SELF-REFERENTIAL PROCESSING AND PSYCHOPATHIC TRAITS IN INCARCERATED ADOLESCENTS

by

ANDREW P. BONTEMPS

RANDALL T. SALEKIN, COMMITTEE CHAIR
THEODORE S. TOMENY
RICK A. HOUSER

A THESIS

Submitted in partial fulfillment of the requirements
for the degree of Master of Arts
in the Department of Psychology
in the Graduate School of
The University of Alabama

TUSCALOOSA, ALABAMA

2019

ABSTRACT

Psychopathy is a pattern of traits that can be categorized by three general subdomains: grandiose-manipulative, callous-unemotional, and daring-impulsive. These traits are especially prevalent in incarcerated youth and correlate with antisocial behavior and criminal recidivism, thus posing a large societal cost. Recent EEG research has shown that an area of the brain known as the default mode network (DMN) has been associated with self-referential processing, essentially showing greater activation when people recognize traits that are true of themselves. Generally, this activation of the DMN has been associated with alpha band power in frontal cortical regions. The current study investigated the DMN through both EEG recording of alpha activity and source localization analyses (sLORETA) to determine whether incarcerated youth showed differential DMN activation while completing a measure of psychopathy and a measure of general personality characteristics. It was hypothesized that incarcerated youth with greater levels of psychopathic traits would show greater DMN activation while completing a measure of psychopathic traits compared to general personality. While measures of alpha wave activity did not support the general hypotheses, the sLORETA did reveal approach-motivated activation patterns during completion of the measure of psychopathic traits, and inhibition of DMN structures during the measure of general personality. The social implications of these findings are discussed, and areas of future research are identified both in terms of future EEG studies and treatment.

LIST OF ABBREVIATIONS AND SYMBOLS

APD	Antisocial Personality Disorder
CD	Conduct Disorder
CU	Callous-Unemotional
DI	Daring-Impulsive
DMN	Default Mode Network
EEG	Electroencephalogram
F	F-ratio (measure of variance)
FFM	Five Factor Model of personality
FFT	Fast Fourier Transformation
GM	Grandiose-Manipulative
IASR-B5	Interpersonal Adjectives Scale Revised for Big 5
LPE	Limited Prosocial Emotions
M	Mean
N	Sample size
p	Probability (p-value)
PCL-R	Psychopathy Checklist – Revised
PSCD	Proposed Specifiers for Conduct Disorder

r	Pearson product moment correlation
R^2	Coefficient of determination (percent of variance explained)
SD	Standard Deviation
sLORETA	Standardized Low Resolution Brain Electromagnetic Tomography

ACKNOWLEDGEMENTS

I would like to express my deepest appreciation to my committee and especially my advisor, Randy Salekin, for his support in developing and bringing this project to fruition. I am also extremely grateful to my lab-mates, Blair Batky, and Betty Mendez for their tireless efforts in recruitment and data collection. A big thanks to my lab-mate emeritus, Abby Clark, for all of her help with sLORETA analyses. Thanks also to my parents, Doug and Stephanie, for their support of my journey through graduate school and my undergraduate advisor Yueping Zhang for encouraging my interest in EEG research. Finally, I would also like to express my deepest gratitude and adoration for my editor and partner, Alena Borgatti, whose patience with me and my writing knows no bounds.

CONTENTS

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

Hervey Cleckley introduced a modern definition of psychopathy in 1941 in his seminal work "The Mask of Sanity." The original volume contained information gathered from a sample of men in a closed hospital setting who displayed behavior that was inherently disordered, but inconsistent enough with contemporary diagnoses that they were frequently released after only a short stay at the hospital. Cleckley described the key traits of psychopathy as arrogance and superficial charm; he emphasized the low levels of guilt and empathy, high levels of reckless irresponsibility, and overall antisocial tendencies (Cleckley, 1941/1964). After the initial conceptualization, Cleckley offered updates to his work as he encountered a wider variety of people with psychopathic traits, but few in the psychological community examined the broad spectrum of psychopathic behavior and personality traits for many years. In 1980, a new method of quantifying psychopathic traits became available with the publication and popularization of Hare's Psychopathy Checklist (PCL) and subsequent revision (PCL-R) in 1991 used to measure psychopathic traits in adult, criminal populations (Hare, 1980; Hare 1991).

Factor analyses of the PCL and PCL-R initially indicated that the spectrum of responses was best described by loading them onto a two-factor solution (Harpur, Hare, & Hakistan 1989). Factor 1 of the PCL, known as the Interpersonal/Affective factor, correlates largely with the Cleckley criteria of pathologic egocentricity and incapacity for love, lack of remorse or shame, general poverty in major affective reactions, untruthfulness and insincerity, superficial charm and good intelligence, unresponsiveness in general interpersonal relations, and impersonal, trivial, and poorly integrated sex life (Harpur, et al., 1989). Factor 2, assessing Socially Deviant

Lifestyle, was most closely correlated with failure to follow any life plan, general poverty in major affective reactions, inadequately motivated antisocial behavior, unreliability, poor judgement, and failure to learn from experience (Harpur, et al., 1989). Over time, however, a four-factor model emerged, splitting the original two factors into facets that were associated with disturbances in interpersonal, affective, lifestyle, and antisocial behavior domains (Hare & Neumann, 2005).

In 2003, Hare and colleagues released a version of the PCL designed to be used with an adolescent offender population (the Psychopathy Checklist: Youth Version or PCL: YV; Neumann, Kosson, Forth, & Hare, 2006) which led to substantial research into how psychopathy develops from childhood (e.g., Neumann, Kosson, Forth, & Hare 2006; Jones, Cauffman, Miller, & Mulvey 2009; Kosson, et al., 2013; Hawes, Mulvey, Schubert, & Pardini 2014). Like the PCL, research into the PCL: YV demonstrated that both a three- and four-factor solution best describe its latent constructs (Neumann, et al., 2006; Kosson, et al., 2013). The similarities between the three- and four-factor solutions of the PCL: YV are striking. The three-factor model as put forth by Cooke and Michie (2001) for use with the PCL-R suggests the subfactors of Arrogant, Deceptive Interpersonal style (e.g. grandiose sense of self-worth and pathological lying), Deficient Affective Experience (e.g. lack of remorse and shallow affect), and Impulsive, Irresponsible Behavior (e.g. stimulation seeking and impulsivity). Likewise, the four-factor model put forth by Hare and Neumann (2005) includes a factor for Interpersonal (grandiose sense of self-worth and pathological lying), Affective (lack of remorse and shallow affect), Lifestyle (stimulation seeking an impulsivity), and Antisocial (poor anger control and juvenile delinquency). Similarly, factor analyses of another well-validated measure of psychopathic traits, the Psychopathic Personality Inventory, revealed a two- and three-factor solution including fearless-dominance, self-centered impulsivity, and cold-heartedness (Neumann, Malterer & Newman, 2008). Thus, psychopathy is generally conceptualized as personality traits that fall within three general categories: Grandiose-manipulative (i.e. fearless-dominance/Arrogant, Deceptive Interpersonal Style/Interpersonal), Callous-unemotional (i.e. Cold-heartedness/Deficient Affective Experience/Affective) and Daring-impulsive (i.e. Self-centered impulsivity/Impulsive, irresponsible behavior/Lifestyle).

In the time period surrounding the development of the PCL: YV, psychologists began to study psychopathic traits in children and its pathway of development from aggressive behaviors leading to Conduct Disorder (CD) in children to psychopathy and Antisocial Personality Disorder (APD) in adults (Loeber, Burke & Lahey, 2002; Schaeffer, Petras, Ialongo, Pduska, & Kellam, 2003). It was discovered that a subset of children who developed antisocial behavior patterns particularly early in childhood showed substantially worse outcomes later in life (Moffitt, Caspi, Harringon, & Milne, 2002). Other researchers also found that if taken into consideration, callous-unemotional traits (CU traits) provided more predictive power in determining which children might need more preventative care to avoid worse adult outcomes (e.g. Barry, et al., 2000).

In 2013, the Diagnostic and Statistical Manual 5th edition (DSM—5) offered an update to the criteria of the childhood diagnosis of Conduct Disorder (American Psychiatric Association, 2013). To meet criteria for diagnosis of CD, a child must show "a repetitive and persistent pattern of behavior in which the basic rights of others or major age-appropriate societal norms or rules are violated…" and must show this pattern of behavior by expressing three of 15 criteria over a 12-month period and one of the 15 criteria in the past six months. These criteria currently include: aggression toward people and animals, destruction of property, deceitfulness or theft, and serious violations of rules (e.g. often initiates physical fights, has deliberately destroyed others' property, often lies to obtain goods, and truancy from school, respectively) (American Psychiatric Association, 2013). While this allows for a greater number of behaviors that can be labeled as CD and thus allows for more children to be treated, it can also lead to difficulty in treatment due to the overall heterogeneity of the diagnosis.

In order to help reduce the apparent heterogeneity within the diagnosis of CD, provide clinicians with criteria to evaluate the child's underlying personality traits, and allow clinicians the ability to better care for children that may need more attention, the DSM – 5 added the "limited prosocial emotions" (LPE) specifier (American Psychiatric Association, 2013). To qualify for the specifier, in addition to meeting the criteria for CD, a child must also display a pattern of behavior that includes a lack of remorse or guilt, lack of empathy, shallow or deficient affect, and lack of concern about performance (American Psychiatric Association, 2013). The validity of two of the four qualifications for the LPE specifier ("shallow affect" and "unconcerned about performance") have already been questioned by Lahey (2014). However, the remaining qualifications for the LPE specifier may reduce the overall heterogeneity of the diagnosis by allowing for subclassification somewhat akin to the different presentations of the Attention-Deficit/Hyperactivity Disorder diagnosis (American Psychiatric Association, 2013). However, when compared to the original model provided by Cleckley (1941/1964) that was then further reinforced by Hare and Neumann (2008), it is apparent that many of the key components of psychopathy may still be lacking from the current CD diagnosis (Salekin, 2016). Thus, if the goal of adding the LPE specifier was to reduce heterogeneity of the CD diagnosis rather than just classify severe cases of CD which has also been questioned in terms of the LPE alone, there is a case to be made for including specifiers that more completely represent the three or four factor models of psychopathy.

As noted by Salekin (2016), it is essential to divide the general traits of psychopathy into three categories rather than keep psychopathy under one overarching syndrome. The first category, Grandiose-Manipulative (GM) traits target the glib, superficial charm often characterized in psychopathy. The second category, Callous-Unemotional (CU), is most akin to the LPE specifier adopted by the DSM – 5 CD diagnosis. The CU traits primarily parallel the affective characteristics of psychopathy including a lack of remorse and empathy. Third, the Daring-Impulsive (DI) traits concern the bold and impulsive actions frequently viewed in psychopathic individuals (Hawes, et al., 2014). Of the three factors, CU traits have been considered to be the most studied because they are often thought to indicate a "core" dimension of psychopathy (e.g. Frick, Ray, Thornton, & Kahn, 2014). However, it has been questioned whether the use of CU traits alone when diagnosing or specifying CD is enough to forego the use of the other latent variables of the psychopathy construct (i.e. GM and DI traits) (Salekin, Andershed, Batky, & Bontemps, 2018; Salekin, Andershed, & Clark, 2018). When the clinician makes their decision under the current model, they make it without all of the pertinent information, potentially missing behavior that may direct the course of the child's treatment (Salekin, et al., 2018).

Electroencephalogram and Self-Referential Thinking

Raichele and colleagues (2001) suggested that the brain has a "default mode network" (DMN) that spans the precuneus/posterior cingulate cortex, the medial prefrontal cortex, and medial, lateral, and inferior parietal cortex that shows a consistent pattern of deactivation when the brain engages in goal-oriented behavior. In other words, studies have found that the brain has an idle, at-rest circuit that is active when an individual is at rest and shows reduced activation when an individual engages in some cognitively demanding activity (Raichele, et al., 2001). However, a notable exception to this rule of reduced activation within the DMN appears when the individual is completing autobiographical or self-referential tasks, suggesting that the network may be a central component for self-referential processing within the brain (Knyazev, 2013). Since electroencephalography (EEG) cannot directly measure the activation of subcortical structures, the technique was not utilized for measuring DMN activation until recently. In 2013, Knyazev summarized a large number of studies that have examined the combination of EEG oscillations combined with the blood-oxygen-level dependent (BOLD) signal from functional magnetic resonance imaging (fMRI). This review provided evidence that alpha frequency waves are typically the most commonly correlated with the DMN and that there may be a specific alpha-band network that is directly associated with a self-referential train of thought (Knyazev, 2013).

Lending credence to the conclusions of Knyazev's review paper, Esslen and colleagues (2008) conducted a study using low-resolution brain electromagnetic tomography (LORETA), a technique that estimates the source of EEG activity, to map activation of subcortical structures while individuals participated in a self- or other-referential task. During the task, participants were shown three-word sentences, one word at a time including a pronoun (e.g. "I" or "He/she"), a corresponding verb (e.g., "am", "are"), and then an adjective (e.g. "beautiful", "stupid"). The participants would then rate whether they thought the adjective applied to themselves or to a predetermined other person (i.e. a close friend or relative). The authors found greater activation in the dorsomedial prefrontal cortex, the medial frontal gyri on the right frontal lobe and underlying insula, and the left medial temporal gyrus for sentences that used a first-person sentence ("I am") compared to sentences that use a third person sentence ("he/she is") (Esslen, et al., 2008). This activation of structures that make up part of the DMN suggest that in normal healthy participants, medial-frontal activation is associated more with self-referential thinking (Esslen, et al., 2008). To quote directly, "Activation of the [medial prefrontal cortex] seems to be essential for self-referential processing" (Esslen, et al., 2008). Lending further evidence to the function of the DMN, a lesion study conducted by Philippi and colleagues (2012) found that damage to the medial prefrontal cortex eliminates a self-referential memory advantage, suggesting that the medial prefrontal cortex is crucial for self-reference.

In addition, Mu and Han (2010), using a sample of healthy adults, demonstrated that rating oneself on a series of adjectives compared to rating the font of the text was correlated with greater desynchrony of alpha waves over frontal-central areas of the scalp (i.e. alpha waves that are out of phase when compared with one another leading to lower overall alpha power). They also found that adjective self-ratings compared to ratings of another person showed greater alpha synchrony over the central regions. Finally, they found a task x valence interaction that revealed greater alpha synchrony (i.e. greater power) over parietal sites for negative adjectives relative to positive adjectives during self-judgement. The authors state that greater alpha band synchrony is linked to a state of cortical inhibition which may help to establish highly selective activation (i.e. greater concentration on the self and inhibiting attention to outside stimuli) (Mu & Han, 2010). Combined with the frontocentral location of the alpha waves that they studied, the alpha desynchrony suggests lower levels of inhibition for the frontocentral brain region and gives evidence to the idea that greater levels of alpha over the brain areas involved in the DMN indicate DMN self-referential activation in non-psychopathic individuals (Mu & Han, 2010).

A pilot study conducted by Keune, Mayer, Jusyte, and Schonenberg (2017) revealed that during a resting state, adult offenders who were higher in CU traits showed a pattern of alpha-wave asymmetry in the frontal lobe. Specifically, the researchers had hypothesized that they would find greater levels of alpha activity over the left hemisphere, consistent with approach motivated behavior (e.g. Coan & Allen, 2003; Matthewson, et al., 2011); instead, they found the opposite, which is more consistent with withdrawal-motivated behavior. This pattern of alpha activity held for a global measure of CU traits (as measured by the Inventory of Callous-Unemotional traits) and callousness and uncaring subscales which have been previously associated with conduct disorder symptoms, aggression, and antisocial behavior. The authors speculate that the pattern of withdrawal-related alpha waves may be related to CU traits insofar as individuals with CU traits are typically not characterized as being impulsive, but rather may inhibit impulses and plan their actions (Keune, et al., 2017). However, as Keune and colleagues (2017) chose to only assess psychopathic traits using CU traits, this relationship may not extend to adults who are higher in GM or DI traits.

Additionally, Collins and Persinger (2014) used LORETA imaging techniques to assess DMN structures in a community sample rated high or low in "egocentricity" (as measured by the Personal Philosophy Inventory). They found that individuals who scored higher in "egocentricity" showed greater levels of activation in the DMN compared to reference structures during a period of mind-wandering. The items that measured "egocentricity" in their study (e.g. "I like to spend time persuading people to do things" and "I sincerely believe that I am very special") are theoretically similar to those items used to assess grandiose-manipulative psychopathic traits (e.g. "You use or 'con' other people to get what you want") (Collins & Persinger, 2014). Because of the similarities between the questions asked, it is plausible that psychopaths higher in GM traits would show a similar level of resting-state activity in the DMN to controls and more alpha activity compared with other psychopathy subgroups.

Finally, a recent study by Calzada-Reyes and colleagues (2013) sought to explore EEG spectrum differences between violent offenders with various scores on the PCL-R during a resting state EEG analysis. They found that decreased alpha energy was associated with psychopaths when compared to non-psychopath controls (Calzada-Reyes, et al., 2013). Thus, it may be that those individuals higher in psychopathic traits seem to show lower levels of alpha activation typically associated with the DMN, and thus seem to be lower in self-referential ability than non-psychopathic controls. Due to the use of repeated t-tests and likelihood of inflated Type-I errors, these findings require more rigorous replication.

The Current Study

To better understand how adolescents with and without psychopathic traits view themselves, the current study aimed to compare and analyze brain activation of the DMN, an area specifically related to self-referential behavior, between adolescents who have varying levels of psychopathic traits. Throughout testing, participants wore a 19-channel EEG cap recording brain activity. While being recorded, the adolescents completed a fully computerized version of the Proposed Specifiers for Conduct Disorder (PSCD), a short measure used for studying psychopathic traits which will allow for the division of the sample into groups based on the three-factor model of psychopathy (i.e. Grandiose-manipulative, Callous-unemotional, and Daring-impulsive) (Salekin & Hare, 2016). The adolescents also completed a computerized version of the full IASR-B5. The adjectives from the measure were displayed on screen with their provided definitions. While completing both measures, the participants were asked to think about each adjective for five seconds and then respond with their rating during another five second window, which provided more than ample time for capture of alpha frequencies (Esslen, et al., 2008; Mu & Han, 2010). As they thought about the adjectives, the DMN was hypothesized to activate further, indicating that the adolescent was self-referencing to a greater extent and that the adjective applied to them to a greater degree, or may stay at a neutral baseline indicating a lack of self-referential thought and that the adjective did not apply to them as much. Psychopathy total scores as well as dimension scores were compared to the data generated from EEG (i.e. alpha band power and sLORETA).

Hypotheses

As the DMN is typically involved in processes regarding the individual and their relationship to others, adolescents higher in psychopathic traits were hypothesized to show greater levels of alpha frequency oscillations while completing the IASR-B5 items related to psychopathy and the PSCD compared to the adolescents lower in psychopathic traits. Second, using an sLORETA analysis, it was expected that there would be increased alpha power originating in areas specifically associated with the DMN (i.e. the medial-frontal regions of the brain) when completing the PSCD compared to the IASR, demonstrating greater identification with psychopathic traits. It was further hypothesized that increased alpha would be observed in the dorsomedial prefrontal cortex, the medial prefrontal cortex, the right area of the frontal lobe, and the medial parietal lobe mirroring the results found by Keune and colleagues (2017). Finally, an exploratory analysis was conducted to evaluate alpha strength for each of the three psychopathic trait categories (i.e. GM, CU, and DI traits for the PSCD and Arrogant Calculating, Deceitful Manipulation, and Callous Cruelty for the IASR-B5_psychopathy). As a form of convergent and discriminant validity, alpha (de)synchrony was compared across psychopathic trait groups to the octants of the IASR-B5. Specifically, for adolescents who fell within the cold-quarrelsome and arrogant-calculating octants, those higher in psychopathic traits generally compared to those lower in psychopathic traits were expected to show higher levels of alpha synchrony. Lower levels of alpha synchrony (i.e. higher levels of alpha desynchrony) were expected for those adolescents who are higher in psychopathic traits generally, and who fall within the warm-agreeable, unassuming ingenuous, and unassured submissive octants, indicating good identification with their own personality traits. Within psychopathic type groups, it was hypothesized that adolescents highest in GM traits would show the greatest levels of alpha convergence, and adolescents higher in CU traits would show the poorest level of alpha convergence. Adolescents higher in DI traits were expected to show moderate levels of alpha convergence indicating a reasonable self-awareness of their risk-taking behavior.

METHOD

Participants

Participants consisted of 26 male juvenile offenders recruited from a juvenile detention center located in the Southeastern United States. Participants had an average age of 15.84 (*SD* = 1.38). The sample was ethnically diverse with seven European-American (White) participants (23.3%), sixteen African or Caribbean-American (Black) participants (53.3%) and three participants (10%) indicating their ethnicity as Latin-American or other. Four participants (13.3%) preferred not to answer. Participants were recruited during visitation hours when a parent was available to give informed consent for the adolescent to participate in the study. At a separate time, usually within a week of the original parental consent, the adolescent completed the rest of the testing procedure (i.e. a computerized version of the IASR-B5 and PSCD). The adolescent was brought to a quiet, monitored room within the detention center and given the opportunity to give their assent to participate.

Measures

Proposed Specifiers for Conduct Disorder (PSCD; Salekin & Hare, 2016). The PSCD is a 24-item scale that provides a total psychopathy index and conduct disorder traits. Items are rated on a three-point Likert scale ranging from “Not True” to “Totally True.” In addition to providing a total score, the items also load onto four factors: Grandiose-Manipulative, Callous-Unemotional, Daring-Impulsive, and Conduct Disorder traits. Initial, yet unpublished, confirmatory factor analyses using a sample of about 1000 youth in a Chinese sample and a separate sample of over

2,500 youth from Spain show promising results in terms of reliability, factor structure, and validity.

Interpersonal Adjectives Scale Revised for Big 5 (IASR-B5). The IASR-B5 is a 124 item self-report measure of personality used to assess the personality traits of the five-factor model (FFM) of personality: Agreeableness, Extraversion, Conscientiousness, Neuroticism, and Openness to Experience. The original Interpersonal Adjective Scale (IAS) was developed in the 1970s as a lexical personality inventory which conceptualized personality as interpersonal interactions with eight octants of personality traits: Assured-Dominant, Arrogant-Calculating, Cold-Hearted, Aloof-Introverted, Unassured-Submissive, Unassuming-Ingenious, Warm-Agreeable, and Gregarious-Extraverted (Wiggins, 1996). The IAS originally had two factors, Dominance and Nurturance, which were found to be highly correlated with the FFM traits Extraversion and Agreeableness, respectively (McCrae & Costa, 1989). A revised version of the original IAS added 60 items to assess the remaining FFM personality traits of Openness to Experience, Conscientiousness, and Neuroticism. The full version of the IASR-B5 takes approximately 20 minutes to complete (Wiggins & Trobst, 2002). The scale shows strong support for a two-dimensional solution mapping onto the Dominance and Nurturance (Extraversion and Agreeableness on the IASR-B5) and strong internal consistency (Wiggins, Trapnell, & Philips, 1988). The IASR-B5 also shows strong convergent validity with the NEO personality inventory—revised, the gold-standard for measuring FFM traits (Wiggins & Trobst, 2002). Additionally, the IASR psychopathy scale developed by Salekin and colleagues (2010) will be calculated using its total score and three subscales: Arrogant superiority, Deceitful manipulation, and Callous cruelty (for details on calculating the total and subscales, see Salekin, et al., 2010).

Computer Tasks

All measures were administered via laptop computer in conjunction with the EEG collection software and was coded in the E-Prime 3.0 software (Psychology Software Tools, Pittsburgh, PA). Throughout the recording procedure, all participants were asked to remain as still as possible to reduce the number of myogenic artifacts in the EEG data. During the main portion of the study, participants completed a computerized version of the IASR-B5 and the PSCD. The measures were not counterbalanced, and participants were always administered the IASR-B5 first followed by the PSCD. Instructions for the measures were both displayed on the screen and read aloud by the researcher. Throughout testing, the researcher was available to answer any questions that the participants had about the testing procedure. For the computerized IASR-B5, participants were presented with an adjective from the list of IASR-B5 adjectives, and its definition from the IASR-B5 glossary. In total they saw each adjective for ten seconds which was broken up into a five second reflection period and a five second response period after which the computer would automatically show them the next adjective. During the reflection period, the participants were shown the word and its definition from the IASR-B5 glossary and asked to reflect on whether the word described them as a person. During the response period, participants were presented with an 8-point Likert scale at the bottom of the screen ranging from 1- extremely inaccurate to 8 – extremely accurate and were given five seconds to press the key (from 1 to 8) that corresponded to how well they think the adjective describes them. After the response period, the computer displayed the next word from the IASR-B5.

Likewise, the PSCD was administered via computer, and responses were directly entered in E-Prime. Participants viewed each item for ten seconds total, broken up into a five second reflection period and a five second response period. During the reflection period, the participant viewed the item and were asked to think about whether it was true of them. Then, during a five second response period, the participant was asked to respond whether the item related to their behavior was “Not True,” “Somewhat True,” or “True.” After the five second response period, the computer automatically displayed the next item.

EEG Procedure

The EEG was completed with a 19-channel electrode cap. The electrodes in the cap were positioned to be evenly distributed using the international 10-20 system using the right earlobe as a ground and a single-ended electrode near the Cz position as the reference point. Impedance for all electrodes was kept below 10 kOhm during the entire recording session in accordance with the standard set by Ferree and colleagues (2001). All EEG signals were recorded through the Mistar EEG-201BT system. The amplifier recorded using 4 poly channels with a sampling rate of 2000 Hz and a 250 Hz storage rate, recording channels directly to a computer hard drive using the EEGStudio acquisition software.

The electrode cap was placed on subjects’ heads after their heads were brushed with a stiff brush to remove excess skin and oil. During the cap fitting, research assistants discussed the importance of remaining still and quiet during testing procedures (as muscle movements could impact data quality) and answered any questions participants had. EEG recordings occurred in a quiet, climate-controlled room with the experimenter and recording equipment present. No cell phones were permitted into the detention center, so no specific precautions were taken to reduce potential cellphone interference with EEG recordings. All subjects were instructed to relax and to avoid excessive blinking during testing to minimize artifacts produced by ocular movements. During the recordings, all participants were observed to be awake with their eyes open, seated upright.

Before the testing trials commenced, participants completed two resting-state trials. During the two three-minute resting state trials (one eyes open, one eyes closed), the researcher visually scanned the EEG data, prompting the participant to remain still if needed, to wake up if they fall asleep during any of the eyes closed resting state, and fixed any noticeable problems with electrodes (e.g. bad channels, higher-than-acceptable impedance, etc.). During the main trials, the researcher redirected the participant if they became distracted and were available to answer questions about the item definitions.

Data Analysis

EEG processing. Any participants with missing EEG data were not included in the analysis (missing data includes data lost due to equipment malfunction, problems transferring data, problems with participant completion of tasks, etc.). The original sample included 27 participants, and one was excluded from the final analysis due to missing EEG data. Alpha signal processing was conducted with BrainVision Analyzer 2.1 (BrainProducts GmbH, Munich, Germany). Data were re-referenced to Cz and band-passed filtered between .01 and 100 Hz with 12dB roll-offs with a 60Hz notch employing a zero-phase shift Butterworth filter. Eye blinks were reduced using the ICA-based ocular artifact rejection function within the BrianVision analyzer software (Fp1 served as the VEOG channel; BrainProducts, 2013). The function examines the data for an ocular artifact template in the Fp1 channel and finds ICA-derived components that account for a user-specified (50%) amount of variance in the template-matched portion of the signal from Fp1. The components were then removed from the EEG signal which was reconstructed for further processing. Data was then segmented into twenty 500ms epochs coinciding with each question asked in both the IASR-B5 and PSCD. Using an automated artifact rejection program, segments were removed when there was more than a 100 µV change in a moving 200ms time window. Less than 5% of data was rejected for each participant. A fast Fourier transformation (FFT) was employed using 0.244-Hz bins and a Hamming window (50% taper). Spectral power was then averaged across the alpha frequency bandwidth (8-13Hz) for the frontal electrode sites (F3, F4, Fz, F7, and F8). Absolute Alpha power at each of the electrodes was natural log transformed to approximate a normal distribution. Alpha was compared across hemispheres and across homologous electrode sites (i.e. F3 to F4, and F7 to F8) to investigate Alpha synchrony.

sLORETA Analysis. sLORETA uses a standardized current density to estimate intracerebral generation of cortical activity (Collins & Persinger, 2014). In other words, when analyzing the electrical signals obtained from the scalp, the sLORETA program standardizes the density of the obtained signal and uses that to estimate the original source of the electrical current from within the cortex. For the sLORETA analysis, EEG data was first pre-processed using the EEGLab plugin for Matlab (Delorme & Makeig, 2004). Data was rereferenced to Cz, and band-passed filtered between .01 and 100 Hz with a 60 Hz notch filter. Individual Component Analysis (ICA) was used to identify and remove eye blink and saccade patterns from the data. Afterward, the data was examined, and artifacts were removed by hand. Data was then saved and sLORETA analysis was performed using Brainstorm (Tadel et al. 2011), which is a Matlab plugin that is documented and freely available for download online under the GNU general public license. Data was averaged across all participants and subjected to an FFT for each measure to form a composite of alpha activity for each measure. It was then subjected to the sLORETA procedure using the OpenMEEG BEM model (Kybic, et al., 2005; Gramfort, Papadoupoulo, Olivi, & Clerc 2010). The data were then subjected to a permutational t-test to determine areas of the brain that show significantly different alpha response between the IASR-B5 and PSCD.

General Data Analysis. Descriptive statistics were calculated for both the PSCD and IASR-B5 measures and their subscales. The measures were graphed and checked visually for skew and the dataset was analyzed for excess kurtosis using an adjusted version of Pearson's kurtosis (i.e. kurtosis minus 3). It was expected that the PSCD would be skewed left but would be relatively normally distributed. The means for the PSCD, scores were expected to be generally higher than a community sample, on which the PSCD has been normed to date, due to the fact that incarcerated populations generally have higher scores on measures of psychopathy. The means for the various subscales for the IASR-B5 were expected to be generally normally distributed. Due to the five second response window, some data was lost due to participants not responding quickly enough. For each item of the IASR-B5, on average 3.47 observations were missing across all participants though no individual was missing more than 8% of their data. Additionally, for each item of the PSCD self-report, on average 2.83 observations were missing across all participants. Missing data from both the IASR-B5 and PSCD were imputed of five iterations of the multiple imputation package from SPSS which included all items from the IASR-B5 and PSCD (respectively) (IBM Corp, 2017). All imputation models were averaged, and analyses were run from the concluding data set.

A correlation matrix was formed comparing psychopathy total score and its subtypes with IASR-B5 components and EEG alpha wave power at frontal sites. Based on previous research, it was expected that the psychopathy total score from the PSCD would be unrelated to IASR-B5 aloof-introverted, unassured dominant, unassuming ingenuous, and warm agreeable octants. Alpha convergent analyses were conducted based on PSCD total score, GM, CU, and DI subscales, and adjectives from the IASR-B5 focusing on specific octants from the IASR-B5. Alpha synchrony was expected to be lowest when the adolescents higher in psychopathic traits are reading adjectives that load on to the aloof-introverted, unassured dominant, unassuming ingenuous, and warm agreeable octants, and highest when reading items from the PSCD.

Psychosocial Measure Analysis. Data from the adolescent-completed PSCD were summed to form a total psychopathy index score. Subscale scores were also calculated to analyze GM, DI, and CU traits. Data from the IASR-B5 was analyzed as per the instructions laid out in the IASR-B5 manual (Trapnell & Wiggins, 1990). First, octant scores were calculated by adding together the subject ratings for the adjectives associated with each octant. Next, raw octant scores were converted to Z-scores using the sample means and standard deviations. Then factor scores for Dominance and Nurturance were calculated with a formula incorporating the octant Z-scores which can, in turn, be used to plot each individual on the circumplex graph (Trapnell & Wiggins, 1990). IASR psychopathy scores were calculated using the method described previously by Salekin and colleagues (2010).

RESULTS

Descriptive Statistics

Means (*M*) and Standard Deviations (*SDs*) were calculated for all psychosocial variables (Table 1). Overall, the mean total psychopathy score on the PSCD was 22.87 ($SD = 9.59$) and the mean total psychopathy score from the IASR-B5 Psychopathy scale was 14.36 ($SD = 3.07$). In addition, means and standard deviations were also calculated for alpha spectrum density at each site and frontal, left, and right composites were created by averaging across electrode sites. Table 2 shows total alpha density across sites by task.

Alpha Power

It was hypothesized that there would be greater alpha power density over areas associated with the DMN. Specifically, it was hypothesized that greater levels of alpha frequency oscillations would be associated with completing the PSCD and the IASR adjective self-ratings related to psychopathy for adolescents higher in psychopathic traits. An exploratory hypothesis also expected that alpha power would be greater for each of the three psychopathic trait groups (i.e. GM, CU, and DI traits for the PSCD and Arrogant Calculating, Deceitful Manipulation, and Callous Cruelty for the IASR-B5-psychopathy). Average alpha power across all frontal sites was not significantly correlated with PSCD total scores ($r = -0.015$, $p = 0.942$) nor was it significantly correlated with GM ($r = 0.066$, $p = 0.75$), CU ($r = -0.053$, $p = 0.77$), or DI traits ($r = -0.06$, $p = 0.77$). At the individual electrode level, PSCD total scores and subscale scores were not significantly related to alpha power at any individual electrode. Additionally, alpha power across all frontal sites was not significantly correlated with the IASR-B5 Psychopathy total score (r = -0.26, p = 0.19), the Arrogant Calculating (r = - 0.22, p = 0.27), Deceitful Manipulation (r = -0.19, r = 0.35), or Callous Cruelty octants (r = -0.24, p = 0.23). At the individual electrode level, there were no significant correlations between the IASR-B5 psychopathy total score and alpha power at any frontal electrode sites. Although no results reached significance, overall correlations were strong, indicating that the current study may have suffered from a lack of power (see limitations section). Future studies should consider replicating the current findings with a larger sample size.

sLORETA Analysis

sLORETA analyses were conducted to determine whether there were significantly different alpha responses while completing the IASR-B5 compared to the PSCD. Data were subjected to a permutation t-test that was, in turn, subjected to a false discovery rate correction of multiple comparisons (family-wise p = .05). The results of the t-test are displayed graphically in Figure 1. Results showed that there was significantly more alpha activation in the left-frontal and left prefrontal regions of the brain. These areas approximately coincide with Brodmann's areas 6, 8, 9, 10, and 46. Additionally, results indicated that there was significantly more alpha activation during the IASR-B5 compared to the PSCD in medial frontal and ventro-medial portions of the brain. These areas approximately coincide with Brodmann's areas 10, 11, 12, 25, and the right-hemisphere 38. Combined, these results give mixed support to the hypothesis that the DMN would be more active (i.e. providing more alpha activity) during the PSCD compared to the IASR-B5.

Exploratory Analysis

It was hypothesized that there would be a significant relationship between total Psychopathic traits and alpha synchrony across frontal sites. Specifically, it was hypothesized that there would be greater levels of alpha synchrony while completing the PSCD compared to the IASR-B5. Total alpha synchrony (i.e. the absolute value of the average of alpha power at F7 and F3 compared to average alpha power at F8 and F4) while completing the IASR-B5 was not significantly correlated to PSCD total score ($r = -0.167$, $p = .414$), nor was it significantly correlated with GM ($r = -0.142$, $p = 0.49$), CU ($r = -0.086$, $p = 0.68$) or DI traits ($r = 0.37$, $p = 0.06$). When completing IASR-B5 items related to psychopathy, total alpha synchrony was not significantly correlated with PSCD total score ($r = 0.19$, $p = 0.34$), nor was it significantly correlated with GM ($r = -0.037$, $p = 0.86$), CU ($r = -0.02$, $p = 0.92$), or DI traits ($r = 0.32$, $p = .10$). Total alpha synchrony while completing the PSCD was not significantly correlated with PSCD total score ($r = 0.25$, $p = 0.22$) nor was it significantly correlated with GM ($r = 0.206$, $p = 0.31$), CU ($r = 0.18$, $p = .38$), or DI traits ($r = 0.22$, $p = 0.28$).

Finally, in terms of the IASR-B5 octant score analyses, IASR-B5 octant scores were investigated to see whether they predicted alpha synchrony while completing the PSCD. It was hypothesized that adolescents who were higher in psychopathic traits who fell within the cold-quarrelsome and arrogant-calculating octants would have significantly higher levels of alpha synchrony compared to adolescents who were higher in psychopathic traits who fell within the warm-agreeable, unassuming, ingenuous, and unassured submissive octants. However, due to the small sample size, all individuals were retained in the regression model and psychopathic traits (i.e. total score from the PSCD) were entered into the regression model as a covariate. Octant scores were calculated, and dummy coded with Warm-Agreeable coded as the comparison group. A regression model was formed predicting Alpha synchrony during the PSCD using PSCD total score entered in step one and dummy coded octant scores entered in step two. Results indicated that the combination of psychopathy score and IASR-B5 octant scores predicted a non-significant portion of the variance in alpha synchrony while completing the PSCD ($R^2 = 0.32$, $F(8,17) = 1.03$, p =0.45). A similar regression model was formed predicting alpha synchrony while completing the IASR-B5. Results also showed that the predictors accounted for a non-significant portion of the variance ($R^2 = .27$, $F(8,17) = 0.78$, $p = 0.62$). At the individual octant level, no specific octant significantly predicted alpha (de)synchrony during either task.

DISCUSSION

The current study focused on the interaction between psychopathic traits, as measured both by the PSCD and the IASR-Psychopathy scale, and neural correlates related to the activation of the DMN. The proposed hypotheses generally supported the idea that there should be greater alpha power density across the frontal regions of the brain, which have previously been associated with greater activation of the DMN (e.g. Jann, et al., 2010; Mu & Han, 2013; Knyazev, 2013). If significant, these hypotheses would lend support to the validity of using alpha band response as a proxy to measure DMN activation using EEG methodology.

Alpha Power Spectrum Analyses

The hypothesis that adolescents who were higher in psychopathic traits would show greater levels of alpha frequency oscillations while completing the IASR-B5 items related to psychopathic traits and the PSCD was not supported by the data. Additionally, the exploratory analysis looking at the connection between alpha power and IASR-psychopathy and PSCD subscales returned no significant results. Previous research has suggested a connection between activation of deeper cortical regions of the DMN and greater levels of alpha power above those regions (e.g. Mantini, Perrucci, Del Gratta, Romani, & Corbetta, 2007 Mo, Liu, Huan, & Ding, 2013; Ros, et al., 2013). However, when measuring psychopathic traits across both the IASR-psychopathy total and subscales, and the PSCD total and subscales, psychopathic traits did not significantly relate to alpha power density while completing measures of psychopathic traits. This may indicate that youth high in psychopathic traits have differential functioning of the DMN resulting alpha power band differences compared to non-psychopathic control groups.

This claim is not outlandish given the wide variety of research that has shown differential neural functioning of those higher in psychopathic traits compared to those who are generally lower in psychopathic traits (e.g. Gao, Raine, & Schug, 2011; Koenigs, Baskin-Sommers, Zeier, & Newman, 2011; Keune, et al., 2017). However, additional research would be required to compare DMN responding between those high and low in psychopathic traits, as the current study did not have a non-psychopathic control group with which to compare. Additionally, few researchers have investigated alpha band differences between those high and low in psychopathic traits, with one group of researchers finding decreased alpha band power in the left centro-temporal and parieto-central regions in a psychopath group comparison to a non-psychopath group (during a resting-state condition) (Calzada-Reyes, et al., 2013). However, another group of researchers found no relation between psychopathic traits and global alpha power during a task of empathic concern (Decety, Lewis, & Cowell, 2015). The current study may duplicate Decety and colleagues' (2015) finding that while in non-resting state conditions, psychopathic traits are generally not related to alpha band frequency. However, the dearth of alpha band research on groups with psychopathic traits leaves this conclusion ultimately unsatisfying. Additional research should further elucidate alpha band differences between youth higher and lower in psychopathic traits.

Finally, exploratory analyses assessed whether a combination of psychopathic traits and personality classification by the IASR-B5 octants would significantly predict alpha desynchrony while completing both the IASR-B5 and PSCD. The model attempted to use general personality profiles with a covariate of psychopathic traits to predict alpha power, indicating that certain personality profiles were affected differentially by psychopathic traits. However, this hypothesis was not supported. Additionally, none of the individual octants specifically predicted alpha desynchrony at a significant level in the absence of psychopathic traits.

sLORETA analyses

The second hypothesis, that alpha power would increase over areas specifically associated with the DMN when completing the PSCD compared to the IASR-B5, was partially supported. Specifically, significantly greater left frontal alpha activity was observed during the PSCD compared to the IASR-B5. There was also significantly greater alpha activation observed in the ventral frontal, prefrontal, and right frontal temporal areas during the completion of the IASR-B5 compared to the PSCD. This does not align with the original hypothesis that alpha activation would increase across medial frontal regions of the brain when completing a theoretically more self-engaging task (i.e. the PSCD rather than the IASR-B5). While the findings hold for the hypothesis in part, they also leave room for multiple alternative explanations.

Previous EEG and sLORETA research has indicated that during resting state, the frontal lobes of incarcerated youth and youth with psychopathic traits have been less active than when engaged in a task, suggesting a greater activation of the DMN (e.g. Calzada-Reyes, 2017). Additionally, compared to other-ratings, Mu and Han (2010) found that self-ratings were correlated with increased activation of the DMN as evidenced by greater alpha power in the frontal regions. Increased alpha wave activity was observed in the frontal region of the brain while completing the PSCD compared to the IASR. This may indicate that the DMN was more active for these participants while completing a measure of psychopathy. Thus, one may conclude that incarcerated youth, who tend to score higher on measures of psychopathy than non-incarcerated youth, are equally able to identify their own psychopathic personality traits.

Additionally, they may identify with their psychopathic traits than other traits of general personality.

The significantly greater pattern of alpha response while completing the PSCD mirrors the myriad of frontal alpha asymmetry studies previously conducted. To briefly summarize the findings of many decades of research, frontal alpha asymmetry has been found to be a good proxy of approach and withdrawal motivation (e.g. Davidson, Ekman, Saron, Senulis, & Friesen, 1990; Davidson, 1992; Keune, et al., 2017). Greater alpha activity has been found over the left hemisphere of the frontal lobes when a person is shown a positively valanced stimulus that they would be motivated to approach (either physically approach or move towards emotionally) or that evokes within them a positive emotion. Conversely, if there is greater alpha activity over the right hemisphere of the frontal lobe, the individual would likely withdraw from that particular stimulus or that the stimulus evokes feelings of disgust (Davidson, et al., 1990; Davidson, 1992; Keune, et al., 2017). The approach-withdrawal effect has only found to exist within the frontal regions of the brain and seems to be specific to alpha band power.

In the current study, the sLORETA analysis revealed that alpha band power was significantly stronger while completing the PSCD compared to the IASR-B5 when the signals originated from frontal areas of the brain that were left-lateralized. One possible explanation for this effect may be that the participants were approach-motivated during the PSCD at a significantly greater rate than they were while completing the IASR-B5 more general personality traits.

First, the approach motivation displayed by the left lateralized alpha pattern may indicate that while self-referencing, the adolescents were both capable of recognizing personality traits that they had, and liked their own personality, thus displaying approach motivated behavior. For example, Corr and McNaughton (2012) propose the idea that approach motivated behavior may be driven by attractors which they define as any kind of reinforcement that increases a specific behavior (i.e. negative or positive reinforcers). They note that over time, if consistently reinforced, state behaviors (such as being outgoing or nervous) can translate into traits (such as extraversion or neuroticism respectively) if reinforced (Corr & McNaughton, 2012). Therefore, it may follow that those who recognize traits that are true of themselves and have previously been reinforced in some way (i.e. the adolescents have previously been reinforced for psychopathic behavior) then they may show greater approach motivation toward the traits that had been reinforced. One of the possible conclusions from the study, then, might be that incarcerated adolescents both recognize and positively value their own psychopathic traits which leads to greater approach motivation as demonstrated by the greater levels of left-lateralized alpha band waves.

Conversely, a recent study by South and Wood (2006) found that within an incarcerated population, social desirability was similar to in non-incarcerated populations in that there was a social hierarchy and people desired to be at the top of the hierarchy (South & Wood, 2006). Interestingly, they noted that belief in the importance of social status was related to engagement in bullying and aggressive behavior (South & Wood, 2006). That relationship, appeared to be mediated by moral disengagement which they defined, citing Bandura, as the "cognitive restructuring of inhumane conduct into a benign or worthy behavior" (Bandura, 2002, p. 101). Their findings provide evidence that if one engages in conduct disordered behavior and engages in thinking styles that overlap with psychopathic traits, that they would see themselves as more important in the social sphere of their prison.

Thus, it may be that in our sample the results lend themselves to a solution of social desirability. While completing the PSCD, the participants may see the psychopathic traits as more socially desirable compared to the relatively neutral words presented in the IASR-B5 which was then, in turn, recorded as left-lateralized frontal asymmetry indicating approach motivation. However, these findings directly contradict the findings of Keune and colleagues (2017), which showed a significant relationship between CU traits and withdrawal motivation. As a result, more research is necessary to further explore the effect of frontal alpha asymmetry with regard to psychopathic personality traits.

Secondarily, ventral areas of the prefrontal cortex associated with the DMN displayed more alpha activation during the IASR-B5 compared to the PSCD. Previously, alpha band waves have typically correlated with inhibition of a cortical area (e.g. Coan & Allen, 2003; Matthewson, et al., 2011). As noted regarding alpha asymmetry, a greater level of left-lateralized alpha waves would indicate inhibition of the left cortical region. When applied to the increased level of alpha waves in the ventral cortical regions during the IASR compared to the PSCD, we can draw the conclusion that participants generally suppressed cortical activity in those ventral areas. As illustrated by Northoff and Bermpohl (2004), the ventral areas of the prefrontal cortex (i.e. the areas displaying greater levels of activity during the IASR) are associated with representation of the self. This could suggest that while completing the IASR, participants generally inhibited areas of the brain associated with their own self-representation. This would potentially suggest that when completing measures of general personality, incarcerated youth were generally less self-referential overall. Taken together with the results of alpha activation that were greater during the PSCD, we can posit that incarcerated youth may show greater approach motivation and more self-referential processing when completing measures of psychopathic traits (which may serve a social purpose) compared to completing a measure of general personality where they were neither approach nor withdrawal motivated, and less self-referential.

Analysis of Brodmann's Areas. As noted above, the results of the sLORETA analysis highlight activation in specific regions of the brain. Results showed that there was significantly more alpha activation in the left-frontal and left prefrontal regions of the brain during the PSCD compared to the IASR-B5 in Brodmann's areas 6, 8, 9, 10, and 46; and showed more alpha activation during the IASR-B5 compared to the PSCD in medial frontal and ventro-medial portions of the brain coinciding with Brodmann's areas 10, 11, 12, 25, and the right-hemisphere 38. More specifically, area 6 is part of the premotor cortex, area 8 is part of an area that is involved in visual attention and eye movement, areas 9 and 46 are part of the dorsolateral prefrontal cortex, 10, 11, and 12 are part of the Orbitofrontal cortex, 25 is part of the Ventromedial Prefrontal cortex, and 38 is part of the Temporopolar Area (Baars & Gage, 2013).

At a more granular level, area 6 is specifically related to lexical decision making and syntactical processing as well as motor planning (Nolte, 2008). Areas 8, 9, 10, and 46 likewise are involved in attention, motor planning, regulation, memory retrieval, and decision making (Nolte, 2008). Taken together, activation in these areas would show a process of lexical processing (i.e. reading and processing the words on the screen), followed by further processing and preparation for responding to the stimulus. Taken together with the increase in alpha activity in the left hemisphere Brodmann's areas, it appears that the patterns of activation are consistent with a pattern of approach motivation for the PSCD compared to the IASR-B5 (e.g. Davidson, et al., 1990; Davidson, 1992; Keune, et al., 2017).

Brodman's areas 10, 11, and 12 are part of the orbitofrontal cortex, an area associated with, among other functions, emotional (re)processing and goal directed behavior (Fettes, Schulze, & Downar, 2017). Likewise, area 25 appears to be implicated in emotional processing (Öngür & Price, 2000). Area 38, conversely, appears to be involved specifically in semantic processing (e.g. Visser, Maya, & Jefferies, 2010). In the context of the current study, these areas showed increased alpha activity during the completion of the IASR-B5 compared to the PSCD. What this may indicate is a reduction in goal directed behavior, which might be expected during the completion of a task with no direct goal, but also a reduction of emotional processing or reprocessing. The results may suggest that psychopathic individuals, while self-evaluating, do so with lesser emotionality. Future research may wish to investigate this prospect with a direct comparison to non-psychopathic controls.

Limitations

The major notable limitation to the study is sample size. Only 26 participants took part in the study due to restrictions in access to the protected population of incarcerated youth. This may have augmented the Type II error rate, as the study may lack the necessary power to detect relatively small effect sizes. While several results trended toward significance (p-values in the range of 0.09-0.06), none reached significance, likely due to sample size. However, as this is a population that is generally higher in psychopathic traits compared to those in the community (e.g. Kiehl & Hoffman, 2011), these findings may have provided insights that a more robust community sample would be unable to show. Thus, although there are fewer significant effects, the effects that were found (i.e. from the sLORETA analysis) are robust and deserve consideration. Additionally, although previous work on psychopathic traits typically includes largely European-American samples, our population was reasonably diverse (with over 50% of participants self-reporting as being African-American). Additional research investigating psychopathic traits has found differential response patterns across ethnic groups (e.g. Cooke, Kosson, & Michie, 2001). Differential responses may have added some additional variability that we were unable to assess due to low sample size. In sum, future research should assess these theories with a large, diverse sample to detect relatively smaller effect sizes.

In terms of the EEG analysis, the results may have been affected by drugs still in particpants' bloodstreams. Tuscaloosa county reported in 2011 that drug and alcohol use within the county is higher than both the state and national averages, though more specific data on teen drug use could not be located (PRIDE of Tuscaloosa, 2011). While the participants were not likely directly under the influence of marijuana or other illicit substances at the time of testing, it cannot be ruled-out that previous drug use would not have an effect on our results (e.g. Volavka, Dornbush, Feldstein, Clare, Zaks, Fink, & Freedman, 1971). Future studies may wish to consider the impact of drug use on EEG recordings and either control for previous drug use or choose to use a sample that is drug-naïve.

Another potential limitation to the current study is the use of an electrode cap with 19 total electrodes compared to a larger cap density. In their 2004 review, Michel and colleagues found a significant increase in precision when calculating source localization when they increased electrode density from 31 channels to 63 or 123 channels. However, the authors also note in their review that uniform distribution of channels across the scalp does play a positive role in the precision of source localization (Michel, et al., 2004). To this, the current author raises two arguments. First, the current study used a 19-channel electrode cap that was evenly distributed around the scalp. As such, it should not suffer from as much inaccuracy as would a study with more electrodes that were not as evenly distributed (Michel, et al., 2004). Second, as the current study is an initial foray into source localization for the DMN and its relationship to psychopathic traits, the author argues that modest, cautiously presented precision is adequate for addressing the presented hypotheses. Additionally, the current study provides preliminary evidence that there are differential response patterns when completing an inventory of personality compared to an inventory of psychopathic traits for incarcerated youth. Future studies should seek to replicate this finding using caps with greater electrode density.

Although the above study used a method of multiple imputation that is reasonably supported in the literature (e.g. Barnard & Rubin, 1999), the time limitation on the response period did lead to missing data in the final data set. A longer response period may have increased the amount of available data to the point of not needing the multiple imputation procedure to handle missing data. However, due to the possibility of decreased attention over time in the current population possibly leading to worse quality data, and due to the overall limitation of time available to the researchers, the current response period was chosen. Any future studies using computerized measures may choose to increase the response window or may choose to use paper copies of the forms in addition to the computerized tasks to ensure complete data sets.

Finally, the current study relied exclusively on self-report data for both the IASR-B5 and the PSCD. While this is one of the most common methods for assessment in studying psychopathic traits, it does not come without limitations (Sellbom, Lilienfeld, Fowler & McCrary, 2006). Of note, people higher in psychopathic traits tend to lie and have bad insight into their own personality which can pose great threats to the validity of self-report measures (Sellbom, et al., 2006). However, as concluded by Sellbom and colleagues (2006) and again in a more modern study of psychopathic trait measurement modality, there appear to be minimal differences between self-report measures of psychopathy and externally reported measures of psychopathy (e.g. parent- or clinician-rated) in terms of their correlates to external behaviors associated with psychopathic traits (e.g. interpersonal behaviors, antisocial behaviors, etc.) (Hunt, Bornovalova, Kimonis, Lilienfeld, & Poythress, 2015). Specifically, the later study found only minor differences between the two measurement modalities on the interpersonal and affective facets of psychopathy and external behavioral correlates; previously believed to be a primary difference between self- and other-reported psychopathy (Hunt, et al., 2015). While the literature does suggest that self-report data should be sufficient to measure both general personality and psychopathic traits, future studies might consider using a clinician reported measure of psychopathic traits in addition to further bolster the validity of the data.

Conclusion and Directions for Future Study

While many of the results above regarding alpha wave power and its relation to the DMN remained non-significant, there are still many avenues of study that should be investigated before firm conclusions can be drawn. Specifically, DMN functioning should be compared across resting and active tasks, and the intersection of psychopathic traits and self-referential functioning should continue to be researched. The sLORETA analysis indicated that incarcerated youth tend to show approach motivated alpha patterns while completing a measure of psychopathic traits, and no motivation (approach or withdrawal) when completing a general measure of personality. This may be especially important for laying the groundwork for treatment of psychopathy. One possible explanation, outlined above, suggests that the approach motivation is driven by youth recognizing traits in themselves that have previously been reinforced. If this explanation is supported by future studies, treatment for incarcerated youth should aim to focus on developing skills that are akin to the traits that had been previously reinforced but are expressed in a more prosocial way. For example, if an adolescent strongly values their trait of low emotional reactivity, it may be useful to help guide them to positive careers wherein maintaining emotional control under stress is key (e.g. firefighting, working as an Emergency Medical Technician, etc.). It may also be possible to draw a connection between the works of South and Wood (2006) and the developmental taxonomy introduced by Moffit (1993). In Moffit's seminal article, she noted an increase of antisocial behavior and psychopathic traits in a subset of adolescents during the beginning of their pubescent years. Psychopathic traits spiked and then generally returned to a normal baseline by these individuals' early adult years (Moffit, 1993). We might assume that the neurological underpinning demonstrated in the current study shows the pathway by which certain youth begin showing this preference (i.e. approach motivation) towards psychopathic traits in order to gain status in a social hierarchy (as suggested by South & Wood, 2006). If this is the case, it would be important to consider changes at both an individual and societal level to alter motivations of these youth for violent or antisocial behaviors. Ideally, such changes could prevent them from developing further psychopathic traits and reducing the likelihood of incarceration

REFERENCES

American Psychiatric Association. (2013). *Diagnostic and statistical manual of mental disorders* (5th ed.). Arlington, VA: American Psychiatric Publishing.

Baars, B. J., & Gage, N. M. (2013). *Fundamentals of cognitive neuroscience: A beginner's guide*. San Diego, CA: Elsevier Academic Press.

Barnard, J., & Rubin, D. B. (1999). Miscellanea. Small-sample degrees of freedom with multiple imputation. *Biometrika*, *86*, 948-955.

Barry, C. T., Frick, P. J., DeShazo, T. M., McCoy, M., Ellis, M., & Loney, B. R. (2000). The importance of callous–unemotional traits for extending the concept of psychopathy to children. *Journal of Abnormal Psychology, 109*, 335-340.

Bell, M. A., & Cuevas, K. (2012). Using EEG to study cognitive development: Issues and practices. *Journal of Cognition and Development*, *13*, 281-294.

Calzada-Reyes, A., Alvarez-Amador, A., Galan-Garcia, L., & Valdez-Sosa, M. (2013). EEG abnormalities in psychopath and non-psychopath violent offenders. *Journal of Forensic and Legal Medicine*, *20*, 19-26. doi:10.1016/j.jflm.2012.04.027

Calzada-Reyes, A., Alvarez-Amador, A., Galán-García, L., & Valdés-Sosa, M. (2017). QEEG and LORETA in teenagers with conduct disorder and psychopathic traits. *Clinical ÉEG and Neuroscience,* 48, 189-199.

Cleckley, H. M. (1941/1964). *The mask of sanity*. St. Louis: Mosby. http://cassiopaea.org/cass/sanity_1.PdF

Coan, J. A., & Allen, J. J. (2003). Frontal EEG asymmetry and the behavioral activation and inhibition systems. *Psychophysiology*, *40*, 106-114.

Collins, M. W. ., & Persinger, M. A. (2014). Enhanced Power Within the Default Mode Network in Normal Subjects with Elevated Scores on an Egocentric Scale. *The Open Neuroimaging Journal*, *8*, 5–10. http://doi.org/10.2174/1874440001408010005

Cooke, D. J., & Michie, C. (2001). Refining the construct of psychopathy: Towards a hierarchical model. *Psychological Assessment*, *13*, 171-188. doi:10.1037/1040-3590.13.2.171

Corr, P. J. and McNaughton, N. (2012). Neuroscience and approach/avoidance personality traits: a two stage (valuation-motivation) approach. Neuroscience & Biobehavioral Reviews, 36, pp. 2239-2354. doi: 10.1016/j.neubiorev.2012.09.013

Davidson, R. J., Ekman, P., Saron, C. D., Senulis, J. A., & Friesen, W. V. (1990). Approach-withdrawal and cerebral asymmetry: emotional expression and brain physiology: I. *Journal of Personality and Social Psychology*, *58*, 330-341.

Delorme, A., & Makeig, S. (2004). EEGLAB: an open source toolbox for analysis of single-trial EEG dynamics including independent component analysis. *Journal of Neuroscience Methods*, *134*, 9-21.

Esslen, M., Metzler, S., Pascual-Marqui, R., & Jancke, L. (2008). Pre-reflective and reflective self-reference: A spatiotemoral EEG analysis. *NeuroImage*, *42*, 437-449. doi:10.1016/j.neuroimage.2008.01.060

Ferree, T. C., Luu, P., Russell, G. S., & Tucker, D. M. (2001). Scalp electrode impedance, infection risk, and EEG data quality. *Clinical Neurophysiology*, *112*. doi:10.1016/S1388-2457(00)00533-2

Fettes, P., Schulze, L., & Downar, J. (2017). Cortico-striatal-thalamic loop circuits of the orbitofrontal cortex: promising therapeutic targets in psychiatric illness. *Frontiers in systems neuroscience*, *11*, 25.

Frick, P. J., Ray, J. V., Thornton, L. C., & Kahn, R. E. (2014). Can callous-unemotional traits enhance the understanding, diagnosis, and treatment of serious conduct problems in children and adolescents? A comprehensive review. *Psychological Bulletin, 140*, 1-57. http://dx.doi.org/10.1037/a0033076

Gao, Y., Raine, A., & Schug, R. A. (2011). P3 event-related potentials and childhood maltreatment in successful and unsuccessful psychopaths. *Brain and Cognition*, *77*, 176-182.

Gramfort A, Papadopoulo T, Olivi E, Clerc M (2010) OpenMEEG: opensource software for quasistatic bioelectromagnetics. *BioMedical Engineering OnLine*, *45*.

Hare, R. D. (1980). A research scale for the assessment of psychopathy in criminal populations. *Personality and Individual Differences*, 1, 111-119. doi:10.1016/0191-8869(80)90028-8

Hare, R. D. (1991). The Hare psychopathy checklist-revised. North Tonawanda, NY: Multi-Health Systems.

Hare, R. D., & Neumann, C. S. (2005). The PCL-R assessment of psychopathy: Development, structural properties, and new directions. In *Handbook of psychopathy* (pp. 58-90). New York, NY: Guilford Press.

Hare, R. D., & Neumann, C. S. (2008). Psychopathy as a Clinical and Empirical Construct. *Annual Review of Clinical Psychology*, *4*, 217-246. doi:doi.org/10.1146/annurev.clinpsy.3.022806.091452

Harpur, T. J., Hare, R. D., & Hakstian, A. R. (1989). Two-factor conceptualization of psychopathy: Construct validity and assessment implications. *Psychological Assessment: A Journal of Consulting and Clinical Psychology*, *1*, 6.

Hawes, S. W., Mulvey, E. P., Schubert, C. A., & Pardini, D. A. (2014). Structural coherence and temporal stability of psychopathic personality features during emerging adulthood. *Journal of Abnormal Psychology*, 123, 623-633. http://dx.doi.org/10.1037/a0037078

Hoza, B., Gerdes, A. C., Hinshaw, S. P., Arnold, L. E., Pelham Jr, W. E., Molina, B. S., ... & Odbert, C. (2004). Self-perceptions of competence in children with ADHD and comparison children. *Journal of Consulting and Clinical Psychology*, *72*, 382.

Hunt, E., Bornovalova, M. A., Kimonis, E. R., Lilienfeld, S. O., & Poythress, N. G. (2015). Psychopathy factor interactions and co-occurring psychopathology: Does measurement approach matter?. *Psychological assessment*, *27*, 583.

IBM Corp. Released 2017. IBM SPSS Statistics for Windows, Version 25.0. Armonk, NY: IBM Corp.

Jarrett, M. A., & Ollendick, T. H. (2008). A conceptual review of the comorbidity of attention-deficit/hyperactivity disorder and anxiety: Implications for future research and practice. *Clinical Psychology Review*, 28, 1266-1280. doi:10.1016/j.cpr.2008.05.004

Jones, S., Cauffman, E., Miller, J. D., & Mulvey, E. (2006). Investigating different factor structures of the Psychopathy Checklist: Youth version: Confirmatory factor analytic findings. *Psychological Assessment, 18*, 33-48.

Keune, P. M., Mayer, S. V., Jusyte, A., & Schonenberg, M. (2017). Frontal alpha asymmetry and callous-unemotional traits in imprisoned violent offenders: A pilot study. *Psychophysiology*, *55*. doi:10.1111/psyp.12981

Kiehl, K. A., & Hoffman, M. B. (2011). The criminal psychopath: History, neuroscience, treatment, and economics. *Jurimetrics*, 51, 355.

Knyazev, G. G. (2013). EEG correlates of self-referential processing. *Frontiers in Human Neuroscience*. doi:10.3389/fnhum.2013.00264

Koenigs, M., Baskin-Sommers, A., Zeier, J., & Newman, J. P. (2011). Investigating the neural correlates of psychopathy: a critical review. *Molecular Psychiatry*, *16*, 792.

Kosson, D. S., Neumann, C. S., Forth, A. E., Salekin, R. T., Hare, R. D., Krischer, M. K., & Sevecke, K. (2013). Factor Structure of the Hare Psychopathy Checklist: Youth Version (PCL: YV) in Adolescent Females. *Psychological Assessment*, *25*, 71-83. http://doi.org/10.1037/a0028986

Kybic J., Clerc M., Abboud T., Faugeras O., Keriven R., Papadopoulo T. (2005). A common formalism for the integral formulations of the forward EEG problem. *IEEE Transactions on Medical Imaging*, *24*, 12-28.

Lahey, B. B. (2014). What we need to know about callous-unemotional traits: Comment on Frick, Ray, Thornton, and Kahn (2014). *Psychological Bulletin*, 140, 58-63. doi:10.1037/a0033387

Loeber, R., Burke, J. D., & Lahey, B. B. (2002). What are adolescent antecedents to antisocial personality disorder? *Criminal Behaviour and Mental Health, 12*, 24-36. doi:10.1002/cbm.484

Mantini, D., Perrucci, M. G., Del Gratta, C., Romani, G. L., & Corbetta, M. (2007). Electrophysiological signatures of resting state networks in the human brain. *Proceedings of the National Academy of Sciences*, *104*, 13170-13175.

Mathewson, K. E., Lleras, A., Beck, D. M., Fabiani, M., Ro, T., & Gratton, G. (2011). Pulsed out of awareness: EEG alpha oscillations represent a pulsed-inhibition of ongoing cortical processing. *Frontiers in Psychology*, *2*, 99.

McCrae, R. R., & Costa, P. T. (1989). The structure of interpersonal traits: Wiggins's circumplex and the five-factor model. *Journal of Personality and Social Psychology*, *56*, 586-595.

Michel, C. M., Murray, M. M., Lantz, G., Gonzalez, S., Spinelli, L., & de Peralta, R. G. (2004). EEG source imaging. *Clinical Neurophysiology*, 115, 2195-2222.

Mo, J., Liu, Y., Huang, H., & Ding, M. (2013). Coupling between visual alpha oscillations and default mode activity. *NeuroImage*, *68*, 112-118.

Moffitt, T. E., Caspi, A., Harrington, H., & Milne, B. J. (2002). Males on the life-course-persistent and adolescence-limited antisocial pathways: Follow-up at age 26 years. *Development and Psychopathology, 14*, 179-207. doi:10.1017/s0954579402001104

Mu, Y., & Han, S. (2010). Neural oscillations involved in self-referential processing. *NeuroImage*. doi:10.1016/j.neuroimage.2010.07.008

Neumann, C. S., Kosson, D. S., Forth, A. E., & Hare, R. D. (2006). Factor structure of the Hare Psychopathy Checklist: Youth Version (PCL: YV) in incarcerated adolescents. *Psychological Assessment, 18*, 142-154.

Neumann, C. S., Malterer, M. B., & Newman, J. P. (2008). Factor structure of the Psychopathic Personality Inventory (PPI): Findings from a large incarcerated sample. *Psychological Assessment, 20*, 169-174.

Nolte, J. (2008). *The Human Brain E-Book: An Introduction to its Functional Anatomy With student consult Online Access*. Elsevier Health Sciences.

Northoff, G., & Bermpohl, F. (2004). Cortical midline structures and the self. *Trends in Cognitive Sciences*, *8*, 102-107.

Öngür, D., & Price, J. L. (2000). The organization of networks within the orbital and medial prefrontal cortex of rats, monkeys and humans. *Cerebral cortex*, *10*, 206-219.

Philippi, C. L., Duff, M. C., Denburg, N. L., Tranel, D., & Rudrauf, D. (2012). Medial PFC damage abolishes the self-reference effect. *Journal of Cognitive Neuroscience*, *24,* doi:10.1162/jocn_a_00138

Raichle, M. E., MacLeod, A. M., Snyder, A. Z., Powers, W. J., Gusnard, D. A., & Shulman, G. L. (2001). A default mode of brain function. *Proceedings of the National Academy of Sciences*, *98*, 676-682. doi:10.1073/pnas.98.2.676

Salekin, R. T. & Hare, R. D. (2016). Proposed Specifiers for Conduct Disorder. Unpublished questionnaire.

Salekin, R. T. (2016, September). Psychopathy in childhood: Toward better informing the DSM-5 and ICD-11 conduct disorder specifiers. *Personality Disorders: Theory, Research, and Treatment*, 7, 180-191. doi:10.1037/per0000150

Salekin, R. T., Andershed, H., Batky, B. D., & Bontemps, A. P. (2018). Are Callous Unemotional (CU) Traits Enough? *Journal of Psychopathology and Behavioral Assessment,40*, 1-5. doi:10.1007/s10862-018-9663-9

Schaeffer, C. M., Petras, H., Ialongo, N., Poduska, J., & Kellam, S. (2003). Modeling Growth in Boys Aggressive Behavior Across Elementary School: Links to Later Criminal Involvement, Conduct Disorder, and Antisocial Personality Disorder. *Developmental Psychology, 39*, 1020-1035. doi:10.1037/0012-1649.39.6.1020

Sellbom, M., Lilienfeld, S. O., Fowler, K. A., & Patrick, C. (2006). The self-report assessment of psychopathy: Challenges, pitfalls, and promises. In: *Handbook of psychopathy*, 107-132.

South, C.R. and Wood, Jane L. (2006) Bullying in Prisons: the Importance of Perceived Social Status, Prisonization and Moral Disengagement. *Aggressive Behavior*, 32, 490-501. ISSN 0096-140X

Tadel F., Bock E., Niso G., Mosher J.C., Cousineau M., Pantazis D., Leahy R. M., Baillet S. (2019). MEG/EEG Group Analysis with Brainstorm. *Frontiers in Neuroscience, 13*, 76.

Trapnell, P. D., & Wiggins, J. S. (1990). Extension of the Interpersonal Adjective Scales to include the Big Five dimensions of personality. *Journal of Personality and Social Psychology, 59*, 781-790. http://dx.doi.org/10.1037/0022-3514.59.4.781

Visser, M., Jefferies, E., & Lambon Ralph, M. A. (2010). Semantic processing in the anterior temporal lobes: a meta-analysis of the functional neuroimaging literature. *Journal of cognitive neuroscience*, *22*, 1083-1094.

Volavka, J., Dornbush, R., Feldstein, S., Clare, G., Zaks, A., Fink, M., & Freedman, A. M. (1971). Marijuana, EEG, and behavior. *Annals of the New York Academy of Sciences*, *191*, 206-215.

Wiggins, J. S. (1996). An informal history of the interpersonal circumplex tradition. *Journal of Personality Assessment*, *66*, 217-233. doi:10.1207/s15327752jpa6602_2

Wiggins, J. S., Trapnell, P., & Phillips, N. (1988). Psychometric and geometric characteristics of the revised interpersonal adjective scale (IAS-R). *Multivariate Behavioral Research*, *23*, 517-530. doi:10.1207/s15327906mbr2304_8

Wiggins, J. S., & Trobst, K. K. (2002). The interpersonal adjectives scales: Big five version (IASR-B5). In B. de Raad & M. Perugini (Eds.), *Big Five Assessment* (pp. 264-276). Ashland, OH, US: Hogrefe & Huber Publishers.

APPENDIX

TABLES

Descriptive Statistics of Outcome Variables

Table 1

Descriptive Statistics

Study Variable	Mean	SD	Minimum	Maximum
PSCD-Total	22.87	9.59	0.00	38.00
PSCD-GM	6.26	2.26	0.00	10.00
PSCD-CU	3.87	3.04	0.00	10.00
PSCD-DI	6.98	2.92	0.00	11.00
IASR-Psychopathy Total	14.63	3.07	10.33	21.25
IASR-Psychopathy Arrogant-Superiority	5.23	0.99	2.76	6.88
IASR-Psychopathy Callous-Cruelty	4.50	1.55	1.71	8.00
IASR-Psychopathy Deceitful-Manipulation	4.90	1.10	2.63	7.29
IASR-Octant Scores				
IASR-Assured Dominant	5.38	1.09	2.57	7.63
IASR Arrogant-Calculating	4.57	1.09	2.18	7.25
IASR-Cold-hearted	4.32	1.51	1.75	8.00
IASR-Aloof-Introverted	4.17	1.41	1.38	7.75
IASR-Unassured-Submissive	3.83	0.97	2.00	5.75
IASR-Unassuming-Ingenuous	5.00	0.97	2.25	6.41
IASR-Warm-Agreeable	5.72	1.34	1.50	7.63
IASR-Gregarious-Extraverted	5.67	1.48	1.85	7.75

Descriptive Statistics of Alpha Density

Table 2

Descriptive Statistics Alpha Density

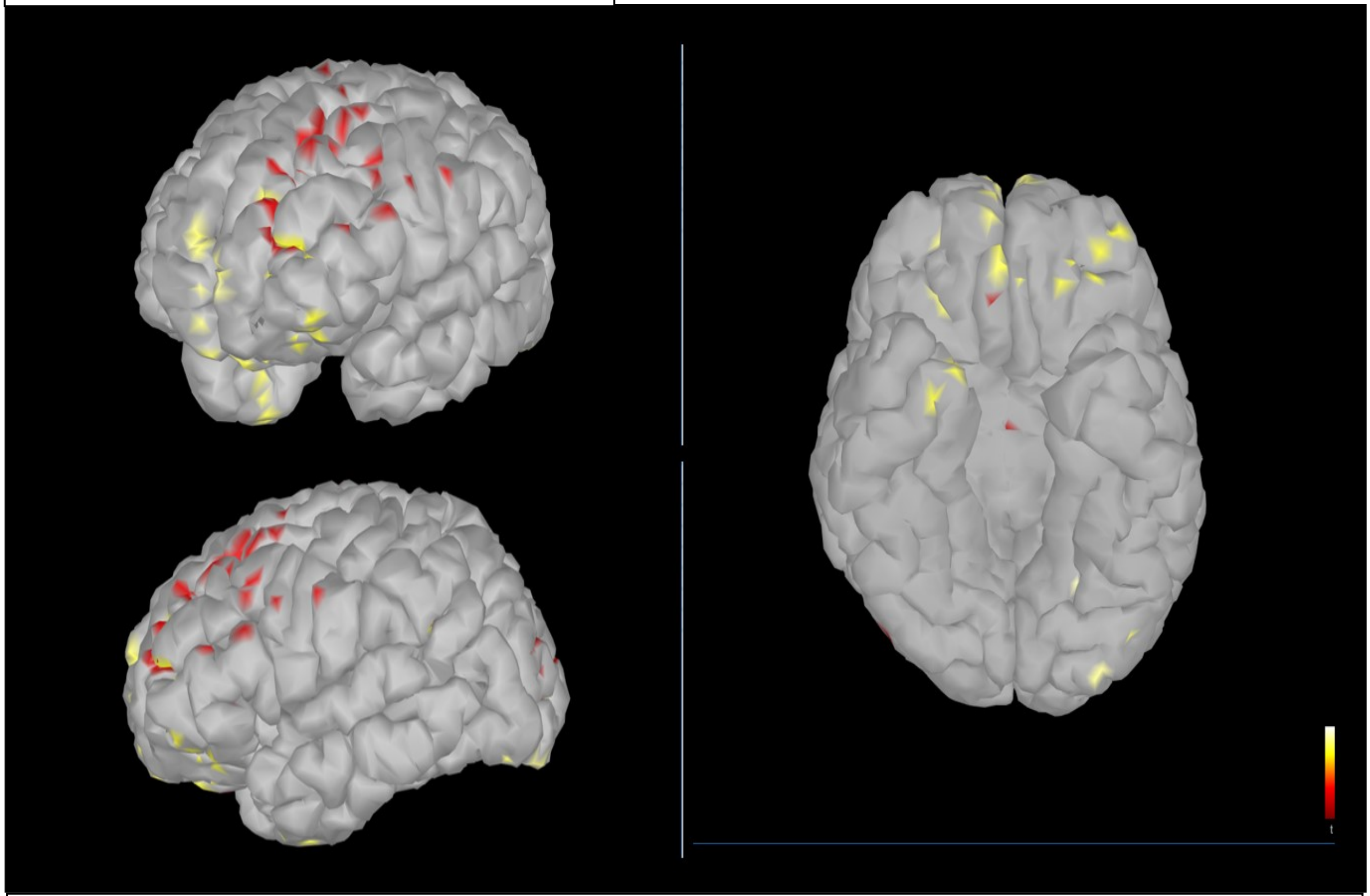
	Mean	SD	Minimum	Maximum
PSCD				
F7	-4.25	0.89	-5.74	-2.11
F3	-5.28	1.05	-7.58	-2.30
Fz	-5.60	0.97	-7.28	-3.26
F4	-5.50	0.87	-7.78	-4.12
F8	-4.49	0.70	-5.41	-2.61
				-
IASR-B5 Psychopathy				
F7	-2.10	0.91	-3.33	0.47
F3	-3.25	0.92	-5.30	-0.98
Fz	-3.52	0.84	-5.19	-1.34
F4	-3.53	0.75	-4.88	-2.36
F8	-2.52	0.66	-3.80	-2.11
IASR-B5				-
F7	-4.40	0.79	-5.72	-2.25
F3	-5.56	0.92	-7.63	-3.60
Fz	-5.76	0.89	-7.53	-3.56
F4	-5.74	0.86	-7.46	-4.26
F8	-4.79	0.71	-6.07	-2.67

Note: All alpha power is presented as natural log transformation

FIGURES

SLORETA Permuted T-test

Figure 1. sLORETA- Permuted t-test results



Note: Yellow indicates significantly more alpha power during the completion of the IASR and red indicates significantly more alpha power during the completion of the PSCD.