Structural Variation of the Insula and Psychopathic Traits: A Community Sample Study

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Universidade do Minho
Escola de Psicologia

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Professora Doutora Adriana Sampaio

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STATEMENT OF INTEGRITY

I hereby declare having conducted this academic work with integrity. I confirm that I have not used plagiarism or any form of undue use of information or falsification of results along the process leading to its elaboration.

I further declare that I have fully acknowledged the Code of Ethical Conduct of the University of Minho.

Acknowledgements

In 1159 John of Salisbury said: "We are like dwarfs sitting on the shoulders of giants”, it is a great quote for the academia, given that every step that we accomplish can always be traced back to someone else’s work.

I have come to see in the past year that I’m a lucky dwarf, seeing that I’m being supported not by one, but by a great many number of giants throughout my path, and now it’s the time to thank them all for their efforts.

In these short lines I would like to show my appreciation to my family and close friends for their strength in times when I felt down or like giving up. To all laboratory colleagues, that helped me both in my work and personally and to my girlfriend for the enormous academic encouragement given in the past few months.

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Abstract

Psychopathy is a personality disorder marked by deficit in emotional processing, antisocial behavior, interpersonal manipulation and impulsive and erratic lifestyle. Functional and structural imaging studies have been used for analyses in cortical thinning and volume of grey and white matter in brain structures to identify the underlying abnormalities in psychiatric disorders. Previous studies indicate that individuals with psychopathy show an impaired response in the insula when processing emotional information, and this has been hypothesized to contribute to their callous-unemotional behavior. In parallel, it has also been found that these individuals display structural alterations in this region. Psychopathy is regarded as a dimensional construct and evidence points to continuities in the neurocognitive mechanisms that underlie the disorder. However, it is yet unknown whether the functional and structural abnormalities found in clinical and forensic samples can also be verified in subclinical groups or even if the same impaired processes are applied. Furthermore, it is still uncertain if the structural variation associated with psychopathic traits contribute to the etiology of the disorder or not. The objective of this study was to test if the same pattern of insula structural alterations was associated with the variance in psychopathic traits in the general population. Using a community sample (n=58) and measures of grey matter and white matter computed of T1 MRI data, our results show that the grey matter volume in the right insula and the white matter volume bilaterally is negatively associated with several psychopathic traits, indicating continuities in the neuro correlates of this disorder.

Key words: White matter, grey matter, Insula, psychopathic, community sample

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Psychopathy

Psychopathy was first classified in Hervey Cleckley's 1941 "The Mask of Sanity", as the condition present in a person who could disguise his or her internal conflicts and lack of structure and continuously pursue violent behavior (Pemment, 2013). A decade later, after the forming of the American Psychiatric Association, the DSM (1952) defined the Antisocial Reaction in "individuals who are chronically in trouble and do not seem to change as a result of experience or punishment, with no loyalties to anyone" (Pull, 2013). Currently, the DSM-5 classifies the Antisocial Personality Disorder as "a persistent pattern of disrespect and violation of the other's rights". It is necessary to note that there are several distinct aspects in the psychopathic personality that set it apart from Antisocial Personality Disorder: one is the use of instrumental aggression – predatory (proactive) and goal-oriented (Glenn & Raine, 2009); the second is the lack of empathy and remorse towards violent behaviors, acts which psychopaths are remarkably prone to (Glenn & Raine, 2009).

In 1980, Robert Hare developed a tool to evaluate psychopathy, the PCL (Psychopathic Checklist), based on Checkley's 1941 documented psychopathic traits. Throughout the years it became an important method to appraise psychopathy (Hare & Neumann, 2006), were the current version is the Hare's PCL-Revised second edition (2003), which continuous to fuel the study of the disorder. Nowadays psychopathy has a more clearly defined boundaries of diagnosis (Pemment, 2013), and Hare's PLC-R is currently the standard measure of psychopathy in clinical and forensic settings (Filho, Teixeira, & Almeida, 2014). The PCL-R measures psychopathic traits in its various facets: (a) interpersonal, which is represented as superficial charm, manipulation and deception of others, frequently along with a grandiose view of one's self; (b) callous affect, expressed through the lack of empathy and remorse, and superficial affection towards others; (c) erratic lifestyle, that combines irresponsibility, impulsivity, lack of self-motivation and unrealistic future perspectives; (d) antisocial behavior, conveyed by delinquency and poor behavioral control (Bishopp & Hare, 2008; de Oliveira-Souza et al., 2008; Glenn, Raine, Yaralian, & Yang, 2010). These four facets can be grouped in 2 higher-order factors: Factor 1, which comprises interpersonal and affective facets and factor 2 which comprises erratic lifestyle and antisocial behavior facets (Bishopp & Hare, 2008; Filho et al., 2014).

The development of self-report instruments, such as the Self Report Psychopathy Scale 4 (SPR-4) (Paulhus et al., 2016) or its short form the SRP-SF (Paulhus et al., 2016), allowed for the measurement of psychopathy in samples without clinical/forensic records and thus the development of studies in the general population which have demonstrated that psychopathy is a dimensional construct (see e.g. Seara-Cardoso & Viding, 2015 for a review). That is, psychopathic traits are distributed continuously and are present in different degrees both in prison samples and in the general population (e.g., Edens, Marcus, Lilienfeld, & Poythress, 2006;Hare & Neumann, 2008).

Neural basis of psychopathy

The neural basis underlying psychopathic traits are still somewhat elusive (Ewbank et al., 2018). In the past decades, studies using structural and functional imaging techniques have been trying to identify the neural substrata in the psychopathic personality, which could shed some light on the underlying aspects of human social behavior (Cope et al., 2012). One method to inspect the neural substrates involved in the mental process of psychopathic behavior is by using advanced brain imaging techniques such as fMRI, coupled with tasks that invoke the root processes associated in the impaired functioning of psychopaths. (e.g. Anderson et al., 2017;Espinoza et al., 2018; Pera-Guardiola et al., 2016; Yoder, Harenski, Kiehl, & Decety, 2015).

With the access to functional image techniques, various authors hypothesize that the primarily impairment in psychopathic individuals could be due to the dysfunction on affective processing networks (e.g. Thijssen, & Kiehl,2017;Espinoza et al., 2018; Anderson et al., 2017; Yoder et al., 2015). One of these key regions is the insula. This little subcortical area is crucial in emotional processes, decoding internal stimuli, and thought to play a critical role in empathic and moral processing (Horan, Brown, Jones, & Aber, 2016; Namkung, Kim, & Sawa, 2018; Seara-Cardoso & Viding, 2015; Seara-Cardoso et al., 2016).

Consistent with the notion that psychopathy is linked to abnormal affective functioning, and that this is one of the defining deficits of the disorder, fMRI studies have consistently reported abnormal neural response in the insula (Seara-Cardoso & Viding, 2015). For example, it has been found that individuals with psychopathy present reduced insula response when responding to emotional stimuli (Anderson et al, 2018), during emotional learning (Birbaumer et al., 2005), empathic processing (Decety & Yoder, 2015; Meffert, Gazzola, Den Boer, Bartels, & Keysers, 2013) and in affective theory of mind tasks (Decety

& Yoder, 2015). Abnormal functioning in the insula in individuals with psychopathy is thus thought to contribute to their callous and unemotional behavior towards others (Critchley., Mathias., & Dolan, 2002; Seara-Cardoso & Viding, 2015; Namkung et al., 2018).

In light of the idea that there are continuities in the neurocognitive mechanisms that underlie psychopathy, studies with samples from the community have found that psychopathic traits in the general population are negatively associated with insula response during empathic processing (Seara-Cardoso, Viding, Lickley, & Sebastian, 2015), moral processing (Seara-Cardoso et al., 2016) and recognizing fearful expressions (Sethi et al., 2018).

Studies using structural imaging techniques have scrutinized if volumetric alterations could also be found in this region, considering there is considerable literature that show reduced activity in the insula in individuals with higher psychopathic traits. Several studies have reported finding anatomical differences in the insula. For example, grey matter reductions (de Oliveira-Souza et al., 2008;Tiihonen et al., 2008; Pera-Guardiola et al., 2016), insula thinning (Ly et al., 2012) and, negative correlations between PCL-R antisocial and lifestyle facets and insula's grey matter (Cope et al., 2012). However, conflicting findings have been stated, Ermer and colleagues(2014) found no associations between anatomical measures of the insula and PLC-R results.

In conclusion, most of structural studies points to negative associations between insula's volume and psychopathic traits, regardless, it is important to note that even though these findings are critical to understand the neural substrates of psychopathy, most studies have clinical or forensic samples, making it difficult to assess how psychopathy and its neuro correlates are represented in a continuum in the general population.

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Insula and its components

The insula it's a trapezoid shaped structure, that is deep-seated in the lateral sulcus bilaterally and associated to several neural pathways and areas, such as the dorsolateral prefrontal cortex, amygdala and anterior cingulate cortex (Chiarello, Vazquez, Felton, & Leonard, 2013; Namkung, Kim & Sawa, 2018). It is also incorporated into the paralimbic system (Kiehl, 2006) and divided into posterior and anterior regions. Whereas the posterior area is thought to be involved in motor integration/control and somatosensory processing and, the anterior area is associated to the processing of salient inputs and is assimilation into motivational, cognitive and emotional information (Namkung, Kim & Sawa, 2018).

Furthermore the insula is thought to process salient information from the subjective feelings, which could be the foothold for the formation of one's "self" (Namkung, Kim & Sawa, 2018).

As almost every other brain structure, the insula is composed of grey matter and white matter. These two types of brain substance have different compositions, that result in different functions throughout the brain. Grey matter is composed mainly of neuronal cell bodies and glia cells and is commonly associated with information-processing ability, whereas white matter it's composed of myelinated axons and thought to be implicated in the information stream between brain areas (Zatorre, Fields, & Johansen-Berg, 2012; Privado, Román, Saénz-Urturi, Burgaleta, & Colom, 2017).

These two types of brain matter are essentially to the proper neural functioning, whereas damage to one or the other can result in impairments to our normal behavior (Namkung, Kim & Sawa, 2018; Filley & Fields, 2016; Hart, Wyttenbach, Hugh Perry, & Teeling, 2012;Walhovd, Johansen-Berg, & Káradóttir, 2014;Karadottir & Walhovd, 2014)

The present study

In sum, recent evidence suggests that psychopathy is a dimensional, rather than a categorical, construct. That is, psychopathic traits are distributed in a continuum in the general population. Findings from behavioral and fMRI studies in the general population are in line with this notion (Seara-Cardoso & Viding, 2015). Yet, it is still unknown whether variance in psychopathy traits in the general population is associated with volumetric alterations in the insula in the same way as has been found in forensic and clinical samples. In this study, we aim to inspect if anatomical correlates of grey matter volume (GMV) and white matter volume (WMV) of the insula are related with psychopathic traits in individuals from the general population. Particularly the insula since it has been consistently found to be impaired in clinical samples and its dysfunction has been hypothesized to be linked to the callous-unemotional behavior that is the hallmark of the disorder. As an overarching hypothesis, we anticipate that variance in psychopathic traits will be negatively associated with volumetric indices of this region.

Methods

Participants

The database was composed of brain images of 59 subjects recruited for a research project at University College London. Only right-handed males were selected from the community and subjects' age range was between 20- 40 years with a mean age of 24.7 years. All participants filled in a psychopathic trait's questionnaire (the SRP-SF) (table 1), and afterwards MRI scans were performed. Each participant was given a written informed consent comprising all necessary information about the study, as well as a small monetary payment. BUCNI, University College of London, Birckbek Ethics Committee approved this research.

Table 1: Sample characteristics

Measures	Participants (n=58)				
	Mean	SD	Range	Minimum	Maximum
Age	24,74	4,87	20	20	40
SRP Total	54,38	14,65	64	30	94
Interpersonal Manipulation	14,44	5,31	20	7	27
Callous Affect	13,84	4,42	21	7	28
Erratic Lifestyle	15,93	5,25	24	7	31
Criminal Tendencies	10,15	3,63	18	7	25
Factor 1	28,29	8,91	41	14	55
Factor 2	26,08	7,54	32	14	46

Note. SD= Standard deviation

Materials

Self-Report Psychopathy Short Form (SRP-SF; Paulhus et al., 2016).

The Self-Report Psychopathy Short Form (SRP- SF) is a self-report inventory that utilizes a 5-point Likert scale (1 = strongly disagree to 5 = strongly agree), having 29 selected items of its original 64 items version, the Self-Report Psychopathy scale 4 (SRP-4) (Paulhus et al., 2016). It establishes the same models as the PCL-R, the four-factorial model (interpersonal manipulation, callous affect, erratic lifestyle and antisocial/ criminal tendencies), or the two factor model (factor 1 and factor 2 of psychopathy) (Paulhus et al., 2016). The total score and the individual facets score are acquired through the sum of individuals item points.

MRI Acquisition

MRI scans were acquired using a Siemens Avanto 1.5 T MRI scanner at the Birkbeck-UCL Centre for Neuroimaging with a 32-channel headcoil. A high-resolution, 5.5 min 3D T1-weighted structural scan was acquired using a magnetization prepared rapid gradient echo (MPRAGE) sequence. Imaging parameters were: 176 slices; slice thickness = 1 mm; gap between slices = 0.5 mm; TR = 2730 ms; TE = 3.57 ms; field of view = 256 mm x 256mm2; matrix size = 256 × 256; voxel size = 1 × 1 × 1 mm resolution).

MRI Processing

Analyses were completed using the standard FreeSurfer (5.1) processing stream (http://surfer.nmr.mgh. harvard.edu/), following the associated workflow procedures. Data on volume and thickness of grey matter and white were obtained from high-resolution T1 MPRAGE volumes in DICOM format and then imported into the FreeSurfer image analysis environment. Semi-automated methods employing the default surface-based and volume-based pipelines were used, including registration with the Hammers atlas (Hammers et al., 2003), intensity normalization, skull stripping, pial and white matter boundary determination (Churchwell & Yurgelun-Todd, 2013). To label each voxel in a MRI volume it was required an automated registration procedure based on probabilities estimated from a manually labelled training set (Churchwell & Yurgelun-Todd, 2013). To determine insula's boundaries and volumes, Hammers' (2003) Atlas of maximum probability of Human brain areas, was used in FreeSurfer program. Due to the extended cost of human resources in time to manually define anatomic boundaries in brain regions, Hammers and his colleagues decided to restrain the map to 49 structures, including right and left insula.

In Hammers' Atlas the posterior extremities of the insula have been delimitated by the sulcus circularis insulae. In superior and inferior boundaries, the insula was delineated by the parietal lobe and defined as part of it; Noting that in the case of the inferior limit it was admitted as part of parietal lobe, solely if it was still connect physically with others areas labelled as in the parietal lobe (Hammers et al., 2003). The different measures of the insula in Hammers' brain map are then labeled as: [H_VWM_lIns] for volume of white matter in left insula, [H_VWM_rIns] for volume of white matter in right insula, [H_VGM_lIns] volume of grey matter in left insula and, [H_VGM_rIns] volume of grey matter in right insula.In regard of thickness measures the labels are: [H_TWM_lIns] for white matter thickness of in left insula, [H_TWM_rIns] for white matter thickness in the right insula, [H_TGM_lIns] grey matter thickness in the left insula and the last as [H_TGM_rIns] for grey matter thickness in the right insula. In table 2 is represented all the anatomical variables utilized and its respective mean and standard deviation.

Table 2: Anatomical measurements

Measures	Participants (n=58)				
	Mean (mm^3)	SD	Range	Minimum	Maximum
Total grey matter	761,6	61,53	280,63	637,40	918,04
Total white matter	581,03	49,76	240,51	458,81	699,33
Thickness grey matter left insula	1,67	,09	3,878	1,44	1,89
Thickness grey matter right insula	1,78	,13	3,67	1,48	2,21
Volume grey matter left insula	8,75	,746	,44	7,01	10,89
Volume grey matter right insula	8,79	,75	,72	7,36	11,03
Thickness white matter left insula	1,09	,07	4,35	,90	1,27
Thickness white matter right insula	1,15	,08	4,03	,99	1,47
Volume white matter left insula	8,62	,92	,36	6,32	10,68
Volume white matter right insula	8,20	,88	,47	5,95	9,99

Note. SD= Standard deviation

Data Analysis

Statistical analyses between SRP-SF scores and insula volumes were conducted using Statistical Package for the Social Sciences, version 25 (SPSS-25). We performed three distinct analyses utilizing our database. Two of which were to ensure that our sample was within the necessary assumptions needed for conducting Pearson correlations. Descriptive analysis was carried out to verify the presence of outliers within our sample and the normality of the data distribution. We identified the one outlier in the sample where it showed extreme results in most scores of the self-report measures preformed, being remove afterward from the sample.

A second analysis was carried out to ensure a normal distribution of our data, of which we report that all variables follow a normal distribution.

The third and final analyses was partial correlations between insula measurements ([H_VWM_lIns],[H_VWM_rIns], [H_VGM_lIns],[H_VGM_rIns], [H_TWM_lIns], [H_TWM_rIns], [H_TGM_lIns], [H_TGM_rIns]) and SRP-SF scores (SRP Total; Interpersonal Manipulation; Callous affect; Erratic Lifestyle; Criminal Tendencies; factor1 and Factor2). For each of the analysis two variables were always introduced as controlling covariates. To control individual fluctuations in brain mass (De Brito et al., 2009), we used age and total grey matter volume or total white matter volume, depending on which measure we were analyzing as control variables.

Results

Partial correlations between insula grey matter and SRP-SF scores

Partial correlations between insula's grey matter volume and thickness and SRP-SF scores, controlling for age and total grey matter, revealed a weak but significant negative correlation (r= -.268 *p*= .046) between right insula grey matter volume and SRP Factor 2 (i.e. Erratic Lifestyle – Criminal tendencies dimension At-trend association was also found between left insula grey matter volume and factor 2 (r= -,262 *p*= ,051). All other correlations were non-significant (table 3).

Table 3: Analysis of correlation between Insula's grey matter measures and SRP factors

	SRP Scores						
	SRP Total	Interpersonal Manipulation	Callous Affect	Erratic Lifestyle	Criminal Tendencies	Factor 1	Factor 2
Left insula grey matter							
Thickness (Age and TGM)	-,060	,102	,012	-,159	-,175	,066	-,196
Volume (age and TGM)	-,242	-,188	-,132	-,200	-,253	-,176	-,262
Right insula grey matter							
Thickness (Age and TGM)	,040	,136	,045	,034	-,141	,103	-,044
Volume (age and TGM)	-,236	-,181	-,112	-,218	-,241	-,162	-,268*

Note. TGM = Total Grey matter; SRP= Self-Report Psychopathy Scales

p < .05. **p < .01.

Partial correlations between insula white matter and SRP-SF scores

In a similar fashion to grey matter analysis in insula, we performed partial correlations controlling for participants' age and total white matter, between white matter measurements of the insula and SRP-III results. In comparison to grey matter analysis results, significant correlations in white matter appeared in several SRP-III scores. In table 4 it is possible to verify that white matter volume in the left insula has a moderate and negative correlation with the *Interpersonal Manipulation* facet and *Factor* 1 (r= -,293, *p*= ,029 and *r*= -,298 *p*= ,024 respectively). Furthermore, in table 4 it is present the correlations between the same white matter measurements (volume and thickness) and right insula. Negative associations appear between white matter volume and *Erratic Lifestyle* (r= -,264, *p*=,049) with a weak correlation, with

SRP total score (r= -,277, *p*= ,039) and *Factor 1* (r= -,294, *p*= ,028) with modest correlations, only strong and negative correlations occur with *Interpersonal Manipulation* (r= -,312, *p= ,*019).

Table 4: Analysis of correlation between Insula white matter and SRP factors

	SRP Scores						
	SRP Total	Interpersonal Manipulation	Callous Affect	Erratic Lifestyle	Criminal Tendencies	Factor 1	Factor 2
Left insula White matter							
Thickness (Age and TGM)	-,022	,118	-,013	-,062	-,152	,063	-,118
Volume (age and TGM)	-,242	-,293*	-,247	-,201	,054	-,298*	-,113
Right insula white matter							
Thickness (Age and TGM)	,052	,106	,036	,098	-,131	,081	,004
Volume (age and TGM)	-,277*	-,312*	-,216	-,264*	-,006	-,294*	-,187

Note. TGM = Total Grey matter; SRP= Self-Report Psychopathy Scales

p < .05. **p < .01.

Discussion

The stringent notion of Cleckley's psychopathy is no longer a contemporary one. Research in the mechanism underlying psychopathic behavior expose some of the specific deficits in this interesting disorder and indicate that psychopathic traits are represented in various degrees in the general population

(Edens, Marcus, Lilienfeld, & Poythress, 2006; Hare & Neumann, 2008; Seara-Cardoso & Viding, 2015). The majority of functional studies in psychopathy point to impairments in emotional/affective networks (Espinoza et al., 2018; Seara-Cardoso & Viding, 2015), in which the insula is a feature region in several processes (Horan, Brown, Jones, & Aber, 2016; Namkung, Kim, & Sawa, 2018; Seara-Cardoso et al., 2016). Structural research in forensic/clinical samples have reported negative associations between psychopathic facets/factors and volumetric measures of grey matter in the insula (e.g. de Oliveira-Souza et al., 2008; Ly et al., 2012; Tiihonen et al., 2008).

Considering previous structural research in the insula and taking into account that psychopathic traits have a dimensional representation in the general population, the present study attempted to investigate if volumetric alterations of white matter and grey matter in the insula were associated with psychopathic traits in the general population. In line with our hypothesis, the main findings in this study can be summarized in three distinct elements: adults from the community show a (i) significant negative association between right insula grey matter volume and erratic lifestyle and criminal tendencies ; (ii) significant negative association between left insula white matter volume and interpersonal manipulation psychopathic traits; and finally (iii) a significant negative association between right insula white matter volume and interpersonal manipulation traits and erratic lifestyle traits.

Previous studies with forensic and clinical samples and healthy control groups indicate that psychopathy traits are negatively associated with insula grey matter volume and thinning (de Oliveira-Souza et al., 2008; Pera-Guardiola et al., 2016; Tiihonen et al., 2008). Plus, Cope and colleagues (2012) report negative correlations between specific PCL-R facets, respectively the antisocial behavior (criminal tendencies) and erratic lifestyle, and the volume of grey matter in the insula using a community sample.

We found a significant negative association between erratic lifestyle and criminal tendencies and right insula grey matter volume, and an at-trend negative association with left insula grey matter volume, which appear to be in line with previous reports in forensic samples (e.g. Cope et al., 2012). Grey matter is thought to be involved in information processing (Privado, Román, Saénz-Urturi, Burgaleta, & Colom, 2017) which means that when damaged, difficulties arise in its capability to do so. Nevertheless damage to grey matter seems to have a lesser impact in neural response than damage to white matter (Berthiaume, Shultz, & Dammann, 2010). The insula is thought to be implicated in processes such as cognitive, motivational, emotional and moral processing, as well as processing the salient information from subjective feelings states (Horan et al., 2016; Namkung et al., 2018; Seara-Cardoso, Neumann, Roiser, McCrory, & Viding, 2012). Its dysfunction is associated with abnormal social emotion processing (Namkung et al., 2018).

It is possible that decreased grey matter in this region gives leads to its poorer functioning and thus give rise to characteristics such as erratic lifestyle and antisocial behavior/criminal tendencies which require a certain level of disregard for the well-being of others and of one's self. Importantly, this finding are aligned with studies from clinical/forensic samples, suggesting that there are continuities in the neural correlates of psychopathic traits throughout its continuum.

To the best of our knowledge, our findings regarding the negative associations between insula white matter volume, bilaterally, and psychopathic traits have not been reported before, either in forensic or community samples.

Our results show negative associations between insula's white matter volume, bilaterally, and several SRP-SF facets and factor 1. White matter is responsible for transferring information across brain areas, connecting all the brain regions within itself (Zatorre, Fields, & Johansen-Berg, 2012), and when white matter its affected neural connectivity is reduced(Cristofori. et al., 2015).

Although some caution is required in the making of inferences, these results are in-line the hypothesis of a network impairment, according to which dysfunctions in specific networks, related to emotional and affective processing, are the core feature of behavioral and emotional deficits in psychopathic individuals. The volumetric reduction in white matter in the insula could represent short comings in neural connectivity with other areas, since it is connect to several structures including the amygdala, anterior cingulate cortex, the dorsolateral and the ventromedial prefrontal cortices (Chiarello, Vazquez, Felton, & Leonard, 2013; Namkung, Kim and Sawa, 2017), areas known to be related with abilities that are typically compromised in individuals with high levels of psychopathic traits such as, emotional processing and social behavior (Anderson et al., 2017; Thijssen, Kiehl 2017; Tiihonen et al., 2008).

Contrarily to Ly and colleagues (2012) we did not find any correlations between grey matter or white matter thickness in the insula and psychopathic traits. This difference between results could be due the methodology used in each study. For starters in our study, thickness measures were computed through the Maximum Probability Atlas of the human brain developed by Hammers et al.(2003), in contrast, in Ly and collegaues (2012) thickness measures were calculated individualy for each participant and using the distance between the pial surface and the surface of white matter. Since Ly et al. (2012) method for collecting brain anatomical data was done in a individual manner, it is possible that a more rigorous clouster of thickness measures was gathered, and therefore different results could emerge.

Potential limitations in this study are (1) that we didn't performed tests to evaluate IQ or drug abuse, therefore not being able to control for those variables. This would be relevant because IQ has been showed to have positive correlations with grey and white matter volume in the insula (Haier, Jung, Yeo, Head, & Alkire, 2004) and the impact in functional and structural alterations due to substance abuse have repeatedly been indicated in the literature (Fowler, Volkow, Kassed, & Chang, 2007); and (2) no evaluation was made regarding psychiatric disorders, such as depression or anxiety, this being a limitation given that these disorders have been reported as having an impact in insula's grey matter volume (Namkung et al., 2018). (3) Compared to the posterior insula, the anterior region of the insula seems to be more involved in emotional processes, in this study we computed both regions as a whole structure, this methodological approach could somewhat provoke bias effects in the analyses.

Regardless of these limitations, including participants of various backgrounds, promotes a heterogeneous sample, heightening the generalization power of the results.

Future research investigating the continuum of structural alterations associated with psychopathic traits in community samples should focus in: (1) larger sample to strengthen the statistical power, and (2) consider the usage of methods to collect brain measurements data, with specific "handmade" calculations as Ly et al. (2012), since it's not based in a probabilistic approach.

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