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REDUCED CORTICAL THICKNESS AND INCREASED SURFACE AREA IN ANTISOCIAL PERSONALITY DISORDER

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Abstract—Antisocial personality disorder (ASPD), one of whose characteristics is high impulsivity, is of great interest in the field of brain structure and function. However, little is known about possible impairments in the cortical anatomy in ASPD, in terms of cortical thickness (CTh) and surface area (SA), as well as their possible relationship with impulsivity. In this neuroimaging study, we first investigated the changes of CTh and SA in ASPD patients, in comparison to those of healthy controls, and then performed correlation analyses between these measures and the ability of impulse control. We found that ASPD patients showed thinner cortex while larger SA in several specific brain regions, i.e., bilateral superior frontal gyrus (SFG), orbitofrontal and triangularis, insula cortex, precuneus, middle frontal gyrus (MFG), middle temporal gyrus (MTG), and left bank of superior temporal sulcus (STS). In addition, we also found that the ability of impulse control was positively correlated with CTh in the SFG, MFG, orbitofrontal cortex (OFC), pars triangularis, superior temporal gyrus (STG), and insula cortex. To our knowledge, this study is the first to reveal simultaneous changes in CTh and SA in ASPD, as well as their relationship with impulsivity. These cortical structural changes may introduce uncontrolled and callous behavioral characteristic in ASPD patients, and these potential biomarkers may be very helpful in understanding the pathomechanism of ASPD.

Key words: cortical anatomy, impulsivity, response inhibition, MRI, cortical thickness, surface area.

INTRODUCTION

Antisocial personality disorder (ASPD) describes patterns of antagonism and impulsively aggressive behaviors that begin in childhood and remain stable throughout the lifespan according to Diagnostic and Statistical Manual of Mental Disorders (DSM-V). Epidemiological studies report a prevalence of 2–3% in the general population, with estimates of approximately 3% in men and 1% in women (Gibbon et al., 2010). Furthermore, 47% of male prisoners in worldwide prison systems were diagnosed with ASPD (Fazel and Danesh, 2002), showing a very close link between ASPD and criminal behavior.

Abnormal brain structures are found to correlate with ASPD, based on morphological MRI studies. Raine et al. found that the prefrontal gray matter volume in ASPD was reduced by about 11% in comparison to that of the control group (Raine et al., 2000). The reduced gray matter volume in the prefrontal cortex was replicated in many other studies of ASPD (Yang and Raine, 2009). Reduced gray matter volume of temporal regions was also revealed in ASPD (Bassarath, 2001; Barkataki et al., 2006). Additionally, the relationship between impulsive aggression and the reduced volume of the frontal lobe was also found in ASPD patients (Raine et al., 2000; Laakso et al., 2002). These studies of ASPD mainly focused on gray matter volume. However, the cortical gray mater volume is essentially jointly determined by biologically distinct cortical attributes of cortical thickness (CTh) and surface area (SA), each having its own cellular mechanism and genetic underpinning, thus providing unique and complementary information of the cortex (Chen et al., 2013; Lyall et al., 2015; Li et al., 2016). More importantly, CTh and SA have been found distinctively correlated with cognitive functions, but also differentially affected in various brain disorders (Lyall et al., 2015). Hence, studying CTh and SA can better capture subtle, but important, cortical changes associated with ASPD. Ly et al. found that psychopathy patients showed cortical thinning in a number of regions, specially the left insula, bilateral anterior temporal cortices and right inferior frontal

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Abbreviations: ACC, anterior cingulate cortex; ASPD, antisocial personality disorder; CTh, cortical thickness; DSM-V, diagnostic and statistical manual of mental disorders; EF, executive function; GLM, general linear model; MFG, middle frontal gyrus; OFC, orbitofrontal cortex; SA, surface area; SFG, superior frontal gyrus; SFS, superior temporal sulcus; STG, superior temporal gyrus.

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gyrus (Ly et al., 2012). Though psychopathy shares behavioral overlap with the clinical diagnosis of ASPD, ASPD is not synonymous of psychopathy (Blair, 2012). Currently, the study of cortical anatomy on ASPD population is still scarce. The changes in CTh and SA in ASPD still remain unclear.

Impulsivity is a central and important characteristic of ASPD according to DSM-V. Response inhibition, i.e., impulse control is the main impulsivity variable (Dougherty et al., 2005). Swann et al. found that ASPD was characterized more by increased rapid-response impulsivity, while aspects of impulsivity about reward-delay or attention appear relatively intact (Swann et al., 2009). GoStop impulsivity paradigm developed by NRLC-group can measure the level of impulse control or rapid-response impulsivity precisely (Dougherty et al., 2005). This paradigm has been used in all kinds of people, e.g., borderline personality disorder (BPD) (Cackowski et al., 2014), internet addiction (Li et al., 2014a), and substance abuse (Coffey et al., 2011). But to date, there is no study on the correlation between CTh/SA changes and the levels of impulse control in ASPD.

In this study, we hypothesized that there were distinct alterations in CTh and SA in ASPD, and there also were potential relationships between these structural changes and the ability of impulse control. This study will provide valuable information regarding to the abnormal neuroanatomy of ASPD, while also highlighting the potential relations between structural changes and impulsivity in ASPD patients.

EXPERIMENTAL PROCEDURES

Participants

The School for Youth Offender of Hunan Province performed ‘‘Enclosed-style” management and reformatory education for those offenders under 18 years of age, when committing certain crimes, e.g., robbery and violent attacks. We recruited volunteers at legal age (18 years of age at scan) from this school. The participants were diagnosed whether with ASPD or not, according to the following steps. In the first step, all the volunteers in groups were tested by a professional using the Personality Diagnostic Questionaire-4 +(PDQ-4 +). For those ASPD scores equal to or above 4 score, two senior psychiatrists then tested whether they had Axis 1 disorders of major mental illness and excluded those with Axis 1 disorders. The remaining volunteers were continuously tested using the structured clinical interview for DSM-IV (SCID-II) by the same psychiatrists. The SCID-II is a diagnostic exam to determine personality disorders. Finally, 27 subjects were diagnosed with only ASPD, i.e., all ASPD disorders met both PDQ-4 criteria and SCID-II criteria for ASPD. We also chose 25 healthy control subjects, who met neither PDQ-4 criteria nor SCID-II criteria for ASPD. All the controls were tested using the same methods as ASPD disorders by the same psychiatrists. The control subjects were matched to the ASPD subjects in age, education, and IQ (Table 1). IQ score of each subject was obtained using Wechsler Adult Intelligence Scale. One-way ANOVAs were performed on the demographics of the groups to test whether the groups were well matched.

Table 1. Characteristics of the participants in this study

	ASPD (Mean ± SD)	Controls (Mean ± SD)	*p*-Value
Number	27	25	–
Gender	27 males	25 males	–
Age (Years)	20.30 ± 3.01	21.13 ± 3.16	0.385
Education (Years)	9.54 ± 3.42	10.26 ± 2.33	0.753
IQ	94.55 ± 8.62	95.30 ± 10.5	0.797

ASPD: Offenders with antisocial personality disorder.

All subjects were right-handed native Chinese speakers, with no history or current diagnosis of drugs abuse, and they were kept away from alcohol at least 6 months before the experiment. They were accompanied by three instructors individually during the experiment. This study was approved by the Ethics Committee of the Third Xiangya Hospital of Central South University and also the Ethics Committee of the School for Youth Offender of Hunan Province. All volunteers signed on the written informed consent after they understood the study.

Impulsivity measure

In the task, we used GoStop impulsivity paradigm to measure the level of impulse control. Black five-digit numbers are presented successively on the computer screen (with each 500 ms following by 1-s blank screen). When the present number is the same as the previous number, the participant should press a mouse button as quickly as possible (‘no-stop trials’). When the target’s color changes from black to red (‘stop signal’, occurring from 50, 150, 250 to 350 ms after stimulus onset), the response needs to be withheld (‘stop trials’). If the five-digit number does not exactly match the previous number, the participant must withhold responding (‘novel trials’). In our study, no-stop trials were 25% of the trials, stop trials 25%, and novel trials 50%. The total number of all trails was 160 and the task lasted 240 s. Before the normal task, the participants received a detailed description of the task and underwent a training session of 60 s so as to be familiar with the task. To ensure cooperation, the response accuracy of each subject during ‘‘novel trials” and ‘‘stop trials” were calculated. The subjects whose response accuracies in the ‘‘novel trials” and ‘‘stop trials” conditions were lower than 80% were excluded. The level of impulse control is calculated as the percentage of successful inhibition. Lower percentages of successful inhibitions (during ‘stop trials’) indicate more difficulties with response inhibition.

To investigate whether there were significant differences between groups under different delay tasks, independent-sample *t*-tests were employed.

Image acquisition

T1-weighted structural magnetic resonance images were acquired at the Third Xiangya Hospital of Central South