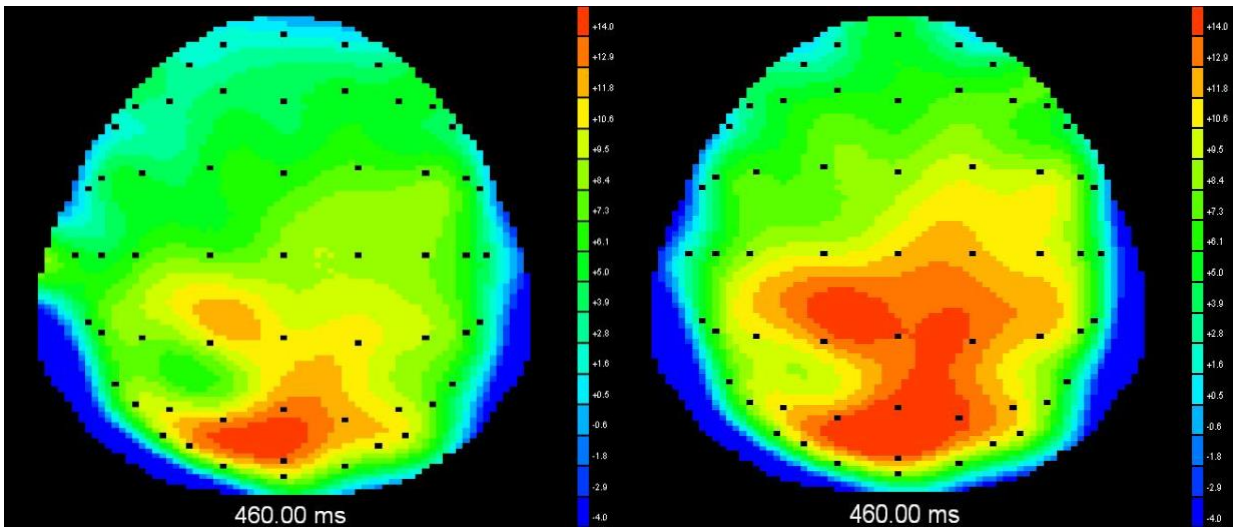
A) High Group CPT B) Low Group CPT



C) High Group SDO D) Low Group SDO

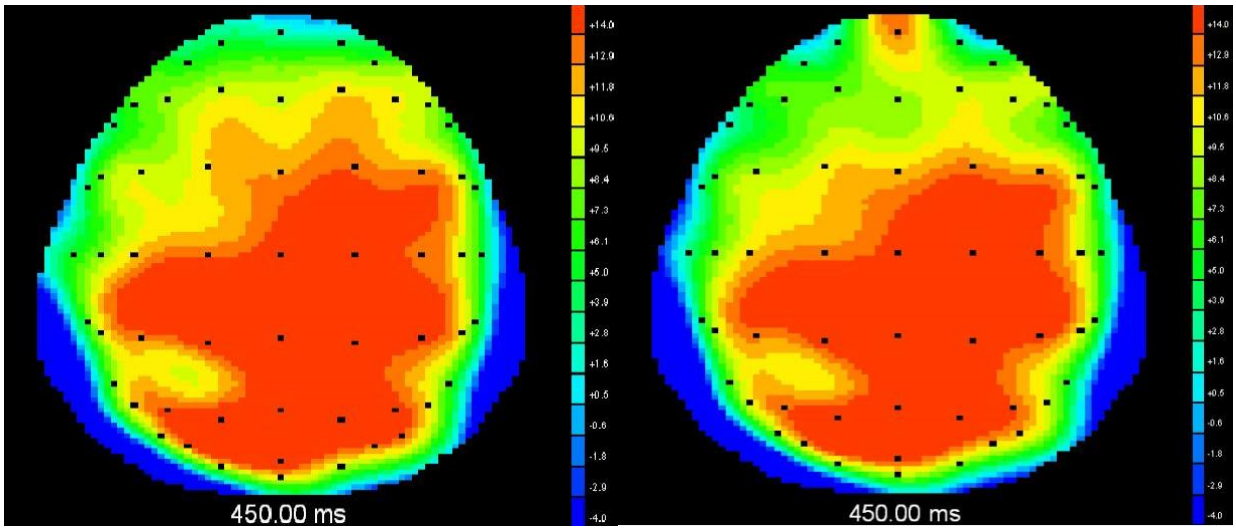


Figure 3. Topographic distribution of the P3 for each task for both the high and low TriPM Disinhibition groups. A) High TriPM Disinhibition Group, CPT, B): Low TriPM Disinhibition Group, CPT, C): High TriPM Disinhibition Group, SDO, D): Low TriPM Disinhibition Group, SDO. TriPM = Triarchic Personality Measure.

Discussion

This study sought to address the discrepancies in the literature concerning whether psychopathy is related to a reduced P3 response, and to clarify whether this reduction in amplitude is driven by paradigm type and/or specific psychopathic traits as suggested by Gao and Raine (2009). To address these aims, I recorded the P3 in two target detection tasks, a SDO and a CPT, in participants who were classified as high or low on various psychopathic traits. I predicted that high trait global psychopathy would be associated with reduced P3 responses to targets during the SDO task, but disproportionately larger P3s during the more demanding CPT. I further hypothesized that PPI-R SCI and TriPM Disinhibition would drive this relationship, whereas factors associated with the affective-interpersonal traits of psychopathy (PPI-R FD, PPI-R C, TriPM Meanness, TriPM Boldness) would not be correlated with P3 amplitude, or may even be associated with increased P3 amplitudes.

Although I replicated the widely reported finding that targets elicited larger P3s than nontargets (Tekok-Kilic, Shucard & Shucard, 2001; for a review see Patel & Assam, 2005), contrary to my hypothesis, I found that P3 amplitude was not predicted by overall PPI-R score, nor was there any interaction between overall PPI-R score and Task. However, there were two other notable interactions. Firstly, there was an overall significant Task by Stimulus interaction. Regardless of psychopathic trait scores, targets in the SDO task elicited larger P3 amplitudes than in the CPT. Johnson (as cited by Luck, 2005) showed that P3 amplitude is reduced if participants are uncertain in their responses; indeed uncertainty should be higher in the CPT task than the SDO task because many of the distractors shared the same basic features (color, shape) as the target in the CPT but not the SDO task.

Secondly, I found a 3-way interaction between Task, Stimulus, and Group when participants were categorized according to TriPM Disinhibition scores. The Task by Group interaction was driven by the target stimuli and these elicited smaller P3 amplitudes in the CPT for the High TriPM Disinhibition group compared to the low group, whereas the opposite relationship was found for the more simplistic SDO task. In my study, a reduced P3 amplitude to target stimuli therefore seems to be related to the impulsive-antisocial aspects of the psychopathic personality, which is consistent with other studies that have found the same phenomenon across a variety of tasks in undergraduate (Carlson et al., 2009) and forensic offender (Venables & Patrick 2014; Venables, Hall, Yancey & Patrick, 2015) samples. However, to my knowledge, this is the first time that a psychopathy-related reduction in P3 amplitude has been shown to be paradigm-specific by using a within subjects design.

In the meta-analysis assessing the P3 response in the psychopathic personality conducted by Gao and Raine (2009) the authors suggested that paradigm type may be a potential explanation for the discrepancies found in the research. The results of the meta-analysis indicated that while studies with psychopathic samples showed reduced P3 amplitudes during SDO tasks, they did not demonstrate this deficiency during paradigms which employed more complex tasks, including those which used a CPT paradigm (Gao & Raine, 2009). Interestingly, I found the opposite phenomenon. My contrary finding may be due to two different factors.

First, I measured psychopathy in a different way than the studies included in the meta-analysis by Gao and Raine (2009) who defined psychopathy only on the basis of total PCL-R scores. Notably, they did not explore the relationship with specific psychopathy factors, and did not include studies which used other psychopathy measures such as the PPI-R and TriPM which were used in the current study. PCL-R and PPI total scores are only moderately correlated (*r*

= .54; Poythress, Edens, & Lilienfeld, 1998) and TriPM total scores are only moderately predictive (R = .53) of PCL-R total scores (Patrick, 2010). Further, the PCL-R is heavily weighted towards the measure of antisocial behavior (Hare, 2003; Patrick, Hicks, Nichol, & Krueger, 2007), while the PPI-R and TriPM were developed to measure a broader spectrum of the psychopathic personality (Lilienfeld & Widows, 2005; Patrick, 2010). Since it has been hypothesized that the impulsive-antisocial traits of the psychopathy construct are more closely linked to the reduction in P3 response (Patrick & Bernat, 2009b), the relationship between P3 and psychopathy may be may be different if the PCL-R, rather than the PPI or TriPM, is used to define psychopathy. Additionally, the meta-analysis by Gao and Raine (2009) limited their analyses to studies that used offender samples. Therefore, differences in symptom severity between the offender populations reviewed in the meta-analyses and the undergraduate sample in the current sample may also be the cause of these discrepant results.

Secondly, Gao and Raine (2009) collapsed all studies which employed CPT, Go/No-Go, Stroop, S1-S2, and conditioning tasks into a single "other" category to conduct their analyses. Therefore, they did not directly compare the P3 in SDO tasks to CPTs. Thus, my finding that high TriPM Disinhibition was associated with reduced P3 amplitude on the CPT but not the SDO task is novel. My results closely align with a study by Carlson et al. (2009) who found PPI SCI was related to reduced P3 amplitudes in an undergraduate sample. They used a "rotated heads" task (Begleiter et al., 1984) in which participants had to press a left or right button to indicate the position of the ear on a schematic face and ignore nontarget ovals. Thus, this task required more effort than a standard oddball and so may be more comparable to the CPT. These results also align with Venables and Patrick's (2014) study which used the "rotated heads" task in a forensic

sample (Begleiter et al., 1984). These authors found an association between reduced P3 response and Factor 2 traits, but not Factor 1 traits as measured by the PCL-R (Venables & Patrick, 2014).

However, my findings largely contrast with those of Anderson et al. (2015), who reported reduced P3 amplitudes to targets using a standard auditory oddball were correlated with the interpersonal traits (Facet 1) of the PCL-R, but not the impulsive-antisocial characteristics in a male forensic sample. I did find a marginally significant effect of Task for the PPI-R C group in the current study whereby the high PPI-R C group showed reduced P3 amplitudes compared to their low PPI-R C group counterparts during the SDO task, but not the CPT task. However, the PPI-R C is more strongly correlated with PCL-R facet 2 (r = .36) than facet 1 (r = .27; Edens, Poythress, Lilienfeld, & Patrick, 2008). My results also contrast with those of Anderson, Stanford, Wan and Young (2011) for a sample of female undergraduate students (*n* = 72) who completed a two-stimulus auditory SDO and visual SDO task. These authors found a positive relationship between P3 amplitudes and total PPI-R scores. It appears that P3 amplitude reductions are more consistently associated with Factor 2 traits on slightly more complex oddball tasks (e.g., CPT, or rotated heads), than standard oddball tasks. However, future within-subject research comparing P3 amplitudes across the most commonly used oddball tasks (i.e., SDO, CPT, three-stimulus oddball) is warranted to clarify discrepancies in the literature.

The reduced P3 amplitude which was associated with the high TriPM Disinhibition group during the CPT, but not the SDO, likely indicates reduced attentional updating processes during the CPT task (Polich, 2007). Although, the standard oddball task is tedious by design due to its simplistic nature, it may also be less difficult to attend to the targets as compared to the CPT which used a greater variety of nontarget stimuli. The reduced amplitude observed in the TriPM Disinhibition group during the CPT task may reflect greater uncertainty in whether a stimulus

was a target or not, (Johnson, as cited by Luck, 2005), which is congruent with the idea that this personality trait is associated with reduced executive function (Sellbom & Verona, 2007).

Interestingly, the behavioral results observed during the two paradigms did not exactly mirror the neurophysiological results. The CPT designed for this study was intended to be a more challenging task compared to the more simplistic SDO task, and I expected that individuals would perform more poorly on the CPT. However, participants performed very well across both tasks (mean accuracy, 97.5% correct; mean false alarms, < 1), but there were significant differences in the number of correct hits across groups. Participants with high PPI-R Total and TriPM Meanness scores were significantly less accurate across both tasks than their counterparts with low scores. Similarly, participants who were high in PPI-R Coldheartedness (a conceptually similar scale to the TriPM Meanness), PPI-R SCI or TriPM Disinhibition (another conceptually similar dyad) also made marginally less correct hits than their counterparts with low scores.

The behavioral results conform to the idea that individuals with higher trait levels of impulsivity and disinhibition may have deficits in executive functioning. For example, Sellbom and Verona (2007) found that in a sample of undergraduate students PPI-II factors were associated with reduced executive cognitive functioning, while the PPI-I factor was found to be related to enhanced performance on the same battery of neuropsychological tests. Significant group differences for TriPM Meanness and marginally significant group differences for PPI-R Coldheartedness were more unexpected. However, in the creation of the TriPM Meanness items, Patrick (2010) drew from the ESI scales of Relational Aggression, Empathy (reversed), Destructive Aggression, Physical Aggression, Excitement Seeking, and Honesty (reversed). Although this scale is typically thought to reflect interpersonal behavior, it also addresses

externalizing qualities. The relationship between hit rate and PPI-R C may be explained by my finding that PPI-R C is correlated with TriPM Meanness.

In contrast, to the behavioral data, I only found psychopathy-related differences in P3 between the TriPM Disinhibition groups (and a marginally significant difference between PPI-R C groups). Moreover, both relationships showed an interaction with Task. As described above, TriPM Disinhibition was related to P3 reductions to targets on the CPT, but those with higher scores on the Coldheartedness scale had smaller P3 amplitudes overall during the SDO task, but not the CPT task. The task-specific reduction in P3 associated with PPI-R C is more in line with my original hypothesis. It is possible that participants who lack empathy are also more susceptible to boredom. Sellbom & Phillips (2013) discovered a moderate correlation (r = .48) between callous-unemotional traits and boredom susceptibility, which may explain the reduced P3 amplitude observed in the high PPI-R C group during the SDO task, but not the more engaging CPT. In contrast to the P3 findings, there were no interactions between task and any group for the behavioral data. The fact that I saw more group differences in behavioral data than in the ERP data, questions the typical assumption that ERPs are a more sensitive indicator of attentional processing than behavior.

Fundamental differences in the underlying traits that the TriPM and PPI-R measure may help to explain why I saw a significant P3 effect between the TriPM Disinhibition groups, but not the PPI-R SCI groups. These two scales are both intended to measure aspects of the impulsive-antisocial factor of the psychopathic personality, and were found to be strongly correlated in the current sample (r = .704), as well as in other studies (Drislane, Patrick, & Arsal, 2014; Sellbom & Phillips, 2013). However, they tap into slightly different behavioral aspects. Subscales which load onto the PPI-R SCI factor include Blame Externalization (the frequent

blaming of others and rationalization of one's own behaviors), Rebellious Nonconformity (flagrant disregard of social norms), Machiavellian Egocentricity (a tendency towards interpersonal manipulation and indifference towards the rights of others), and Carefree Nonplanfulness (impulsivity of actions; Lilienfeld & Andrews, 2005). Because of the diversity of themes addressed in these subfactors, their respective items were inspired from a variety of sources; Christie and Geis' (1970) construct of Machiavellianism, Chapman et al.'s (1984) Impulsive Nonconformity construct, Millon's (1981) construct of "malevolent project", and Eysenck and Eysenck's (1977) construct of "nonplanning" impulsivity.

Conversely, Patrick (2010) developed the TriPM Disinhibition scale based on items taken from the Externalizing Spectrum Inventory (ESI); which measures features of externalizing pathologies in the DSM-IV (American Psychiatric Association, 2000). Items taken from the ESI to contribute to the TriPM Disinhibition scale include: Irresponsibility, Problematic Impulsivity, Boredom Proneness, Theft, Alienation, Impatient Urgency, Fraudulence, Dependability (reversed), and Planful Control (reversed; Patrick, 2010). It would seem that the SCI factor of the PPI-R encapsulates a broader spectrum of impulsive-antisocial personality traits while the TriPM Disinhibition scale measures a more distilled form of externalizing and impulsive behaviors, which is more directly related to the neural attentional processes reflected in the P3 response. Conversely, it is possible that my study was underpowered to replicate the prior finding that PPI-R SCI was related to reduced P3 amplitudes in a much larger (n= 96) undergraduate sample (Carlson et al., 2009).

Although the focus of this thesis was to investigate the relationship between externalizing behaviors in psychopathy and P3 amplitude, it is possible that the relationship that I found (i.e., high TriPM Disinhibition scores were related to reduced amplitude P3s in the CPT task) was

exclusive to features of externalizing, but not the psychopathic personality per se. Indeed, participants in the high and low TriPM Disinhibition groups did not differ statistically in their PPI-R FD, PPI-R C, and TriPM Boldness scores. These scales measure what Harpur et al. (1988) and others (Fowles & Dindo, 2009; Patrick & Bernat, 2009b; Poythress et al., 1998; Poythress et al., 2010) consider to be the some of the "core" traits of the psychopathic personality. Further, Patrick, Fowles, and Krueger (2009) claim that the psychopathic personality only exists when disinhibitory pathology is paired with high levels of boldness or meanness. In other words, high externalization alone is not sufficient to support a diagnosis of psychopathy. Although the participants in the high and low TriPM Disinhibition groups did not differ significantly in their TriPM Boldness scores, participants in the high TriPM group did have significantly higher TriPM Meanness scores than those in the low group. This provides some justification that psychopathic traits were present in the high TriPM group. However, given the high level of heritability associated with externalizing traits (Hicks et al., 2007; Krueger et al., 2002) future research is needed to determine whether it is disinhibition alone or the psychopathic personality more broadly that drives the relationship with the P3.

The association between reduced P3 responses and impulsive-antisocial psychopathic traits found in the present study and in larger undergraduate samples (Carlson et al., 2009) as well as forensic populations (Venables & Patrick, 2014; Venables et al., 2015) provide evidence that this relationship occurs along the continuum of psychopathic severity. These results also offer evidence to support the presence of disparate psychopathic subtypes (see Karpman, 1941, 1948; Lykken, 1995; Skeem, Poythress, Edens, Lilienfeld & Cale, 2003). Overall, it appears that individuals who are differentially higher on impulsive-antisocial (Factor 2) traits of psychopathy, such as irresponsibility, impulsivity, and lifelong antisocial behaviors, have a pattern of

attentional capacities and executive functioning that is distinct from individuals who are high on interpersonal-affective (Factor 1) traits of psychopathy like grandiosity, glibness, and conning manipulation (Hare, 1999).

This distinction would also align with etiological theories of psychopathy such as the Two-Process Theory proposed by Patrick and Bernat (2009b). This theory proposes that there are separate etiologies for the impulsive-antisocial characteristics (Factor 2), which are typically associated with a reduced P3 response, and the affective-interpersonal (Factor 1) traits of psychopathy which are generally not found to be associated with the reduced P3 response (Patrick & Bernat, 2009b; Venables, Hall, Yancey, & Patrick, 2015; Venables & Patrick, 2014). The relationship between a reduced P3 response and numerous externalizing behaviors and psychopathologies has been well documented (Attou et al., 2001; Bernat et al., 2007; Costa et al., 2000; Iacono et al., 2002, Porjesz et al., 1980; Stanford et al., 2007). The P3 family represents the neural correlates of a complex cognitive network in which early attention processes (measured by the frontal P3a) communicates with the more posterior brain areas in the temporal and parietal lobes to update working memory (P3b; Polich, 2007). Not surprisingly, reduced amplitude P3 responses are linked to deficits in executive functioning (Iacono, Malone, & McGue, 2003; Iacono & McGue, 2006; Schoemaker Mulder, Dekovic, & Matthys, 2013). Further, these neuroanatomical circuits are also implicated in cognitive neuroscience explanations of paralimbic system dysfunction in psychopathy; which posit that the orbital frontal cortex, anterior cingulate cortex, amygdala, and anterior superior temporal gyrus are hyporeactive (Blair, 2005; Kiehl, 2006).

Therefore, the reduced P3 associated with higher Factor 2 scores, may provide an important link between psychophysiological deficits and many of the negative outcomes

typically associated with the psychopathic personality. Factor 2 traits have been associated with a number of externalizing and socially undesirable behaviors connected to psychopathy such as conduct disorder, lower educational attainment, adult antisocial behavior, impulsive aggression, suicidal behavior, alcohol dependence, and drug dependence (Benning et al., 2005; Harpur et al., 1989; Hicks & Iacono, 2005; Verona, Patrick, & Joiner, 2001), as well as undesirable interpersonal traits such as hostility, anger, and impulsivity (Edens & McDermott, 2010). In contrast, Factor 1 traits, are typically correlated with more desirable traits, such as high interpersonal dominance, reduced levels of anxiety and superior executive functioning, (Sellbom & Verona, 2007; Verona et al., 2001). There is some evidence that Factor 1 traits, as measured by the PPI/R FD are associated with enhanced P3 responses in undergraduate samples (Carlson & Thái, 2010; Anderson et al., 2011). This would suggest that FD is associated with enhanced attentional processing and may contribute to positive outcomes that have been found in individuals high in these traits (Howe, Falkenbach, & Massey, 2014; Lilienfeld, Latzman, Watts, Smith & Dutton, 2014). It may be that a reduced P3 amplitude represents a psychophysiological marker for externalizing behaviors which can be addressed through improved evidence-based interventions for these populations.

In some ways, the participants with high trait psychopathy in the current study could be perceived of as successful psychopaths, which is possibly why I did not find evidence for an association between total PPI-R and P3 amplitude. Using a community sample, Gao, Raine, and Schug (2011), identified participants with high psychopathic traits using the PCL-R and separated them into “unsuccessful” and “successful” groups based on prior convictions. The P3 was measured during an auditory three-stimulus oddball task. The unsuccessful psychopath

group showed reduced P3 amplitude to targets whereas the P3 response from the successful psychopath group and control group did not differ.

Limitations and Future Research

While the results of this investigation provide insight and support for existing psychophysiological and etiological theories of psychopathy, further studies are needed to provide a more comprehensive understanding of the association. This study was not without limitations. The two tasks in the current study were designed with the intention that the SDO task, which had only one type of distractor would be substantially less difficult than the more complex CPT task, which had ten distractors, some of which had the same basic features as the target. The high behavioral performance across both tasks, as evidenced by high correct hit and low false alarm rates and the lack of a main effect of task on behavioral accuracy, suggests that the CPT was not much more cognitively demanding than the SDO task. If there had been a greater disparity in task difficulty, it is possible that more neurophysiological task differences would have been found.

Additionally, each task designed for the study took approximately eight minutes to complete, and so neither may have been long enough to elicit boredom in a group of high functioning, relatively motivated undergraduate students. Venables and Patrick (2014) found a significant PCL-R Factor 2 by Block interaction, which suggested that the P3 amplitude for individuals with high Factor 2 traits significantly reduced during the latter part of the experiment using a “rotated heads” task. This block-dependent reduction in a forensic sample suggests a lengthier task may be required to accentuate this pattern in an undergraduate sample who may be more accustomed to more cognitively demanding tasks.

Much of the literature on psychopathic traits and their relation to P3 amplitude has been conducted on samples of incarcerated males (Anderson et al., 2015; Kiehl et al., 1999; Kiehl et al., 2006, Venables & Patrick, 2014; Venables et al., 2015) therefore I make comparisons to these studies with caution. The mixed gender undergraduate sample used in the current study provides a step towards providing a more comprehensive view of psychopathy in terms of gender, yet there was not enough power to explore potential gender differences in the current sample. Given gender disparities in SCI scores in undergraduate samples (Falkenbach, Reinhard, & Larson, 2017), future research is needed to address the possibility of psychopathy-related gender differences in the P3 response.

There was also a lack of power in the current sample to explore potential cultural differences in psychopathic expression and P3 amplitude. There is some evidence that European-American samples high in psychopathic traits show increased levels of impulsivity compared to African-American counterparts (Kosson, Smith, & Newman, 1990) as well as African-American and Hispanic comparison samples (Thornquist & Zuckerman, 1995). Impulsivity, which is a core component of the PPI-R SCI (Lilienfeld & Widows, 2005) and TriPM Disinhibition (Patrick, 2010) scales, has also been associated with reduced P3 amplitudes (Chen et al., 2007, Justus et al., 2001). Based on the good demographic representation in the current sample, it is possible that this relationship would be borne out in the P3 response of the ethnic subsamples in the current study. Conversely, if psychopathy is to be considered a universal pathology than the neurocognitive correlates and their presentation should be consistent across ethnic groups (Sullivan & Kosson, 2006). This again draws into question whether the P3 response is a marker of true psychopathy related differences or only externalizing pathologies related to the construct.

Nonetheless, the dearth of cultural exploration in the context of neurophysiological response in the psychopathic personality prohibits conclusions and warrants future research.

Similarly, it would be informative if this within-subject design was applied to forensic populations to determine if a differential P3 is paradigm-specific in samples with much higher levels of psychopathy. Also, the possibility I raised that participants with high trait psychopathy in this study could reflect a "successful" psychopathic sample, a supposition that would be strengthened if I had collected data on aspects of social success such as criminal records or academic achievement. Lastly, while the sample size of this study conformed to traditional neurophysiological research norms, a larger sample may allow for greater variance in psychopathic traits and produce a more robust response and further insight into the relationships between the neurophysiological and behavioral data.

Conclusion

To my knowledge, this study was the first to provide evidence for a paradigm-specific P3 amplitude reduction for individuals with high trait psychopathy, defined here as those with high levels of TriPM Disinhibition and Meanness, but not Boldness characteristics. I found no association between P3 amplitude and overall psychopathy scores on the PPI-R or TriPM measures, but I did identify an interaction with externalizing traits and task. High TriPM Disinhibition scores were related to reduced amplitude P3 waves to the targets in the CPT, but not the SDO, which suggests a psychophysiological deficit during more difficult tasks of attentional capacity. The association between the P3 and TriPM Disinhibition traits, but not the psychopathic personality more broadly, warrants further research to address whether this relationship is relevant to the psychopathy construct itself or only externalizing psychopathology.

These results may guide efforts to resolve discrepancies regarding specific subscale and paradigm relationships in the P3 literature of psychopathy research.

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