Psychiatry Research: Neuroimaging 265 (2017) 35–44

Contents lists available at ScienceDirect

Psychiatry Research: Neuroimaging

journal homepage: www.elsevier.com/locate/psychresns

Functional connectivity in incarcerated male adolescents with psychopathic traits

Sandra Thijssen[a,b], Kent A. Kiehl[c,d,e,*]

[a] School of Pedagogical and Educational Sciences, Erasmus University of Rotterdam, The Netherlands
[b] Center for Child and Family Studies, Leiden University, The Netherlands
[c] The Mind Research Network, Albuquerque, NM, USA
[d] Department of Neurosciences, School of Medicine, University of New Mexico, Albuquerque, NM, USA
[e] Departments of Psychology, Neuroscience, and Law, University Of New Mexico, Albuquerque, NM, USA

ARTICLE INFO

Keywords:
Psychopathy
Resting state fMRI
Default mode network
Salience network
Juvenile delinquents
Adolescence

ABSTRACT

The present study examined the association between psychopathic traits and functional connectivity in 177 incarcerated male adolescents. We hypothesized that psychopathic symptoms would be associated with functional connectivity within networks encompassing limbic and paralimbic regions, such as the default mode (DMN), salience networks (SN), and executive control network (ECN). The present sample was drawn from the Southwest Advanced Neuroimaging Cohort, Youth sample, and from research at a youth detention facility in Wisconsin. All participants were scanned at maximum-security facilities. Psychopathic traits were assessed using Hare's Psychopathy Checklist-Youth Version. Resting-state networks were computed using group Independent Component Analysis. Associations between psychopathic traits and resting-state connectivity were assessed using Mancova analyses. PCL-YV Total score and Factor 1 score (interpersonal and affective traits) were associated with the power spectra of the DMN. Factor 1 score was associated with SN and ECN spatial maps. Factor 2 score (lifestyle and antisocial traits) was associated with spatial map of the ECN. Only the Factor 1 association with DMN power spectrum survived correction for multiple testing. Comparable to adult psychopathy, adolescent psychopathic traits were associated with networks implicated in self-referential thought, moral behavior, cognition, and saliency detection: functions previously reported to be disrupted in adult psychopaths.

1. Introduction

Psychopathy is a serious mental health disorder characterized by interpersonal, affective and behavioral traits such as lack of guilt and remorse, glibness, and impulsivity (Hare, 2003). As psychopaths are prone to violence and very likely to re-offend after release from prison, psychopathy poses a severe societal problem (Hemphill et al., 1998). Research suggests that psychopathy is developmental in nature, with psychopathic traits becoming apparent before the age of 10 years (Viding et al., 2005). While popular dogma holds that adult psychopaths are relatively resistant to treatment (Kiehl and Hoffman, 2011), youth with elevated psychopathic traits may be susceptible to intervention programs (Caldwell et al., 2007). Moreover, compared to adults, the neural correlates of psychopathic traits in children and adolescents will be less affected by the behavior itself (reversed causality) and/or environmental influences (e.g. lead exposure), and are thus more likely to reflect etiology. Examining the neurobiology of psychopathic traits in adolescents may therefore provide important insights on the development of psychopathy as well as information relevant for treatment and prevention programs. Here, we examined the association between psychopathic traits and functional connectivity in a large sample of incarcerated male adolescents.

As implied by the wide range of emotional and behavioral symptoms that characterize the disorder, psychopathic symptoms in both adults and adolescents have been related to functional and structural differences in limbic and paralimbic structures, such as amygdala, hippocampus, parahippocampal regions, anterior and posterior cingulate cortex, insula, temporal pole, and orbitofrontal cortex (OFC) (Cope et al., 2014; De Brito et al., 2009; Ermer et al., 2013; Harenski et al., 2014; Kiehl et al., 2001; Wallace et al., 2014; Yang et al., 2011). For example, psychopaths are reported to have decreased amygdala, hippocampal, OFC, and temporal pole volume or thickness (Cope et al., 2014; Gregory et al., 2012; Yang et al., 2005). Moreover, psychopathy has been associated with aberrant activation in the

* Corresponding author at: The Mind Research Network, Albuquerque, NM, USA.
E-mail addresses: s.thijssen@fsw.leidenuniv.nl (S. Thijssen), kkiehl@mrn.org (K.A. Kiehl).

http://dx.doi.org/10.1016/j.pscychresns.2017.05.005
Received 4 August 2016; Received in revised form 9 May 2017; Accepted 11 May 2017
Available online 11 May 2017
0925-4927/

amygdala, prefrontal, and temporal cortex during moral decision-making (Harenski et al., 2010; Marsh and Cardinale, 2014), and while viewing emotional faces (Contreras-Rodriguez et al., 2014; Decety et al., 2014).

In recent years, there has been a significant increase in studies examining resting-state functional connectivity. Functional connectivity, defined as the relation between the neuronal activation patterns of anatomically separated brain regions (Aertsen et al., 1989), describes the organization, inter-relationship and integrated performance of functionally coupled brain regions (Rogers et al., 2008). Thus, while task based fMRI studies provide information on brain functioning during specific behavior, resting-state functional connectivity provides information on brain organization. Differences in functional connectivity have been related to several psychological disorders, such as autism and schizophrenia (e.g. Cerliani et al., 2015; Rashid et al., 2014). In adults, psychopathy has most markedly been associated with aberrant functional connectivity in (regions of) the default mode network (DMN), which includes the medial prefrontal cortex, posterior cingulate cortex, precuneus, and angular gyrus (Juarez et al., 2013; Motzkin et al., 2011; Pujol et al., 2012; Sheng et al., 2010). The default mode network has been implicated in self-processing and moral behavior (Andrews-Hanna, 2012; Buckner et al., 2008; Li et al., 2014), and aberrant functioning of this network may play an important role in explaining core psychopathy symptoms, such as inflated sense of self (Hare, 2003), impaired emotion recognition (social perspective taking) (Dawel et al., 2012), and impaired moral decision making (Tassy et al., 2013). As the brain undergoes significant changes during adolescence and early adulthood (Gogtay et al., 2004), adult findings cannot simply be extrapolated to youth with elevated psychopathic traits. Nevertheless, several studies in adolescent samples have also reported associations between psychopathic traits and DMN connectivity (Aghajani et al., 2016; Cohn et al., 2015; Shannon et al., 2011). However, results by Broulidakis et al. (2016) suggest that the DMN is associated with conduct disorder, but not psychopathic traits. Besides the DMN, several other brain networks, such as the salience network (SN, insula), anterior cingulate cortex (ACC, amygdala), and executive control network (ECN, OFC), encompass paralimbic regions, and may thus be involved in psychopathic behavior (Aghajani et al., 2016; Kiehl, 2006).

The present study examined the association between functional connectivity and psychopathic traits in a large sample of incarcerated adolescent boys. Based on prior resting-state, but also task-based functional MRI and structural neuroimaging studies suggesting (para) limbic involvement in psychopathy (for example, Cope et al., 2014; De Brito et al., 2009; Ermer et al., 2013; Harenski et al., 2014; Kiehl et al., 2001; Pujol et al., 2012; Wallace et al., 2014; Yang et al., 2011), we hypothesized that psychopathic symptoms in incarcerated adolescents would be associated with functional connectivity within networks encompassing limbic and paralimbic brain regions, such as the DMN, SN, and ECN.

2. Methods

2.1. Participants

The present sample was drawn from the NIMH-funded Southwest Advanced Neuroimaging Cohort, Youth sample (SWANC-Y), collected between June 2007, and May 2011 in a maximum-security facility in New Mexico and from ongoing (2011–15) research at a youth detention facility in Wisconsin. This research was approved by the University of New Mexico Human Research Review Committee. Youth provided written informed assent as well as parent/guardian written informed consent. Participants were excluded if they had a history of seizures, traumatic brain injury, psychosis, other major medical problems, or were not fluent in English at or above a grade four reading level. Resting-state scans, and Psychopathy Checklist–Youth Version (PCL-YV) scores were available from n = 227 male adolescents. After excluding n = 9 for excessive motion or radiological findings and n = 17 who met the above exclusion criteria after scanning, our final sample consisted of n = 201 participants. The sample contained 177 complete cases. Participants were paid a flat rate, yoked to the standard institutional hourly pay scale, for participation in the study.

2.2. Measures

2.2.1. Psychopathic traits

Assessment with the PCL-YV includes a review of institutional records and a semi-structured interview regarding individuals' school, family, work, and criminal histories, and their interpersonal and emotional skills (Forth et al., 2003). Individuals are scored on 20 items that measure personality traits and behavioral characteristics of psychopathy. Scores range from 0 to 40. For adults, the accepted diagnostic cutoff for psychopathy is 30 and above. However, due to developmental issues, this cutoff is not used for adolescents. Although technically there is no Factor 1 and 2 in the PCL-YV, for comparison to adult samples, we examined a two-factor model of psychopathic traits in addition to a Total PCL-YV score, with Factor 1 composed of interpersonal and affective traits, and Factor 2 composed of lifestyle and antisocial traits. Factor 1 and 2 in youth were computed the same way it is done in adults (Hare, 2003).

This sample covered a wide range of PCL-YV scores, including a sufficient number of high scorers (PCL-YV > = 30, n = 56) indicating a high level of psychopathic traits. Interviews were conducted by trained researchers and videotaped for reliability assessment (12% of interviews (randomly selected) were double-rated; intra-class correlation coefficient (ICC 1,1) = 0.90 for PCL-YV Total score).

2.2.2. IQ

IQ was estimated from the Vocabulary and Matrix Reasoning subtests of the Wechsler Adult Intelligence Scale-Third Edition for participants older than 16 years of age, and from the Wechsler Intelligence Scale for Children–Fourth Edition for participants younger than 16 years of age (Wechsler, 1997, 2003).

2.2.3. Substance use

Trained researchers administered the Kiddie Schedule for Affective Disorders and Schizophrenia (KSADS) (Kaufman et al., 1997). From the KSADS, we examined what substances were used. Moreover, for alcohol and cannabis, participants were asked how many months they used regularly (3 or more times/week). To approach a normal distribution, the duration of alcohol abuse was log transformed. During MRI assessment, all participants were in forced abstinence, many for at least 6 months.

2.2.4. Attention deficit hyperactivity disorder

Attention deficit hyperactivity disorder (ADHD) was diagnosed by trained researchers using KSADS.

2.2.5. Imaging data

All participants were scanned at the maximum-security facilities using The Mind Research Network's 1.5 T Avanto SQ Mobile MRI scanner. We used an EPI gradient-echo pulse sequence with TR/TE 2000/39 ms, flip angle 90°, FOV 24 × 24 cm, 64 × 64 matrix, 3.4 × 3.4 mm in-plane resolution, 5 mm slice thickness, 30 slices. Head motion was minimized using padding and restraint. During the 5-min scan, participants were requested to look at the fixation cross hair and to keep eyes open. Participants were monitored by video.

2.3. Data analysis

2.3.1. Preprocessing

Functional MRI data were preprocessed using the SPM software