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Dysfunctional error-related processing in incarcerated youth with elevated psychopathic traits

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ABSTRACT

Adult psychopathic offenders show an increased propensity towards violence, impulsivity, and recidivism. A subsample of youth with elevated psychopathic traits represent a particularly severe subgroup characterized by extreme behavioral problems and comparable neurocognitive deficits as their adult counterparts, including perseveration deficits. Here, we investigate response-locked event-related potential (ERP) components (the error-related negativity [ERN/Ne] related to early error-monitoring processing and the error-related positivity [Pe] involved in later error-related processing) in a sample of incarcerated juvenile male offenders ($n = 100$) who performed a response inhibition Go/NoGo task. Psychopathic traits were assessed using the Hare Psychopathy Checklist: Youth Version (PCL:YV). The ERN/Ne and Pe were analyzed with classic windowed ERP components and principal component analysis (PCA). Using linear regression analyses, PCL:YV scores were unrelated to the ERN/Ne, but were negatively related to Pe mean amplitude. Specifically, the PCL:YV Facet 4 subscale reflecting antisocial traits emerged as a significant predictor of reduced amplitude of a subcomponent underlying the Pe identified with PCA. This is the first evidence to suggest a negative relationship between adolescent psychopathy scores and Pe mean amplitude.

1. Introduction

Psychopathy is a multifaceted personality disorder characterized by affective, interpersonal, and behavioral dysfunction. Psychopaths have been classically defined by their overall absence of moral emotions and their impulsive, irresponsible lifestyle (Hare, 1991, 2003). About 15–25% of incarcerated offenders meet the diagnostic criteria for psychopathy, with increased prevalence in higher security levels (Hare, 2003). This disconcerting population has often proven impervious to treatment intervention approaches, as highlighted by their increased propensity towards violent recidivism (Hemphill et al., 1998; Rice & Harris, 1997). Researchers have recently attempted to delineate the adolescent manifestation of this condition, as personality traits are still in nascent stages of development. Intervention efforts targeted at youth may have a better chance of altering life-course persistent antisocial behavior if started early (Caldwell, 2011; Caldwell et al., 2007).

Youth scoring high on measures of psychopathic traits exhibit similar neurocognitive deficits as adult psychopathic offenders. For example, youth with elevated psychopathic traits exhibit increased behavioral impulsivity (Roussy & Toupin, 2000), reduced sensitivity to punishment cues (Vitale et al., 2005), and passive avoidance learning (Finger et al., 2008) deficits. Furthermore, using both functional and structural neuroimaging, abnormalities have been observed in youth with elevated psychopathic traits consistent with adult psychopathic offenders as young as fourteen years of age (Cope et al., 2014; Ermer et al., 2013; Harenski et al., 2014; Lockwood et al., 2013; Marsh et al., 2008). Reduced hemodynamic

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activity and reduced gray matter have been found in a number of paralimbic regions, including the orbitofrontal cortex (Cope et al., 2014; Ermer et al., 2013), insula (Lockwood et al., 2013), amygdala (Harenski et al., 2014; Marsh et al., 2008), posterior cingulate cortex (PCC) (Ermer et al., 2013), parahippocampal gyrus (Ermer et al., 2013), and anterior cingulate cortex (ACC) (Cope et al., 2014; Ermer et al., 2013; Marsh et al., 2008).

One additional cognitive deficit juveniles with elevated psychopathic traits may experience is the processing of error-related information. Youth with elevated psychopathic traits often perseverate during behavioral inhibition and experimental learning paradigms, failing to adjust their behavior to meet the demands established by external sources (Budhani & Blair, 2005; Finger et al., 2008; Roussy & Toupin, 2000; Vitale et al., 2005). Event-related potentials (ERPs) are commonly used to examine different components of cognitive control including error-related processing. The two most frequently investigated error-related ERPs are the error-related negativity (the ERN or Ne) and the error-related positivity (Pe). Though closely related temporally, the ERN/Ne and Pe reflect distinct stages of error-related processing. The ERN/Ne reflects initial, automatic error-correction and action-monitoring processes (Falkenstein et al., 1991; Gehring et al., 1993; Yeung & Summerfield, 2012). However, the Pe is involved in later, more elaborative error-processing stages, indexing the accumulation of error-related information (Yeung & Summerfield, 2012), including the motivational (Ullsperger et al., 2010) or affective (Overbeek et al., 2005) appraisal of such stimuli. Additionally, the ERN/Ne is said to arise within the cognitive, caudal division of the ACC (cACC), whereas both the caudal and rostral portions (rACC) of the ACC contribute to Pe amplitude (Edwards et al., 2012; van Veen & Carter, 2002). However, recent evidence suggests that the ERN/Ne may be generated by the PCC (Agam et al., 2011), whereas the insula may additionally contribute to the Pe (Schroder et al., 2012; Ullsperger et al., 2010).

In adult psychopathic offenders, several studies have found comparable ERN/Ne amplitudes between adult psychopaths and control groups when using affectively neutral stimuli (Brazil et al., 2009; Brazil et al., 2011; Maurer et al., in press; Munro et al., 2007; Steele et al., 2016; von Borries et al., 2010). However, reduced ERN/Ne amplitude has been observed in adult psychopathic offenders when incorporating evocative angry and fearful facial stimuli (Munro et al., 2007).

Compared to the ERN/Ne, disparate findings have been observed regarding Pe amplitude in adult psychopathic offenders. Two previous reports with adult males and females have associated reduced Pe amplitude with increased psychopathy scores (Brazil et al., 2009; Maurer et al., in press). However, a recent report associated increased Pe amplitude with higher psychopathy scores in an incarcerated male sample (Steele et al., 2016). Intact ERN/Ne and deficits in Pe amplitude in adult offenders with elevated psychopathic traits suggests that this population can detect that an error has occurred, but exhibit specific dysfunction in regards to post-error processing. Reduced Pe amplitude in adult psychopathic offenders suggests a specific deficit in using information received from errors to improve future behavior (Brazil et al., 2009; Maurer et al., in press), which may partly explain this population's increased propensity towards perseveration in experimental learning paradigms (Newman & Kosson, 1986). Importantly, the Pe component has been shown to be malleable, increasing in amplitude through mindfulness meditation intervention (Larson et al., 2013). Thus, the present study sought to examine whether adolescent psychopathy scores were associated with reduced Pe amplitude. If hypotheses are confirmed, the Pe may be a target for future interventions, such as mindfulness, to help ameliorate dysfunctional post-error processing.

Despite interest in the electrophysiological correlates of adult psychopathic offenders, such processes have never been investigated in youth with elevated psychopathic traits. Here, we address this issue by reporting on error-related electrophysiological indices using ERPs and a response inhibition Go/NoGo paradigm in a sample of incarcerated male adolescents. Psychopathic traits were assessed using the Hare Psychopathy Checklist: Youth Version (PCL:YV) (Forth et al., 2003), a downward extension of the Hare Psychopathy Checklist–Revised (PCL-R) (Hare, 2003) modified for age appropriateness.

Based on previous error-related ERP studies performed with adult psychopathic offenders (Brazil et al., 2009; Brazil et al., 2011; Maurer et al., in press; Munro et al., 2007; Steele et al., 2016; von Borries et al., 2010), we hypothesized adolescent psychopathy scores would be unrelated to early, action-monitoring processes, as indexed by intact ERN/Ne amplitude. In addition, we hypothesized adolescent psychopathy scores would be negatively related to Pe amplitude, consistent with previous studies with adult psychopathic offenders (Brazil et al., 2009; Maurer et al., in press), but contrary to a recent report with adult psychopathic male offenders (Steele et al., 2016). An increased Pe amplitude observed with adult psychopathic male offenders may result from a compensatory mechanism, attempting to overcome initial post-error processing deficits experienced as adolescents. In addition to the use of traditional time-domain ERP analyses, we incorporated an approach based on principal component analysis (PCA), which provides a robust decomposition of overlapping variance both between and within ERP components (Bernat et al., 2011; Dien et al., 2007). This approach has been incorporated in a number of reports (Anderson et al., 2015; Maurer et al., in press; Steele et al., 2015; Steele et al., 2014; Steele et al., 2016), providing a more sensitive and predictive measure compared to traditional time-domain ERP analyses. In the current report, four principal components were extracted, one reflecting mean ERN/Ne amplitude, and the remaining three reflecting early, middle, and late subcomponents underlying the Pe (see Fig. 1). The three separate subcomponents underlying the Pe appear to reflect unique patterns of cognitive processing and hemodynamic activity in subregions of the ACC (Edwards et al., 2012). In particular, the early Pe subcomponent has been previously associated with both cACC and rACC activity, the middle Pe subcomponent has been associated with cACC activity, and the late Pe subcomponent has been associated with rACC activity (Edwards et al., 2012). In regards to PCA analyses, we hypothesized adolescent psychopathy scores would be negatively related to a middle subcomponent underlying the Pe, which has been shown to be dysfunctional in previous reports (Maurer et al., in press; Steele et al., 2016).

2. Method

2.1. Participants

Participants were 142 incarcerated adolescents at a maximum-security juvenile detention center who participated in a larger study (Southwest Advanced Neuroimaging Cohort–Youth (SWANC-Y)). The sample was predominantly right-handed (7% reported being left-hand dominant). Participants were predominantly Hispanic/Latino (76%), with the remaining self-identifying as Black/African American (12%), White (10%), or more than one category (2%).

Incarcerated adolescents are considered a vulnerable population for research, so extra precautions were taken in order to minimize the potential for coercive influences that could reduce their ability to provide voluntary consent to participate (Edens et al., 2011; Gostin et al., 2007). For example, potential study participants may feel inclined to participate in research in order to relieve boredom and interact with people from outside the prisons (Edens et al., 2011). With the issue of coercion in mind, we did our best