

Faculdade de Medicina da Universidade do Porto

**Influence of psychopathic traits on social interaction
patterns: Behavioral and neuroimaging evidence**

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Resumo

A psicopatia é uma combinação de traços de personalidade associados a ausência de remorso, impulsividade e comportamento antissocial. Em virtude destas características, os indivíduos com tendências psicopáticas provocam com frequência danos financeiros, emocionais e físicos a terceiros. Uma melhor compreensão dos mecanismos psicobiológicos que subjazem aos défices afectivos e interpessoais observados na psicopatia poderá contribuir para desenvolver meios para minimizar o impacto negativo que indivíduos com elevados traços psicopáticos têm na sociedade.

O presente trabalho centrou-se na influência de traços psicopáticos no comportamento social e, em concreto, nos correlatos neuronais das decisões sociais e do comportamento interpessoal. O primeiro estudo utilizou ressonância magnética funcional (fMRI) para caracterizar os mecanismos neuronais recrutados por indivíduos com níveis de psicopatia variáveis para tomar decisões no jogo do ultimato. Os resultados sugeriram que as decisões tomadas por indivíduos com valores mais elevados e mais reduzidos de psicopatia resultam de motivações distintas. Apesar de ambos os grupos terem rejeitado a mesma proporção de ofertas injustas, os mecanismos neuronais recrutados na produção de respostas foram divergentes, sendo as decisões preditas por activação do córtice pré-frontal dorsolateral (dlPFC) no grupo de reduzida psicopatia, e por activação do córtice pré-frontal ventromedial (vmPFC) no grupo de elevada psicopatia. De um modo geral, estes resultados sugerem que, contrariamente ao grupo de menor psicopatia, a rejeição de ofertas injustas por indivíduos com tendências psicopáticas mais elevadas não parece ser guiada por preocupação com a justiça das ofertas. Na realidade, parece antes resultar de anomalias no processamento do valor de recompensa das ofertas, conduzindo a rejeição motivada por frustração. Ao demonstrar que mecanismos divergentes podem originar resultados comportamentais semelhantes, este estudo ilustra a importância de investigar os correlatos neuronais das tomadas de decisão social em indivíduos com tendências psicopáticas. O segundo estudo investigou a relação entre traços psicopáticos e regulação da distância interpessoal. Foi demonstrado que a distância interpessoal preferida estava significativamente associada com o traço de “frieza afectiva” (*coldheartedness*), sendo que os participantes com valores mais elevados neste traço preferiram distâncias mais curtas. No seguimento de

demonstrações de que a amígdala está implicada na regulação da distância interpessoal em humanos, estes resultados suportam uma associação entre traços de psicopatia e disfunção amigdalina.

Em suma, os resultados obtidos nos dois estudos contribuem para clarificar as bases neuronais do comportamento social na psicopatia, e suportam modelos anteriores que sugerem a existência de disfunções do vmPFC e da amígdala em indivíduos com elevados traços psicopáticos.

Abstract

Psychopathy is a combination of personality traits strongly associated with remorseless and impulsive antisocial behavior. Due to these traits, highly psychopathic individuals often cause financial, emotional and physical harm to others. A better understanding of the psychobiological mechanisms underlying affective and interpersonal deficits in psychopathy may contribute to develop means to minimize the negative impact psychopathic individuals have on society.

The present work addressed the influence of psychopathic traits on social behavior and its neural correlates. The first study used functional magnetic resonance imaging (fMRI) to characterize the neural mechanisms recruited by individuals varying in psychopathy when making decisions in the ultimatum game. Our findings suggested that decisions by individuals higher and lower in psychopathy result from distinct motivations. Although both groups rejected unfair offers in the same proportion, they recruited divergent neural mechanisms to produce responses, with decisions being predicted by dorsolateral prefrontal cortex activation (dlPFC) in low scorers, and ventromedial prefrontal cortex (vmPFC) in high scorers. Overall, these findings suggest that, contrary to low psychopathy scorers, the rejection of unfair offers by individuals scoring higher in psychopathy does not seem to be driven by fairness considerations. Instead, it appears to result from abnormal processing of the reward value of offers, leading to frustration-induced rejection. By demonstrating that divergent mechanisms can give rise to comparable behavioral outcomes, these findings highlight the importance of investigating the neural correlates of social decision-making in psychopathy. The second study investigated the relation between psychopathic traits and interpersonal distance regulation. It was demonstrated that preferred interpersonal distance was specifically associated with coldheartedness, a component of psychopathy related to interpersonal callousness, with more coldhearted participants preferring shorter distances. Following evidence that the amygdala is implicated in the regulation of interpersonal distance in humans, these results support an association between psychopathy, and specifically callous personality traits, and amygdala dysfunction.

Taken together, the findings obtained in both studies shed light on the neural basis of social behavior in psychopathy, while supporting previous suggestions of vmPFC and amygdala dysfunction in individuals with heightened psychopathic traits.

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Introduction

I. Psychopathy: definition, assessment and psychobiology

1. General definition and social implications

Psychopathy is a developmental syndrome (Lynam, Caspi, Moffitt, Loeber, & Stouthamer-Loeber, 2007; Pardini & Loeber, 2007; Salekin & Frick, 2005) characterized by core personality traits, such as callousness and lack of remorse, and antisocial behavioral tendencies, such as impulsivity and poor anger control (Hare, 1991; Frick & White, 2008). Extreme forms of psychopathy are thought to affect about 1% of the general population but as much as a quarter of prison populations in the U.S., and constitute a strong risk factor for crime and recidivism (Hare, 2006; Salekin, 2008). In Portugal, a study conducted by Gonçalves (1999) estimated that about 49% of inmates in a prison presented moderate to high values on a measure of psychopathy. Psychopaths are five times more likely to engage in violent recidivism within five years of release from prison (Serin & Amos, 1995), and, unlike non-psychopathic criminals, their antisocial conduct persists across the life span (Simourd & Hodge, 2000). Due to psychopathic individuals' penchant for antisocial and immoral behavior, psychopathy has a very high cost to society, being associated with more frequent and severe forms of offending (Kahn, Byrd, & Pardini, 2013; Salekin, 2008; Woodworth & Porter, 2002). Moreover, findings regarding psychopathic individuals' sensitivity to treatment are inconsistent (Anderson & Kiehl, 2013; Felthous, 2011; Salekin, Worley, & Grimes, 2010).

Markers of psychopathy appear early in childhood (Glenn, Raine, Venables, & Mednick, 2007; Wang, Baker, Gao, Raine, & Lozano, 2012) and predict adult psychopathy (Lynam et al., 2007; Lynam, Loeber, & Stouthamer-Loeber, 2008). In children and adolescents, research has focused primarily on a set of affective and interpersonal features commonly termed callous-unemotional traits that are especially predictive of adult psychopathy (Burke, Loeber, & Lahey, 2007). The presence of these traits defines a subgroup of youth with conduct problems who display particularly severe, aggressive and stable patterns of antisocial behavior, and whose emotional, cognitive and personality characteristics are similar to those described in psychopathic adults (Frick, 2009).

Research also suggests that psychopathy, and specifically callous-unemotional traits, are heritable and minimally affected by environmental influence (Larsson, Andershed, & Lichtenstein, 2006; Larsson et al., 2007; Viding, Blair, Moffitt, & Plomin, 2005). Moreover, there is evidence that only antisocial behavior presented by highly callous-unemotional children is heritable, contrary to antisocial behavior manifested by children scoring low on those traits (Viding et al., 2005). These findings highlight the importance of an early detection of psychopathic tendencies (especially callous-unemotional traits), so that the prevention of antisocial behavioral manifestations may start at an early age.

2. Characterization and assessment of psychopathic traits

2.1. *Cleckley's clinical description*

Modern accounts of psychopathy have been greatly influenced by the work of Hervey Cleckley (1903 – 1984), an American psychiatrist who provided the first clinical descriptions of psychopathic individuals. In his seminal work, *The Mask of Sanity* (first published in 1941), Cleckley (1988) pointed out that psychopathy differs from other psychopathologies, as psychopathic individuals often fail to exhibit external symptoms and show no impairment in reasoning abilities, providing an image of a “sane and rational personality” (p. 369), while concealing a “genuine and very serious disability” (p. 367). Cleckley (1988) suggested 16 main criteria that include affective, interpersonal and behavioral features to characterize the prototypical psychopath:

1. Superficial charm and “good intelligence”
2. Absence of delusions and other signs of irrational thinking
3. Absence of "nervousness" or psychoneurotic manifestations
4. Unreliability
5. Untruthfulness and insincerity
6. Lack of remorse or shame

7. Inadequately motivated antisocial behavior
8. Poor judgment and failure to learn by experience
9. Pathologic egocentricity and incapacity for love
10. General poverty in major affective reactions
11. Specific loss of insight
12. Unresponsiveness in general interpersonal relations
13. Fantastic and uninviting behavior with drink and sometimes without
14. Suicide rarely carried out
15. Sex life impersonal, trivial, and poorly integrated, and
16. Failure to follow any life plan.

Based on these features, Cleckley (1988) proposed psychopathic individuals have a deep-rooted emotional deficit that is concealed by successfully mimicking adaptive social behaviors and simulating normal emotion:

“... despite these intact rational processes, these normal emotional affirmations, and their consistent application in all directions, we are dealing here not with a complete man at all but with something that suggests a subtly constructed reflex machine which can mimic the human personality perfectly. This smoothly operating psychic apparatus reproduces consistently not only specimens of good human reasoning but also appropriate simulations of normal human emotion in response to nearly all the varied stimuli of life” (p. 369, 370).

According to Cleckley (1988), due to these characteristics, psychopathy entails a striking paradox: psychopathic individuals display persistent maladaptive behavior with an outward appearance of positive adjustment, often making a positive first impression in social situations.

2.2. *Dimensional approaches*

The ideas of Cleckley inspired personality-based models of psychopathy, which conceptualize it as a constellation of personality traits, as opposed to behavior-based

approaches, which emphasize observable antisocial behavior¹ (Lilienfeld, 1998). Nonetheless, Cleckley's perspective was still inherently clinical, conceiving highly psychopathic individuals as fundamentally different from non-psychopaths. In the last few years, personality-based models have gradually moved from this taxonomic or clinical perspective to a dimensional view of psychopathy, conceiving it as a set of continuous personality traits rather than a clinical taxon (Edens, Marcus, Lilienfeld, & Poythress, 2006; Marcus, John, & Edens, 2004). When present in high levels, these traits strongly predispose the individual to the adoption of antisocial and violent behaviors (Kahn et al., 2013; Viding, Simmonds, Petrides, & Frederickson, 2009; Walsh, Swogger, & Kosson, 2009; Woodworth & Porter, 2002). Therefore, according to this perspective, the manifestation of antisocial and criminal behavior is a potential consequence of core personality traits, rather than an inherent part of the psychopathy construct (Cooke & Michie, 2001).

Dimensional approaches assume that psychopathic traits are continuously distributed in the general population (Skeem, Polaschek, Patrick, & Lilienfeld, 2011), enabling its study not only in forensic or clinical samples, but also in community samples, provided that they have an appropriate range of psychopathy scores (Lilienfeld, 1998). In support of this view, it has been shown that psychopathic traits predict antisocial behavior and instrumental violence in both community and institutionalized individuals (Neumann & Hare, 2008; Seals, Sharp, Ha, & Michonski, 2012; Woodworth & Porter, 2002). Also, in experimental tasks, similar emotional and moral response patterns have been described in both types of samples at the behavioral (Bartels & Pizarro, 2011; Koenigs, Kruepke, Zeier, & Newman, 2012), physiological (Lopez, Poy, Patrick, & Molto, 2013; Rothmund et al., 2012), and neural levels (Contreras-Rodriguez et al., 2013; Deeley et al., 2006; Gordon, Baird, & End, 2004), further strengthening the idea that meaningful psychopathy-related effects may be investigated using individuals from the community. In favor of the use of community samples, it has also been suggested that a better understanding of subclinical psychopathy may help to elucidate the factors (e.g. high IQ, impulse control) that buffer individuals with high psychopathic traits from engaging in antisocial behaviors (Lilienfeld,

¹ Behavior-based approaches deeply influenced the DSM-III and IV diagnosis of Antisocial Personality Disorder (ASPD). The use of such approaches in the classification of psychopathy has received criticisms, as they tend to be both over-inclusive, by encompassing conditions that present antisocial behavior but have different etiologies, and under-inclusive, by failing to identify individuals who present core psychopathic traits but do not display chronic antisocial behavior (Lilienfeld, 1998). A deeper discussion of these approaches and its criticisms, however, falls outside the scope of the present work.

1998). Additionally, the use of community samples potentially enables the study of psychopathic traits in a purer form, by controlling the effect of confounds often associated with institutionalization, such as comorbidity, substance use, and low IQ (Barker et al., 2007; Butler, Indig, Allnutt, & Mamoon, 2011).

2.3. *Assessment of psychopathic traits*

Despite some controversies in the field, most models agree that core personality features of psychopathy include callousness, lack of empathy and guilt, dishonesty, egocentricity, shallow emotional reactions, weak social bonds, low anxiety, superficial charm, and propensity to externalize blame (Frick & White, 2008; Lilienfeld, 1998; Viding, Fontaine, & McCrory, 2012). Based on the extent to which individuals present some of these traits and resulting behavioral profiles, some authors (e.g. Lee & Salekin, 2010; Swogger & Kosson, 2007) have proposed a distinction between primary and secondary psychopathy, two etiologically distinct variants. Primary psychopaths, presenting higher levels of callous and unemotional traits, were classically described as having low anxiety and a core deficit in emotional responding, whereas secondary psychopaths were characterized by high levels of impulsivity and neuroticism (Cleckley, 1988; Lykken, 1957). Recent evidence demonstrated that both variants present high levels of callous and unemotional traits, but are likely to have different etiological pathways, with primary psychopathy being mainly related to difficulties in processing distress cues in others, and secondary psychopathy associated with history of abuse and emotional problems (Kimonis, Frick, Cauffman, Goldweber, & Skeem, 2012).

Irrespective of the evidence supporting the existence of primary and secondary variants, many researchers focus mainly on the study of particular psychopathic traits and their behavioral correlates, in line with a dimensional view of psychopathy. To assess these traits, a number of self-report measures have been developed. Here, we will focus solely on the two measures that were used to operationalize psychopathic traits in the present work: the Psychopathic Personality Inventory – Revised (PPI-R; Lilienfeld & Widows, 2005) and the Triarchic Psychopathy Measure (TriPM; Patrick, 2010).

i) *Psychopathic Personality Inventory – Revised (PPI-R).*

The PPI-R and its predecessor (PPI; Lilienfeld & Andrews, 1996) were developed to comprehensively assess the trait dispositions described by Cleckley in nonclinical samples. The first version comprised 187 items that were reduced to 154 in the revised version, organized in eight subscales: *social influence*, *fearlessness*, *stress immunity*, *Machiavellian egocentricity*, *rebellious nonconformity*, *blame externalization*, *carefree nonplanfulness*, and *coldheartedness*. These subscales (except *coldheartedness*) load into two higher-order factors, PPI-I or *fearless dominance*, and PPI-II or *self-centered impulsivity* (or impulsive antisociality; Benning, Patrick, Hicks, Blonigen, & Krueger, 2003). *Coldheartedness* seems to be largely independent of both these factors (Skeem, Polaschek, Patrick, & Lilienfeld, 2011), and is regarded simultaneously as a subscale and a higher-order dimension. *Fearless dominance* scores are associated with interpersonal dominance, low anxiety, narcissism and thrill-seeking behavior (Benning, Patrick, Salekin, & Leistico, 2005; Edens & McDermott, 2010; Patrick, Edens, Poythress, Lilienfeld, & Benning, 2006); *self-centered impulsivity* is related to reckless and impulsive behavior, self-centeredness and aggressiveness (Benning et al., 2003; Edens & McDermott, 2010); and *coldheartedness* indexes callousness and lack of sympathy for others (Marcus, Fulton, & Edens, 2013). Although originally developed with undergraduate students, the PPI-R and its predecessor show strong associations with psychopathy measures predominantly used in institutionalized samples, such as the Psychopathy Checklist-Revised (PCL-R; Hare, 1991)² (Poythress et al., 2010).

ii) *Triarchic Psychopathy Measure (TriPM)*

The TriPM is based on the triarchic model of psychopathy (Patrick, Fowles, & Krueger, 2009), an integrative framework that describes psychopathy according to phenotypic dimensions and makes no strong assumptions regarding etiological factors. According to this model,

² The Psychopathy Checklist-Revised is an interview-based instrument developed by Robert Hare (1991) to assess psychopathy in forensic samples. It consists of a semi-structured interview, during which the clinician scores several items according to whether they apply to the individual completely (2), partially (1), or not at all (0). PCL-R items are grouped into two main factors, with factor 1 assessing affective-interpersonal traits and factor 2 assessing antisocial behavior. Usually, data collected during the interview is combined with information retrieved from file review. Individuals are then classified as psychopaths or non-psychopaths according to a predefined cut point. Despite being considered for several years the gold-standard of psychopathy assessment, the PCL-R has received some criticism for operationalizing psychopathy as a taxonomic construct, a position that does not seem to have enough empirical support (Marcus et al., 2004). The inclusion of antisocial behavioral manifestations as a necessary criterion for psychopathy as also been questioned (Cooke & Michie, 2001).

psychopathy is not conceptualized as a unitary construct, but as the confluence of three distinct but intersecting phenotypic components: *boldness*, *meanness* and *disinhibition* (Figure 1).

Boldness entails the capacity to remain calm and focused in threatening or unfamiliar situations, ability to recover quickly from stressful events, high self-assurance and social efficacy. It is thought to reflect the same underlying traits as PPI fearless dominance (Patrick et al., 2009), and to be tapped by both factor 1 (affective-interpersonal) and factor 2 (antisocial behavior) of the PCL-R (Benning, Patrick, Blonigen, Hicks, & Iacono, 2005). Behaviorally, it manifests as social poise, assertiveness, imperturbability, persuasiveness, bravery and venturesomeness (Patrick et al., 2009).

Meanness is associated with low empathy, lack of close attachments to others, thrill seeking, exploitativeness and empowerment through cruelty. It is associated with PPI coldheartedness and to the dimensions evaluated by factor 1 of the PCL-R, and is expressed behaviorally by arrogance, defiance of authority, absence of close personal relationships, strategic aggression and exploitation of others, cruelty, verbal derisiveness and aggressive competitiveness (Patrick et al., 2009).

Finally, *disinhibition* is related to lack of planfulness and foresight, tendency towards impulse control problems, deficient behavioral control and insistence on immediate gratification. The traits it entails are tapped by factor 2 of the PCL-R and PPI self-centered impulsivity (Patrick, 2010; Patrick et al., 2009). Behaviorally, it is associated with impatience, rapid action with negative consequences, irresponsibility, alienation and distrust, volatile emotional manifestations (including reactive aggression), untrustworthiness, proneness to substance abuse, and norm violations (Krueger, Markon, Patrick, Benning, & Kramer, 2007; Patrick, 2010). The TriPM includes 58 items that are grouped in three subscales, which assess each of these three phenotypic components.

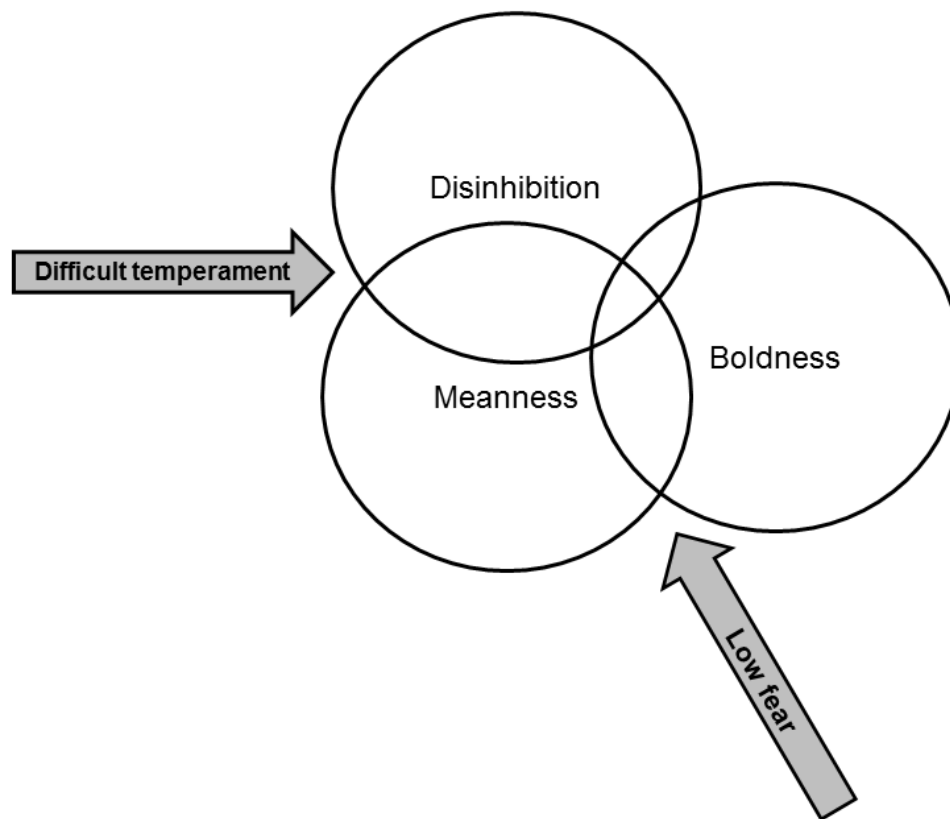


Figure 1: The triarchic model of psychopathy. Schematic representation of the relations between phenotypic components in the triarchic model. Disinhibition and meanness are moderately interrelated, with difficult temperament (including poor emotion regulation, poor executive functioning, impulsivity) potentially contributing for both components. Disinhibition and boldness appear to be minimally interrelated, the same way PPI-R fearless dominance and self-centered impulsivity are largely independent. Meanness and boldness are depicted as somewhat interrelated, based on evidence suggesting low dispositional fear (fearlessness, reduced proneness to stress/anxiety) contributes for both. The triarchic model attempted to reconcile contrasting perspectives in the literature, by defining the psychopathy construct according to phenotypic components and limiting the assumptions about the etiology of each component (Skeem et al., 2011). Reprinted with permission from Cambridge University Press: *Development and Psychopathology*, Patrick, Fowles & Krueger (2009), copyright 2009.

3. Psychobiology of psychopathy: brief overview of emotion-based models

Researchers have long tried to identify psychobiological correlates of psychopathy. Emotion-based views are consistent with Cleckley's (1988) clinically-driven hypothesis that psychopathy is associated with a basic emotional failure. Since then, this has been a central

assumption in several empirically-driven models of psychopathy³ (Blair, 2005; Lilienfeld & Andrews, 1996; Marsh, 2013; Patrick, 1994). Lykken's "low fear" hypothesis (1957) associated psychopathy with deficient fear responding, which manifested on abnormal anticipatory responses to aversive events. This hypothesis was based on Lykken's groundbreaking research on anxiety in psychopathy, which demonstrated that psychopathic criminals showed diminished sensitivity to punishment cues. Using the skin-conductance response to index fear, Lykken (1957) demonstrated that psychopaths showed poor aversive conditioning to buzzers paired with electric shocks, in addition to poor passive avoidance, i.e. failure to withhold behavioral responses that lead to punishment. These findings were replicated in subsequent studies demonstrating that psychopaths' skin-conductance response in anticipation of aversive events was reduced compared to non-psychopaths (Hare, 1965, 1982).

Based on these data, Fowles (1980) adapted Gray's motivational model (Gray, 1971) to psychopathy, proposing that psychopaths have a weak behavioral inhibition system (mediating avoidance behavior), combined with a normal behavioral activation system (mediating approach behavior). This proposal was revised later on to take into account reports that fear deficits were associated with affective features of psychopathy, but not with its behavioral component (Patrick, 1994; Vaidyanathan, Patrick, & Bernat, 2009). To reconcile this evidence, Fowles and collaborators (Dindo & Fowles, 2011; Fowles & Dindo, 2006) proposed a dual-process model, which stated that distinct etiological mechanisms underlie affective-interpersonal (i.e. *meanness* and *boldness*) and antisocial (i.e. *disinhibition*) facets of psychopathy. Specifically, *boldness*- and *meanness*-related traits reflect emotional reactivity impairments, and are associated with deficits in affect-motivational systems located in the amygdala and interconnected structures. This is supported by reports showing a relation between the affective component of both the PCL-R and the PPI, and reduced fear-potentiated startle (Benning, Patrick, & Iacono, 2005; Patrick, Bradley, & Lang, 1993) and deficient amygdala response to aversive and fearful stimuli (Contreras-Rodriguez et al., 2013; Dolan & Fullam, 2009). On the other hand, *disinhibition*-related traits reflect a tendency towards impulse control problems and externalizing behavior, which are likely to be associated with dysfunctional fronto-cortical brain systems. This is consistent with reports

³ Alternative psychobiological approaches associate psychopathy with cognitive, specifically attentional, deficits (Hiatt & Newman, 2006). However, these models fall out of the scope of the present work and will not be discussed here.

of an association between impulse control problems and impaired performance in frontal lobe tasks (Morgan & Lilienfeld, 2000), and reduced amplitudes of the P3 event-related component (Iacono, Carlson, Malone, & McGue, 2002) and of the error-related negativity (ERN) (Patrick, 2008).

Another dominant model in the field proposes that psychopathy is associated with a broader emotional deficit, entailing impairments in both negative and positive affective reactivity. The Integrated Emotion System model (IES) (Blair, 2005; Blair, 2013), a revised version of the earlier Violence Inhibition model (Blair, 2001), constitutes a neurocognitive account of psychopathy that specifies the developmental basis of maladaptive reactive and proactive aggression in psychopathic individuals. Specifically, the IES argues that amygdala dysfunction leads to impairments in aversive stimulus-reinforcement learning, consistent with experimental reports of deficits in aversive conditioning (Birbaumer et al., 2005), passive avoidance (Newman & Schmitt, 1998) and startle reflex modulation (Patrick et al., 1993) in subjects with high psychopathic tendencies. These deficits disrupt the processing of distress cues in others and prevent their association with negative outcomes, thus compromising moral socialization and facilitating the engagement in antisocial behavior and instrumental aggression (Blair, 2007a, 2008). On the other hand, reactive aggression is mainly associated with prefrontal cortex dysfunction, specifically in the ventromedial region, which is responsible for abnormal processing of reinforcement information and response reversal impairments (Birbaumer et al., 2005; Finger et al., 2008). These computational deficits compromise contingency-based decision-making, and render the individual more vulnerable to frustration for not receiving the desired outcomes, thus increasing the risk of reactive aggression. In the most recent version of this model (Blair, 2013), the putative contributions of the striatum, anterior insula and dorsomedial prefrontal cortex for the pathophysiology of psychopathic traits are also highlighted (Figure 2).

behaviors that cause others fear and distress (Marsh, 2013). This proposal is supported by recent findings showing subjects with high psychopathic traits have difficulties in identifying and judging the acceptability of actions that cause fear (Marsh & Cardinale, 2012a), which seem to be associated with abnormal amygdala function (Marsh & Cardinale, 2012b).

In summary, there is abundant evidence to support models of emotional dysfunction in psychopathy. Emotional reactivity problems are likely to generate lack of empathy for others, and give rise to antisocial behavioral patterns, namely instrumental aggression. Supported by the proliferation of neuroimaging research on psychopathy in the last decade, psychobiological models have developed to take into account the neural mechanisms underlying behavioral and cognitive impairments in psychopathic individuals. The next section will review the literature concerning the neural correlates of psychopathy, especially those related to atypical patterns of social functioning.

II. Social behavior and psychopathic traits: relation to neural mechanisms

1. Neural correlates of psychopathy

In recent years, an increasing number of neuroimaging studies have investigated the brain anomalies that potentially generate the affective, interpersonal and behavioral deficits consistently reported in psychopathy. At the structural level, there is evidence of cortical abnormalities within frontal and temporal areas, and also of subcortical and striatal structures. Specifically, it has been shown that adult psychopathic individuals have reduced gray matter volume in frontopolar, orbitofrontal, and anterior temporal cortices (de Oliveira-Souza et al., 2008; Ermer, Cope, Nyalakanti, Calhoun, & Kiehl, 2012; Ly et al., 2012; Yang, Raine, Colletti, Toga, & Narr, 2010, 2011), superior temporal gyrus (Muller et al., 2008) insula (Cope et al., 2012; de Oliveira-Souza et al., 2008), amygdala (Ermer et al., 2012; Yang et al., 2010; Yang, Raine, Narr, Colletti, & Toga, 2009), and hippocampus (Cope et al., 2012; Ermer et al., 2012), and increased volume in the striatum (Glenn, Raine, Yaralian, & Yang, 2010). Additionally, abnormal patterns of structural connectivity (Yang et al., 2012) and white matter alterations, namely in the right uncinate fasciculus (Craig et al., 2009; Motzkin, Newman, Kiehl, & Koenigs, 2011) and corpus callosum (Raine et al., 2003), have been reported. In youth samples, psychopathic traits have also been associated with structural alterations in the orbitofrontal cortex (De Brito et al., 2009; Ermer, Cope, Nyalakanti, Calhoun, & Kiehl, 2013; Fairchild et al., 2013), temporal pole (Ermer et al., 2013), posterior (Ermer et al., 2013) and anterior cingulate cortex (De Brito et al., 2009), insula (Fairchild et al., 2013), and striatum (Fairchild et al., 2013). It should be noted that most structural imaging studies published so far involve mainly incarcerated psychopaths or youths with conduct disorder. More research with structural imaging on community samples varying in psychopathy is necessary to enable a more precise characterization of the anatomical deficits that might be associated with different psychopathic personality traits.

At the functional level, adults with psychopathic traits have shown abnormal neural activation patterns in a variety of tasks that feature processing of social-affective information, such as fear conditioning (Birbaumer et al., 2005), viewing emotional stimuli (e.g. faces (Deeley et al., 2006; Gordon et al., 2004), scenes (Muller et al., 2003) and verbal statements (Marsh &

Cardinale, 2012b)), moral (Glenn, Raine, & Schug, 2009; Harenski, Harenski, Shane, & Kiehl, 2010) and social decision-making (Osumi et al., 2012; Rilling et al., 2007), identification and recollection of emotionally salient words (Kiehl et al., 2001), anticipation of rewards (Buckholtz et al., 2010) and administration of punishment (Veit et al., 2009). In youth samples, callous-unemotional traits have been shown to be associated with abnormal brain activation when processing emotional faces (Marsh et al., 2008; White, Marsh, et al., 2012) and pain-related stimuli (Lockwood et al., 2013; Marsh et al., 2013). During those tasks, psychopathic traits were associated with abnormal activation patterns in cortical, limbic and striatal regions. Specifically, alterations were reported in the dorsolateral (Glenn et al., 2009; Gordon et al., 2004), orbitofrontal (Sommer et al., 2010) and ventromedial prefrontal cortices (Decety, Skelly, & Kiehl, 2012; Harenski et al., 2010), middle and superior temporal gyrus (Harenski et al., 2010; Kiehl et al., 2004), anterior and posterior cingulate cortex (Marsh et al., 2013; Muller et al., 2003), insula (Decety et al., 2012; Veit et al., 2009), amygdala (Marsh & Cardinale, 2012b; Rilling et al., 2007), hippocampus and parahippocampal gyrus (Kiehl et al., 2001), and ventral striatum (Kiehl et al., 2001). Additionally, there is evidence that functional connectivity patterns may also be impaired (Osumi et al., 2012; Juarez, Kiehl, & Calhoun, 2013), specifically in the coupling of amygdala and prefrontal activity (Finger et al., 2012; Marsh, Finger, Fowler, et al., 2011; Motzkin et al., 2011).

In conclusion, neuroimaging evidence suggests psychopathy is associated with both anatomical and functional alterations in a widespread network of regions, comprising areas often included in neurobiological models of human social behavior, such as the amygdala (Adolphs, 2010), the medial prefrontal cortex (Amodio & Frith, 2006; Van Overwalle, 2009) and the striatum (Rilling & Sanfey, 2011). This overlap is consistent with reports of socio-affective problems in high psychopathy scorers, suggesting a neurobiological origin for maladaptive social functioning in psychopathy.

2. Patterns of social behavior in psychopathy

Although maladaptive social behavior is one of the defining characteristics of psychopathy, the way psychopathic traits affect social decision-making has only recently begun

to receive attention, having been investigated in a limited number of experimental studies that yielded somewhat inconsistent results. Furthermore, despite the evidence suggesting brain mechanisms involved in social cognition may be impaired in psychopathy, an even smaller number of studies addressed the neural correlates of social decisions as a function of psychopathic traits. The following two sections present an overview of the literature on social behavior in psychopathy.

2.1. *Social decision-making in the laboratory*

Social behavior has been frequently investigated in laboratory settings through the use of interactive game theory-based paradigms (e.g. Prisoner's Dilemma, Ultimatum Game, and Dictator Game), in which subjects are typically required to weigh personal and social gain to make decisions that will affect both themselves and another player. In the past years, research has begun to elucidate some of the personality variables that affect social decisions in these paradigms (e.g. De Neys, Novitskiy, Geeraerts, Ramautar, & Wagemans, 2011; Grecucci et al., 2013; Takahashi et al., 2012), but the influence of psychopathic personality traits still remains unclear. As discussed in the first chapter, social functioning in psychopathy presents a paradox: individuals with high psychopathic tendencies are described as having a parasitic orientation towards others, show disrespect for social norms, and frequently engage in goal-directed aggression (Frick & White, 2008); nonetheless, their affective deficits and dysfunctional social behavior are often masked by interpersonal features that confer an outward appearance of positive adjustment (Cleckley, 1988), social dominance and charisma (Babiak, Neumann, & Hare, 2010). By enabling the study of the relative importance of social and moral norms, and self-interest in social decision-making, game theory-based paradigms are particularly useful tools to investigate social behavior in psychopathy, allowing us to obtain a clearer picture of the motivations that guide social decisions in individuals varying in psychopathic traits. However, existing studies that examined how psychopathic traits affect behavior in these paradigms have yielded inconsistent findings.

One of the paradigms previously used to investigate social behavior, particularly cooperation, in psychopathy is the Prisoner's Dilemma (PD). In the PD, two players (A and B)

simultaneously and independently decide whether to cooperate or defect with each other, resulting in four possible outcomes in each round of the game: A and B cooperate, A cooperates and B defects, A defects and B cooperates, and A and B defect. In this task, establishing and maintaining mutual cooperation usually yields the highest earnings in the long term⁴ (Figure 3). Most studies that investigated the effect of psychopathy on PD performance found atypical cooperation patterns in participants with high psychopathic tendencies. Although one paper reported that psychopathic individuals cooperated to the same degree as non-psychopaths (Widom, 1976), subsequent studies demonstrated that high psychopathy scorers tend to cooperate less often than low scorers (Curry, Chesters, & Viding, 2011; Mokros et al., 2008; Rilling et al., 2007), particularly with partners that they perceive as having low relational value, i.e. who are unlikely to be useful to them in the future (Gervais, Kline, Ludmer, George, & Manson, 2013). Furthermore, it was shown that subjects higher in psychopathic traits had decreased amygdala activity following negative outcomes, decreased orbitofrontal cortex activity when deciding to cooperate, and decreased dorsolateral prefrontal cortex and rostral anterior cingulate activity when deciding to defect (Rilling et al., 2007). Based on these findings, the authors argued that, conversely to low psychopathy scorers, high scorers are biased towards defection and require additional cognitive effort to cooperate.

		Player A	
		Coop	Defect
Player B	Coop	\$2(2)	\$3(0)
	Defect	\$0(3)	\$1(1)

Figure 3: Example of a payoff matrix in a Prisoner's Dilemma task⁵.

⁴ Although the optimal strategy in the game depends on the partner's strategy, the commonly termed "tit-for-tat" strategy, which consists in reciprocating the partner's move from the previous round, is effective against a wide range of partner strategies (Axelrod, 1984).

⁵ Reprinted from Biological Psychiatry, Volume 61, Issue 11, Rilling, Glenn, Jairam, Pagnoni, Goldsmith, Elfenbein, & Lilienfeld, Neural Correlates of Social Cooperation and Non-Cooperation as a Function of Psychopathy, 1260-1271, Copyright 2007, with permission from Elsevier.

The Ultimatum Game (UG) has also been extensively used to investigate social decision-making. In this paradigm, two players decide how to split an amount of money. One player, the proposer, suggests a split to the other player, the responder. If the responder accepts, the money is divided accordingly; if the responder rejects, none of the players wins anything. From an economic standpoint, the most rational solution to the UG (i.e., the solution that would yield higher monetary rewards) would be for the proposer to offer the smallest possible amount and for the responder to accept any offer. However, the literature shows that proposers offer on average 40 to 50% of the stake to the responder (Oosterbeek, 2004) and that low offers (below 20% of the stake) tend to be rejected approximately half the time (Camerer, 2003). On the proposer's side, offering fair splits in the UG does not necessarily reflect a concern for fairness, and may represent instead a strategic way of avoiding rejection. To dissociate strategy from fairness considerations in the study of the proposer's behavior, researchers often use the Dictator Game (DG) (Koenigs, Kruepke, & Newman, 2010; Steinbeis, Bernhardt, & Singer, 2012), in which the stake is divided according to the proposer's offer and thus the outcome is not affected by the responder's decision. On the responder's side, the rejection of unfair proposals is generally considered a pro-social behavior, commonly termed "altruistic punishment", because the subject forfeits monetary gain to punish a fairness norm violation (Frith & Frith, 2008).

Studies that have investigated the UG/DG performance of individuals varying in psychopathy have found inconsistent results, not allowing for a clear picture about the way psychopathic personality traits affect sensitivity to fairness and strategic considerations in this task. One study reported that highly psychopathic individuals tend to make lower offers in the Dictator Game (Koenigs et al., 2010). Concerning the responder role in both classical and modified versions of the UG, there is evidence that high psychopathy scorers accept more (Osumi et al., 2012; Osumi & Ohira, 2010), less (Koenigs et al., 2010; Masui, Iriguchi, Nomura, & Ura, 2011), and the same amount (Radke, Brazil, Scheper, Bulten, & de Bruijn, 2013; White, Brislin, Meffert, Sinclair, & Blair, 2013) of unfair offers as low scorers. Among these studies, only two investigated the neural correlates of UG decisions as a function of psychopathic traits. Osumi and colleagues (2012) found that individuals with high psychopathic traits displayed less amygdala activity to unfair offers, which probably reflected diminished sensitivity to fairness, leading to the increased acceptance of unfair offers. White and collaborators (2013), using an adolescent sample, reported no relevant associations between brain activity to unfair offers and

callous-unemotional traits, but demonstrated that these traits modulated anterior insula and dorsal anterior cingulate activity during the punishment of unfair offers (i.e. rejection), which indicates that, although callousness is not associated with diminished sensitivity to fairness directed to the self, it may influence fairness-guided behavior towards others.

One of the potential reasons for this inconsistency may be the use of different measures to assess psychopathy in each study, as well as the use of different criteria to define groups. For example, Koenigs and colleagues (2010) used the PCL-R to group subjects and further divided the high psychopathy group into primary and secondary psychopaths according to anxiety scores, whereas Osumi et al. (2012) assessed self-reported psychopathy with the Japanese version of the primary and secondary psychopathy scales (Levenson, Kiehl, & Fitzpatrick, 1995) in a community sample. Although these variations may account for the divergence in results due to a potentially different selection of traits in each study, they are not likely to be the only reason, as some studies reached concordant findings using distinct psychopathy measures (Koenigs et al., 2010; Masui et al., 2011). Therefore, more research is needed to clarify the extent to which psychopathy affects social decisions and, perhaps more importantly, what are the underlying mechanisms driving decisions amongst high and low psychopathy scorers.

2.2. *Interpersonal behavior*

The psychopathic personality is characterized by specific interpersonal characteristics, such as glibness, superficial charm, dominance, persuasiveness, and tendency to lie and manipulate others (Hare & Neumann, 2008). As mentioned previously, despite psychopaths' deviant and often maladaptive social behavior, some of these interpersonal characteristics seem to confer on psychopathic individuals, particularly those scoring high in boldness or fearless dominance-related traits (Lilienfeld, Patrick, et al., 2012; Lilienfeld, Waldman, et al., 2012), an outward appearance of normality and positive adjustment, and even allow them to make a positive impression in social interactions (Babiak & Hare, 2006; Hall & Benning, 2006). As noted by Cleckley (1988),

“the typical psychopath will seem particularly agreeable and make a distinctly positive impression when he is first encountered. Alert and friendly in his attitude, he is easy to talk with and seems to have a good many genuine interests. There is nothing at all odd or queer about him, and in every respect he tends to embody the concept of a well-adjusted, happy person” (p.339).

This incongruous aspect of psychopathy can be somewhat troublesome, given that it is possible that positive adjustment features increase the trustworthiness of psychopathic individuals in the eyes of others, who in turn become more vulnerable to deception, manipulation or aggression (Babiak & Hare, 2006). Therefore, identifying observable behavioral features that potentially signal elevated psychopathic tendencies would be highly desirable, contributing to improve psychopathy assessment procedures. The most frequently used psychopathy assessment tools measure affective and interpersonal traits (e.g. Facet 1 of the PCL-R; some of the PPI subscales that load into the fearless dominance factor, such as social influence), in addition to behavioral features. Moreover, research shows that scores on the affective-interpersonal component is predictive of antisocial behavioral outcomes, such as instrumental aggression (Vitacco, Neumann, Caldwell, Leistico, & Van Rybroek, 2006; Walsh et al., 2009). However, these tools rely mainly on interviews or self-report to measure interpersonal traits, not assessing actual behavioral manifestations. To fill this gap, Kosson and colleagues (Kosson, Steuerwald, Forth, & Kirkhart, 1997) developed the Interpersonal Measure of Psychopathy (IM-P), an observational measure designed to quantify interpersonal interactions during PCL-R interviews, which has shown good associations with the PCL-R affective-interpersonal factor (Kosson et al., 1997; Zolondek, Lilienfeld, Patrick, & Fowler, 2006) and with lay observers’ ratings of interpersonal behavior (Fowler, Lilienfeld, & Patrick, 2009). However, this instrument is not frequently used in the assessment of psychopathy (Vitacco & Kosson, 2010).

Despite the importance of interpersonal traits in the conceptualization and operationalization of psychopathy, patterns of actual interpersonal behavior in psychopathic individuals have been rarely investigated in the laboratory. Thus, very little is known about the behavioral manifestations that may differentiate individuals with high and low psychopathic tendencies in interpersonal interactions. Rimé and colleagues (Rime, Bouvy, Leborgne, &

Rouillon, 1978) examined the non-verbal behavior of 25 incarcerated psychopaths in interviews, and reported that, comparing to non-psychopaths, they made more hand gestures, more eye contact and leaned forward more than non-psychopaths. More recently, Fowler and colleagues (Fowler et al., 2009) were interested in investigating whether non-expert observers could reliably and accurately assess features of psychopathy from small samples, or “thin slices”, of behavior. They asked 40 lay participants to rate 5, 10, and 20 seconds-long excerpts of interviews with male inmates, and found that those ratings were significantly associated with criterion measures of psychopathy. Moreover, subjects’ ratings seemed to be based mainly on non-verbal behavioral cues, consistent with Rime et al. (1978), with the strongest correlations having been obtained in the shortest video durations. Taken together, these findings point to the possibility of detecting psychopathic personality traits from interpersonal behavioral cues based on very short interactions, although more research is needed to identify what those clues might be.

General objectives and methodology

Psychopathy is associated with dysfunctional emotional processing and maladaptive social behavior (Blair, 2006; Hare & Neumann, 2008). A large body of evidence supports the existence of neural deficits, both structural and functional, that account for the affective impairments that have been reported in individuals with heightened psychopathic traits (e.g. Birbaumer et al., 2005; Kiehl et al., 2001; Marsh, Finger, Fowler, et al., 2011; Yang et al., 2010). However, the influence of psychopathic traits on social behavior has received far less attention. Research suggests that deviant social functioning in psychopathy is probably associated with atypical function of structures implicated in emotional processing, such as the amygdala and the ventromedial prefrontal cortex (Blair, 2007b, 2008). Yet, some studies have reported abnormal neural activation during socio-affective tasks in participants with high psychopathy scores in the absence of overt behavioral differences (e.g. Glenn et al., 2009; Harenski et al., 2010; Sommer et al., 2010), suggesting that in some situations psychopathic individuals may recruit alternative neurocognitive mechanisms to produce adaptive social responses despite their neural deficits. This hypothesis is not only consistent with clinical descriptions pointing out the ability of psychopathic individuals to mimic adjusted social behaviors while concealing severe emotional deficits (Cleckley, 1988), but is also in agreement with reports of their success in some professional contexts (Babiak et al., 2010; Lilienfeld, Waldman, et al., 2012). Despite this seemingly contradictory picture, limited research has yet been devoted to the study of social behavior in psychopathy. Moreover, very few studies have directly examined the neural mechanisms underlying social interaction patterns in individuals with varying psychopathic personality traits (Osumi et al., 2012; Rilling et al., 2007; White, Brislin, et al., 2013). The present work addressed this gap in the psychopathy literature by investigating the influence of psychopathic traits on social behavior in the laboratory. Specifically, we aimed at answering two general questions:

1. How do psychopathic traits affect interpersonal behavior and decision-making in social interactions?
2. What are the neural mechanisms driving interpersonal behavior and social decisions in individuals with varying psychopathic traits?

These questions were addressed in two parallel empirical studies, resulting in two publications presented in the following section.

Study 1: Investigation of behavioral and neural correlates of social decisions by high and low psychopathy scorers

In this study, we used functional magnetic resonance imaging (fMRI) to examine the neural mechanisms recruited during decisions in the ultimatum game as a function of psychopathic traits. Based on dimensional approaches that conceptualize psychopathy as a trait continuum (Marcus et al., 2004), we recruited healthy individuals from the community and assessed psychopathic traits using a self-report measure of psychopathy. Participants then underwent fMRI scanning while performing the ultimatum game.

The ultimatum game has been extensively used in the study of social decision-making (e.g. Guroglu, van den Bos, Rombouts, & Crone, 2010; Harle & Sanfey, 2012; Sanfey, Rilling, Aronson, Nystrom, & Cohen, 2003; van 't Wout, Kahn, Sanfey, & Aleman, 2006). It has been demonstrated that both emotional and cognitive motivations may drive decisions in this task, and the neural mechanisms associated with different motivations are well described in the literature (e.g. Rilling, Sanfey, Aronson, Nystrom, & Cohen, 2004; Sanfey et al., 2003; Steinbeis et al., 2012). This, together with the fact that it has a simple structure and clear behavioral predictions, makes the ultimatum game an attractive tool to study social decision-making in the laboratory.

By enabling the study of the relative importance of social norm compliance and self-interest in social decisions, the ultimatum game is particularly useful in the study of social behavior in psychopathy, given that individuals with high psychopathic tendencies show a parasitic orientation towards others, engage in goal-directed aggression in real life settings (Frick & White, 2008), and have been shown to make decisions according to the relational value of the partner in experimental tasks (Gervais et al., 2013). However, studies that examined how psychopathic traits affect responses in the ultimatum game have yielded conflicting results (Koenigs et al., 2010; Masui et al., 2011; Osumi et al., 2012; Osumi & Ohira, 2010; Radke et al., 2013; White, Brislin, et al., 2013).

To clarify previous divergent findings, we included two novel features in the task. On the one hand, to investigate whether the decision to accept or reject offers was influenced by subjective fairness perceptions, we collected fairness ratings of each offer and examined whether they predicted responses. On the other, to dissociate emotion- from strategy-based decisions, we included a cognitive load manipulation in the task. Cognitive load manipulations have been shown to interfere with more deliberative and cognitively demanding decision processes, which are sensitive to the amount of available cognitive resources, while not interfering with more automatic emotional decisions (e.g. Greene, Morelli, Lowenberg, Nystrom, & Cohen, 2008). We then adopted a linear regression approach to investigate the neural mechanisms driving decisions in higher and lower psychopathy scorers. We hypothesized that high and low scorers in psychopathy would recruit distinct neural processes to make decisions in the ultimatum game. This work resulted in Publication 1.

Study 2: Investigation of interpersonal distance preferences as a function of psychopathic traits

This study investigated whether psychopathic traits affect interpersonal behavior, specifically interpersonal distance regulation. A troublesome feature of psychopathy is that despite psychopathic individuals' tendency for antisocial and immoral behavior, their outward appearance very rarely betrays their affective and interpersonal deficits (Babiak et al., 2010; Cleckley, 1988). Identifying behavioral cues that signal individuals with elevated psychopathic tendencies would be highly desirable, although research about interpersonal behavior in psychopathy is scarce. Following evidence that interpersonal distance is regulated by the amygdala (Kennedy, Glascher, Tyszka, & Adolphs, 2009), and that psychopathy is associated with an amygdala dysfunction (Blair, 2008), we tested whether psychopathic traits affected interpersonal distance regulation. Similarly to Study 1, healthy individuals were selected from the community and psychopathy was assessed using a self-report measure. Participants were required to perform a previously validated task (Kennedy et al., 2009), in which they selected the preferred distance between themselves and an experimenter across a series of trials. In light of evidence suggesting callous traits are particularly linked to abnormal amygdala function (Han, Alders, Greening, Neufeld, & Mitchell, 2011), we hypothesized that more callous participants would show a preference for shorter interpersonal distances. This work resulted in Publication 2.

Publications

Publication 1

Vieira, J.B., Almeida, P.R., Ferreira-Santos, F., Barbosa, F., & Marques-Teixeira, J. (2013). Distinct neural activation patterns underlie economic decisions in high and low psychopathy scorers. *Social, Cognitive and Affective Neuroscience* (epub ahead of print). doi: 10.1093/scan/nst093.

Distinct neural activation patterns underlie economic decisions in high and low psychopathy scorers

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Psychopathic traits affect social functioning and the ability to make adaptive decisions in social interactions. This study investigated how psychopathy affects the neural mechanisms that are recruited to make decisions in the ultimatum game. Thirty-five adult participants recruited from the community underwent functional magnetic resonance imaging scanning while they performed the ultimatum game under high and low cognitive load. Across load conditions, high psychopathy scorers rejected unfair offers in the same proportion as low scorers, but perceived them as less unfair. Among low scorers, the perceived fairness of offers predicted acceptance rates, whereas in high scorers no association was found. Imaging results revealed that responses in each group were associated with distinct patterns of brain activation, indicating divergent decision mechanisms. Acceptance of unfair offers was associated with dorsolateral prefrontal cortex activity in low scorers and ventromedial prefrontal cortex activity in high scorers. Overall, our findings point to distinct motivations for rejecting unfair offers in individuals who vary in psychopathic traits, with rejections in high psychopathy scorers being probably induced by frustration. Implications of these results for models of ventromedial prefrontal cortex dysfunction in psychopathy are discussed.

Keywords: psychopathy; functional magnetic resonance imaging; ultimatum game; ventromedial prefrontal cortex

INTRODUCTION

Psychopathy is a disorder characterized by affective, interpersonal and behavioral traits that predispose the individual to a variety of antisocial behaviors (Hare, 1991). Psychopathic traits include disregard for the rights of others, lack of empathy and remorse, impulsivity, and egocentricity (Hare, 1991; Blair, 2005; Blair *et al.*, 2006). These traits may affect social functioning and compromise the ability to make adaptive decisions in social interaction settings. In experimental tasks, psychopathic individuals have previously shown atypical patterns of cooperation (Rilling *et al.*, 2007; Mokros *et al.*, 2008), and difficulties in social exchange and reasoning about social rules (Ermer and Kiehl, 2010). These socio-affective processing deficits are associated with abnormal patterns of brain functioning, which in turn may be linked to structural abnormalities (Birbaumer *et al.*, 2005; de Oliveira-Souza *et al.*, 2008; Veit *et al.*, 2010; Yang *et al.*, 2011; Fairchild *et al.*, 2013). However, recent empirical reports indicate that atypical functioning in brain regions involved in social cognitive and moral tasks may occur in the absence of behavioral differences between subjects with high and low psychopathic tendencies (Gordon *et al.*, 2004; Glenn *et al.*, 2009; Sommer *et al.*, 2010; Marsh *et al.*, 2011; Pujol *et al.*, 2012). This suggests that, in some circumstances, subjects with extreme psychopathy scores might recruit neurocognitive processes that are distinct from those used by low scorers to achieve comparable behavioral outcomes. However, although suggested in the interpretation of previous findings (e.g. Glenn *et al.*, 2009), this hypothesis has never been formally tested.

In the present study, we used functional magnetic resonance imaging (fMRI) to examine the neural processes involved in making social

decisions as a function of psychopathy. We investigated responses to unfairness in an economic bargaining paradigm, the ultimatum game (UG), in which two players must decide how to split an amount of money: the proposer suggests a division to the responder, who decides whether to accept the offer, knowing that if he or she accepts, the stake will be divided according to the offer, and if he or she rejects, both players get nothing. From an economic standpoint, the rational decision in the UG is to accept any offer. However, subjects typically decline offers of <40% of the stake (Camerer, 2003; Oosterbeek *et al.*, 2004). This response, commonly referred to as altruistic punishment, is considered a prosocial behavior because the subject forfeits monetary gain to punish the other player for violating a fairness norm (Frith and Frith, 2008). Brain regions implicated in negative emotional reactions to uneven splits of money and consequent rejection of unfair offers include the anterior insula and the amygdala (Sanfey *et al.*, 2003; Haruno and Frith, 2010; Gospic *et al.*, 2011; Harle and Sanfey, 2012; Osumi *et al.*, 2012). During the acceptance of unfair offers the dorsolateral prefrontal cortex (dlPFC) is recruited (Sanfey *et al.*, 2003; Gospic *et al.*, 2011; Harle and Sanfey, 2012), which may reflect the cognitive effort required to override automatic negative emotional responses to unfairness (Sanfey *et al.*, 2003). Koenigs and Tranel (2007) also highlighted the role of the ventromedial prefrontal cortex (vmPFC) in the UG, demonstrating that vmPFC lesion patients made exaggerated irrational decisions by rejecting even more unfair offers than controls. This finding was interpreted as the result of a failure to down-regulate negative emotions to unfair offers (e.g. anger), providing further evidence of the involvement of the vmPFC in emotion-guided decisions (Bechara, 2004) and suggesting that non-altruistic motives like frustration or revenge can also lead to costly punishment in the UG.

How psychopathic traits affect decision making in the UG is unclear. Reports of the performance of psychopathic individuals in the UG are inconsistent, with high psychopathy scorers having alternately been reported to accept more unfair offers (Osumi and Ohira, 2010; Osumi *et al.*, 2012) and to reject more unfair offers (Koenigs *et al.*,

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2010) than low psychopathy scorers. Increased acceptance of unfair offers by psychopathic individuals was interpreted as the result of diminished sensitivity to unfairness. This interpretation was further supported by reports of no electrodermal differentiation between unfair and fair offers (Osumi and Ohira, 2010) and decreased amygdala activity to unfair offers (Osumi et al., 2012) in high psychopathy scorers. These findings are consistent with observations that psychopathic individuals are generally less responsive to stimuli that elicit automatic emotional responses in healthy subjects. During emotionally charged moral judgments and other emotional processing tasks, individuals with psychopathic traits display reduced activation in the amygdala, medial prefrontal cortex and striatum, but increased activation in the dlPFC (Intrator et al., 1997; Kiehl et al., 2001; Gordon et al., 2004; Rilling et al., 2007; Glenn et al., 2009; Marsh and Cardinale, 2012). Involvement of the dlPFC suggests that psychopathic subjects may recruit effortful abstract reasoning processes during these tasks (Seidman et al., 1994; Crescentini et al., 2011) to produce perhaps more strategic and cognitively demanding responses (Steinbeis et al., 2012). Overall, these findings suggest that individuals with psychopathic traits are more rational decision makers in the UG, displaying reduced emotional reactions to unfairness and favoring economic utility, possibly at the expense of greater cognitive effort.

However, Koenigs et al. (2010) reported an opposite behavioral pattern. Their study demonstrated a similarity between the UG performance of vmPFC lesion patients and subjects with psychopathy, with both groups rejecting unfair offers more frequently than the comparison groups. This finding was interpreted as a result of deficient emotion regulation in high psychopathy scorers due to vmPFC dysfunction. Models of vmPFC dysfunction in psychopathy have also linked this region to abnormal processing of reinforcement information (Birbaumer et al., 2005; Finger et al., 2008), which is thought to compromise the individuals' ability to make adaptive decisions, thus increasing their vulnerability to frustration by not receiving the desired outcomes (Blair, 2010). These findings suggest that, although highly psychopathic individuals may favor economic utility over fairness, this does not necessarily result in rational decisions in the UG, as abnormalities in emotion regulation and reward processing during the game could lead to the rejection of unfair offers as a result of revenge or frustration.

Consideration of the specific neural mechanisms underlying UG decisions in individuals who vary in psychopathic traits may help to explain this apparent inconsistency. In the present study, we incorporated two features designed to disambiguate how psychopathy affects economic decision making. First, to identify the role of compliance with a fairness norm as compared with other motivations (e.g. Koenigs and Tranel, 2007), we examined individual perceptions of the fairness of offers and analyzed their relation to behavioral responses. Then, we used a linear regression approach to investigate the brain regions in which activation predicted both perceptions of fairness and responses to unfair offers in high and low psychopathy scorers, as assessing the relationship between individual performance and brain activation has been suggested to be a more informative approach to analyzing fMRI data than performing simple contrasts (Christakou et al., 2009). Second, we manipulated cognitive load during the UG in order to disentangle automatic emotion-based from controlled strategy-based decisions, under the assumption that controlled responses are more sensitive to the amount of available cognitive resources than automatic responses (Bargh and Ferguson, 2000; Barrett et al., 2004; Evans, 2008).

In line with UG literature, we hypothesized that for low psychopathy scorers behavioral responses would be predicted by the perceived fairness of offers and would not be affected by the increase in cognitive load. At the neural level, we predicted that UG decisions would be mainly associated with amygdala and dlPFC activity. For high

psychopathy scorers, two competing sets of predictions were formulated, based on the divergent evidence outlined above. If high psychopathy scorers are essentially rational decision makers who make strategic responses solely according to economic utility, we would expect their responses to be associated with the perceived fairness of offers and to be affected by the increase in cognitive load. At the neural level, we would expect behavioral responses to be linked with cognitive control-related activity, namely in the dlPFC. Alternatively, if psychopathic individuals are non-rational decision makers whose emotion regulation difficulties lead to anger-motivated responses, we would expect their responses not to be associated with the perceived fairness of offers and not to be affected by the increase in cognitive load. At the neural level, responses to unfair offers would be predicted by activity in the vmPFC.

To our knowledge, this is only the second study using fMRI to investigate responses to unfairness in individuals with psychopathic traits, and the first to directly examine the neural basis of decisions by high and low psychopathy scorers in the UG.

METHODS

Participants

Thirty-six participants (20 females) were recruited from the Georgetown University community through advertisements developed for psychopathy research, which have been shown to produce oversampling of high psychopathy scorers (Widom, 1977; Marsh and Cardinale, 2012). Participants were screened for neurological and psychiatric disorders, as well as brain injuries, which constituted exclusion criteria. All participants were right-handed and reported not taking any psychotropic medication at the time of screening. Average intelligence quotient (IQ) was assessed using the Kaufman Brief Intelligence Test (K-BIT; Kaufman, 1990) (Table 1).

The study was approved by the Institutional Review Board at Georgetown University, and all participants provided informed written consent in accordance with the Declaration of Helsinki.

Psychopathy measures

Psychopathy was assessed using the Triarchic Psychopathy Measure (TriPM; Patrick, 2010), a 58-item self-report instrument conceptually based on the Triarchic Model of psychopathy (Patrick et al., 2009). For each item, subjects indicate how accurately the item applies to them using a 4-point scale (0 = true; 1 = somewhat true; 2 = somewhat false; 3 = false). The TriPM measures psychopathic traits in a dimensional manner, consistent with the idea that psychopathy can be more accurately assessed continuously than categorically (Skeem et al., 2011). The Triarchic Model describes psychopathy as a conjunction of three phenotypic components, boldness, meanness, and disinhibition, which are evaluated by three subscales of the TriPM. This is a relatively new self-report measure of psychopathy but has been reported to have good construct validity and to be able to successfully tap the core traits of psychopathy (Sellbom and Phillips, 2013; Stanley et al., 2013; Marion et al., 2012).

For group analyses, subjects were divided in two groups (high and low psychopathy) by median split of the total TriPM score. Following the split, mean TriPM scores in the high and low psychopathy groups were 90.61 (s.d. = 18.61) and 50.88 (s.d. = 11.96), respectively. Groups did not differ in age or IQ. Average psychopathy scores in males were higher than in females, but the distribution of men and women in the groups was not significantly different ($\chi^2 = 2.44$, $P > 0.05$) (Table 1).

fMRI scanning task

Participants played a series of one-shot UGs featuring two cognitive load conditions (No Load and Load) during fMRI scanning.

Table 1 Sample characterization: age, IQ and psychopathy scores for the whole sample and for each group

Characteristics	Whole sample (<i>n</i> = 35)		Low psychopathy (<i>n</i> = 17, 12 F)		High psychopathy (<i>n</i> = 18, 8 F)	
	Minimum–Maximum	Mean (s.d.)	Minimum–Maximum	Mean (s.d.)	Minimum–Maximum	Mean (s.d.)
Age	18–24	21.06 (1.80)	18–24	21.24 (2.05)	18–24	20.89 (1.58)
IQ	94–132	112.43 (12.02)	94–132	112.65 (11.65)	95–131	112.22 (12.69)
TriPM						
Total score	23–120	71.31 (25.42)	23–63	50.88 (11.96)	66–120	90.61 (18.61)
Boldness	20–55	39.83 (9.49)	20–44	33.12 (6.85)	26–55	46.17 (6.96)
Meanness	1–51	15.71 (11.02)	1–23	8.59 (5.57)	10–51	22.44 (10.72)
Desinhibition	0–37	15.77 (10.58)	0–30	9.18 (6.92)	9–37	22.00 (9.71)

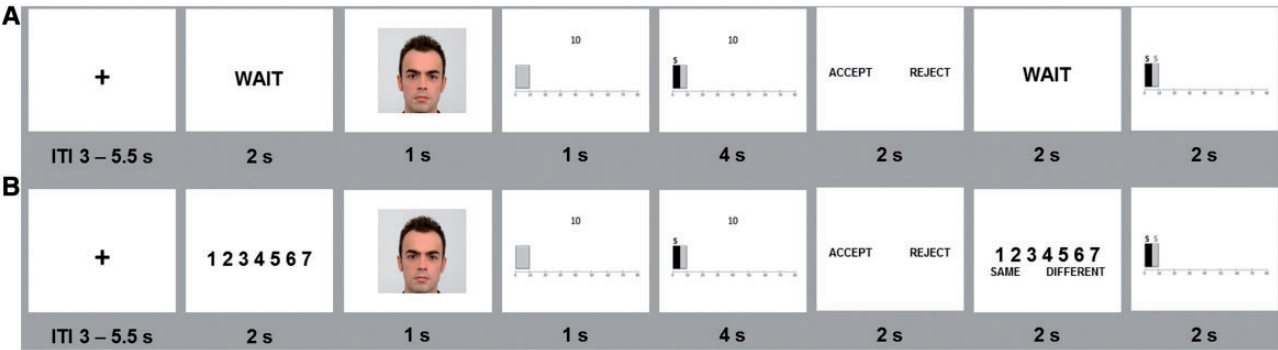


Fig. 1 Task design and stimulus presentation for the No Load (A) and Load (B) condition.

The No Load condition corresponded to the classical UG (Figure 1A). Pictures of other players were selected from the Radboud Faces Database (RaFD) (Langner *et al.*, 2010). All selected pictures displayed closed mouth, eyes facing forward, neutral facial expressions performed by Caucasian actors and an equal number of male and female actors were used. After the picture of the proposer, the stake was displayed, followed by the offer. Participants were instructed to only make a response when the response slide was displayed, using two response buttons held in the right (‘Reject’) and left hand (‘Accept’), respectively. A feedback slide was displayed at the end of the run, showing what each player had won in that round.

In the Load condition, participants were required to play a memory task concurrent with the UG. The introduction of a secondary task was intended to affect the availability of cognitive resources for the main task. Cognitive load manipulations have been shown to be effective in selectively interfering with the production of controlled responses (Greene *et al.*, 2008) and have been used previously in the context of economic decision paradigms (Schulz *et al.*, 2012; Haruno and Frith, 2010). In this condition, a sequence of seven digits was shown before the other player’s picture. Participants were instructed to memorize the digits, disregarding their order in the sequence, because at the end of each round they would be asked to recognize them. Thus, before the feedback slide, another seven-digit sequence was displayed, and participants responded ‘Same’ or ‘Different’, via button press (Figure 1B).

Participants played 48 UG rounds in each condition, in which 24 featured unfair (offers were 20–33% of the stake) and 24 featured fair trials (offers were 40–50% of the stake). There were only two possible offered amounts, 5 and 15, and the stake sized varied, following previous paradigms (Crockett *et al.*, 2008; Van der Veen and Sahibdin, 2011) (Table 2). Each offer was repeated four times within condition.

The task was programmed and delivered in Presentation 0.71 (2003, Neurobehavioral Systems, Inc.).

Table 2 UG offers

Amount offered	Stake size	
	Unfair	Fair
5	15	10
	20	11
	25	12.5
15	45	30
	60	33
	75	37.5

Procedures

Following previous studies (Crockett *et al.*, 2008; Van der Veen and Sahibdin, 2011), participants were informed that the offers they would see during the task were made by people who participated in the study previously and they would have the chance to make offers themselves, after the scan. Subjects were presented with splits of tokens and not monetary units to control for subjective evaluations of the amounts. Participants’ compensation was calculated by converting the total amount of tokens earned during the task to US dollars, according to a predefined conversion rate.

Before entering the scanner, subjects were given the task instructions and played eight practice rounds (four of each condition) on a laptop. Inside the scanner, they completed two runs of the task that corresponded to each of the two conditions. The order of presentation of the conditions was counterbalanced across participants. After the MRI scan, participants were presented once with all the offers shown during the UG and asked to rate their fairness using a 7-point scale (1 = very unfair; 7 = very fair). This task was programmed and delivered in Presentation 0.71 (2003, Neurobehavioral Systems, Inc.) running on a laptop.

Finally, to assure that subjects believed the cover story, they were queried regarding: (i) their reasons to accept and reject offers and (ii) their beliefs about the real objectives of the study. Subjects were also given the opportunity to write down any additional comments about the study. Only then subjects were fully debriefed. One participant was dropped from the analysis because he reported not believing that the offers were really made by other players, resulting in a final sample composed of 35 subjects.

fMRI data acquisition and preprocessing

Participants were scanned on a 3.0 Tesla MRI system (Siemens Magnetom Trio, Erlangen, Germany), at Georgetown University's Center for Functional and Molecular Imaging (CFMI), fitted with a circularly polarized 12-channel head coil. A mirror mounted on the coil allowed participants to view the task via projection. Head movements were minimized through padding.

A high-resolution T₁-weighted structural scan (MPRAGE, magnetization-prepared rapid gradient echo) was acquired between two functional scans (TR = 1900 ms, TE = 2.52 ms, slices = 176, slice thickness = 1.0 mm, FOV = 256 × 256 mm). In the two functional runs of the task a T₂*-weighted gradient echo-planar imaging (TR = 2700 ms, TE = 30 ms, slices = 51, slice thickness = 3 mm, FOV = 256 × 256 mm, acquisition matrix = 64 × 64, flip angle = 90°) was used. The first four TRs of each functional run were excluded from analysis due to magnet stabilization.

Imaging data were pre-processed and analyzed in Analysis of Functional Neuroimaging (AFNI) (Cox, 1996). For each subject, functional images from the two functional runs were concatenated, despiked, motion corrected, spatially smoothed using a 6.0-mm full-width half-maximum Gaussian filter, and then masked to exclude activation outside the brain. The time series were then normalized such that the resulting regression coefficients represent a percent signal change from the mean. Regressors were created that represented four task conditions (Fair No Load, Fair Load, Unfair No Load, Unfair Load) and two contrasts across conditions (Unfair No Load > Fair No Load, Unfair Load > Fair Load). A final regressor of no interest was created for offers to which participants did not provide a valid response and for all events in the task that were not a fixation or an offer. All regressors were created by convolving the train of stimulus events with a gamma-variate hemodynamic response function (Cohen, 1997). Linear regression modeling was performed using the full set of regressors to model baseline drift and residual motion artifact. The baseline was modeled by a first-order function and motion artifacts were modeled using the six estimated rigid-body motion parameters. This produced a beta coefficient and associated *t*-statistic for each voxel and regressor. Participants' anatomical scans were individually registered to the Talairach and Tournoux Atlas (Talairach and Tournoux, 1988).

Statistical analysis

Behavioral data

Average acceptance rates (%) for fair and unfair offers were calculated for each participant in each condition. In addition, we computed difference scores indexing the difference between the percentages of fair and unfair offers accepted, such that the higher the difference score, the greater the number of rejected unfair offers.

To investigate the effects of fairness, cognitive load and psychopathy on acceptance rates, we performed a mixed factors analysis of variance (ANOVA), with fairness (Fair, Unfair) and cognitive load (No Load, Load) as within-subject factors and psychopathy group (High, Low psychopathy) as between-subjects factor. To confirm the results, we performed another mixed factors ANOVA on the difference scores, with load as within-subject factor and psychopathy group as

between-subjects factor. Associations between acceptance rates and psychopathy (total score and subscales) were also explored using correlation analysis, as a dimensional approach is consistent with theoretical conceptions of psychopathy and often results in increased power to detect significant effects.

Average fairness ratings for fair and unfair offers were computed for each subject and represent a measure of perceived fairness. Higher values corresponded to subjects' perceptions of greater fairness. Correlations between fairness ratings and psychopathy scores were performed. Finally, we examined the associations between fairness ratings and acceptance rates within each group.

The threshold for statistical significance was set at $P < 0.05$, two-tailed, for all analyses. Multiple comparisons were addressed through Sidak correction and the Greenhouse–Geisser procedure was used to correct departures from sphericity, when necessary.

fMRI data

We conducted whole-brain analyses setting the threshold at $P < 0.001$, uncorrected, with an extent threshold of 10 contiguous voxels, a procedure that has been suggested to successfully balance Type I and Type II errors in fMRI research (Lieberman and Cunningham, 2009; Marsh and Cardinale, 2012; White et al., 2012).

In order to explore underlying patterns of activation that guide responses to unfair offers among high and low psychopathy scorers, we performed whole-brain linear regression analysis in each group, using activation in the Unfair > Fair contrast in the No Load condition as dependent variable. Difference scores of acceptance rates in the same condition and fairness ratings of unfair offers were entered as predictors. This approach allowed us to explore in which areas activation was uniquely associated with acceptance rates and perceived fairness and, therefore, to isolate the neural mechanisms involved in UG decision from the mechanisms involved in subjective perceptions of fairness. Mean parameter estimates were extracted from functionally defined clusters identified in the regression analyses.

Additionally, as a task validation measure and to explore potential psychopathy × cognitive load interactions, we conducted two whole-brain 2 (Load, No Load) × 2 (High psychopathy, Low psychopathy) mixed factors ANOVA, using brain activation to Unfair and Fair offers independently as dependent variables. We were specifically interested in examining the clusters in which an effect of cognitive load was identified in order to assure that our secondary memory task was successful in increasing the task demands.

RESULTS

Behavioral results

Regarding acceptance rates, we obtained a main effect of Fairness [$F(1,33) = 46.69$, $P < 0.001$, $\eta_p^2 = 0.59$], with fair offers being accepted more often (91.8%) than unfair offers (53.7%). We did not observe any main effects of cognitive load or psychopathy, or any significant interactions (Table 3). Similarly, difference scores were not affected by cognitive load or psychopathy.

Performance in the secondary memory task was analyzed, to assure the efficacy of the cognitive load manipulation. Average accuracy in the task was 78.2% and no differences between groups were found.

Correlation analysis revealed no significant associations between either raw acceptance rates or difference scores and psychopathy (for either total or subscales scores).

We obtained a significant positive association between fairness ratings for unfair offers and psychopathy total score ($r = 0.37$, $P = 0.03$) (Figure 2A). A *t*-test revealed a trend toward higher ratings of unfair offers in high vs low psychopathy scorers ($P = 0.1$). Finally, we examined the associations between acceptance rates and fairness ratings of unfair

offers in each group. In the low psychopathy group, acceptance rates were positively associated with fairness ratings both in the No Load ($r=0.59$, $P=0.012$) and Load conditions ($r=0.58$, $P=0.016$) (Figure 2B). In the high psychopathy group, these associations were not significant (No Load: $r=0.34$, $P=0.162$; Load: $r=0.32$, $P=0.201$) (Figure 2C).

fMRI results

Regression analyses

Results for low psychopathy scorers showed ($P<0.001$, uncorrected, 10 voxel threshold) that acceptance rates were significantly associated

Table 3 Means and standard deviations for acceptance rates and fairness ratings in each group

Group			Low psychopathy	High psychopathy
			Mean (s.d.)	Mean (s.d.)
Acceptance rates (%)	Unfair	No Load	51.21 (39.94)	55.16 (34.18)
		Load	55.14 (41.19)	53.30 (38.17)
	Fair	No Load	89.23 (21.25)	93.27 (14.39)
		Load	88.73 (22.57)	96.07 (10.74)
Fairness ratings	Unfair		2.38 (0.59)	2.67 (0.58)
	Fair		5.38 (1.05)	5.63 (0.68)

with activation in the left middle frontal gyrus [Montreal Neurological Institute (MNI) coordinates, x , y , $z=-49$, 16, 29], with increased activity in this cluster being associated with higher acceptance of unfair offers. In addition, both acceptance rates and fairness ratings were associated with activation in the left superior frontal gyrus (x , y , $z=-4$, 43, 60), with increased activity in this cluster being associated with higher acceptance of unfair offers and perceptions of greater unfairness (Table 4 and Figure 3).

In contrast, results in high psychopathy scorers showed that acceptance rates were associated with activation in the right rostral anterior cingulate (x , y , $z=2$, 42, 8), such that increased rejection of unfair offers was associated with higher activity in this cluster. In addition, fairness ratings were associated with activation in the right medial frontal gyrus (x , y , $z=2$, 31, 43), with increased activity in this cluster being associated with perceptions of greater fairness (Table 4 and Figure 3). No overlapping areas were identified that corresponded to both fairness ratings and acceptance rates in high psychopathy scorers.

Additional analyses (ANOVA)

For Unfair offers, a significant effect of cognitive load was observed ($P<0.005$, uncorrected, 10 voxel threshold) in a network of regions that included a cluster in the left superior extending to middle frontal gyrus (18 voxels; x , y , $z=-22$, 33, 59). Likewise, for Fair offers, we identified a cluster in the left superior/middle frontal gyrus (31 voxels; x , y , $z=-25$, 30, 59). According to previous results about the

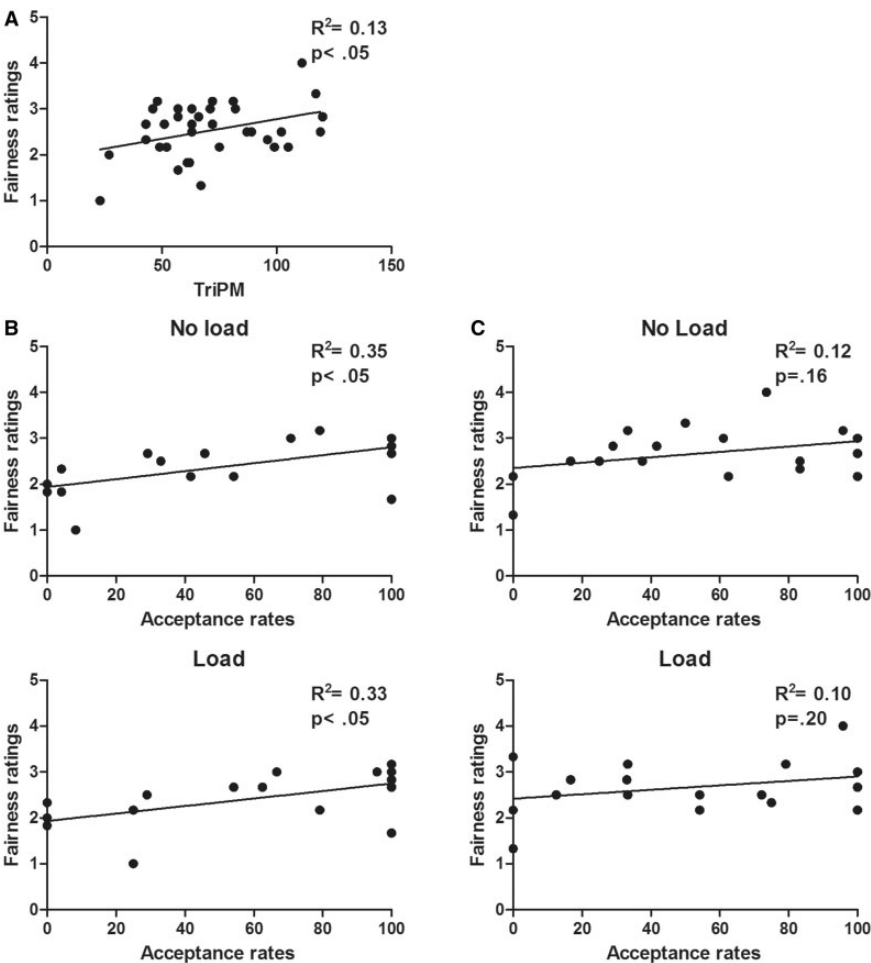


Fig. 2 (A) Association between fairness ratings of unfair offers and psychopathy total score ($P<0.05$). (B) Association between acceptance rates and fairness ratings of unfair offers for the No Load (upper) and Load (bottom) condition, in the low psychopathy group ($P<0.05$). (C) No significant association between acceptance rates and fairness ratings was found in the high psychopathy group.

association between dlPFC activation and working memory load (Barch *et al.*, 1997; Manoach *et al.*, 1997), these results suggest that our manipulation was effective in increasing the task demands. No group differences were observed as a function of cognitive load.

DISCUSSION

In this study, we used fMRI to examine how psychopathic traits affect decisions in the UG. The UG provides a way of exploring how individuals weigh social and individual gain when making social decisions, thereby representing a valuable tool to investigate social decision making in psychopathy. In light of conflicting results from previous research, we formulated two sets of predictions concerning the processes recruited by higher scorers in psychopathy. To test our predictions, we incorporated two novel features into our design and analysis: (i) assessment of subjective perceptions of fairness and (ii) a cognitive load manipulation.

Table 4 Clusters identified by whole-brain linear regression analyses in the Unfair > Fair contrast (No Load), with acceptance rates and fairness ratings as predictors (MNI coordinates are reported; $P < 0.001$, uncorrected, 10 voxel threshold)

Cluster	BA	x	y	z	Voxels
High psychopathy					
Acceptance rates					
R ACC	24, 32	2	42	8	15
Fairness ratings					
R medial frontal gyrus	8	2	31	43	11
Low psychopathy					
Acceptance rates					
R superior parietal lobule	7, 5	35	-51	65	10
R parahippocampal gyrus	30, 19	15	-43	-2	10
L middle frontal gyrus	9	-49	16	29	10
L superior frontal gyrus	8	-4	43	60	10
Fairness ratings					
R inferior parietal lobule	19, 40	44	-71	44	13
L superior frontal gyrus	8	-4	43	60	10

R = Right; L = left.

Our results showed that both high and low psychopathy scorers tend to reject about 50% of unfair offers. This response pattern has been consistently demonstrated in the UG literature and has been interpreted as the result of both negative emotional reactions to unfairness and motivation to actively punish the other player for his unfairness (Fehr and Gächter, 2002; Sanfey *et al.*, 2003; de Quervain *et al.*, 2004; Fowler *et al.*, 2005). More importantly, we demonstrated that this response does not change when individuals are under more cognitively demanding conditions. This finding supports our second set of hypotheses, suggesting that the rejection of an unfair offer is mainly an automatic response in both groups.

Results also showed that, although high and low psychopathy scorers accepted unfair and fair offers in roughly the same proportion, subjects with higher psychopathic traits tended to perceive unfair offers as subjectively less unfair. Furthermore, as we hypothesized, in low psychopathy scorers the acceptance of unfair offers tracked closely with perceived fairness, whereas for high scorers no significant association was found. This suggests that, although both groups provided similar responses in the UG, the motivations to reject unfair offers across groups, as well as their underlying neural mechanisms, may be distinct.

In fact, as we predicted, in low psychopathy scorers the rejection of unfair offers was associated with dlPFC (BA 9) activity, with increased activation in this region being associated with higher acceptance of unfair offers. The dlPFC has been previously shown to be involved in inhibiting pre-potent responses (Suzuki *et al.*, 2011) and making normative choices (Baumgartner *et al.*, 2011; Steinbeis *et al.*, 2012). This pattern of results corroborates the idea that accepting unfair offers requires cognitive control, probably to override an automatic negative reaction to the violation of a fairness norm. Moreover, regions associated with acceptance rates overlapped with regions associated with subjective fairness perceptions, further supporting the idea that in low psychopathy scorers the perceived fairness of offers guides the decision to accept or reject them.

In contrast, high psychopathy scorers recruited a cluster in the rostral anterior cingulate cortex (ACC)/vmPFC (BA 24 and 32), with higher activation in this area being associated with rejection of unfair

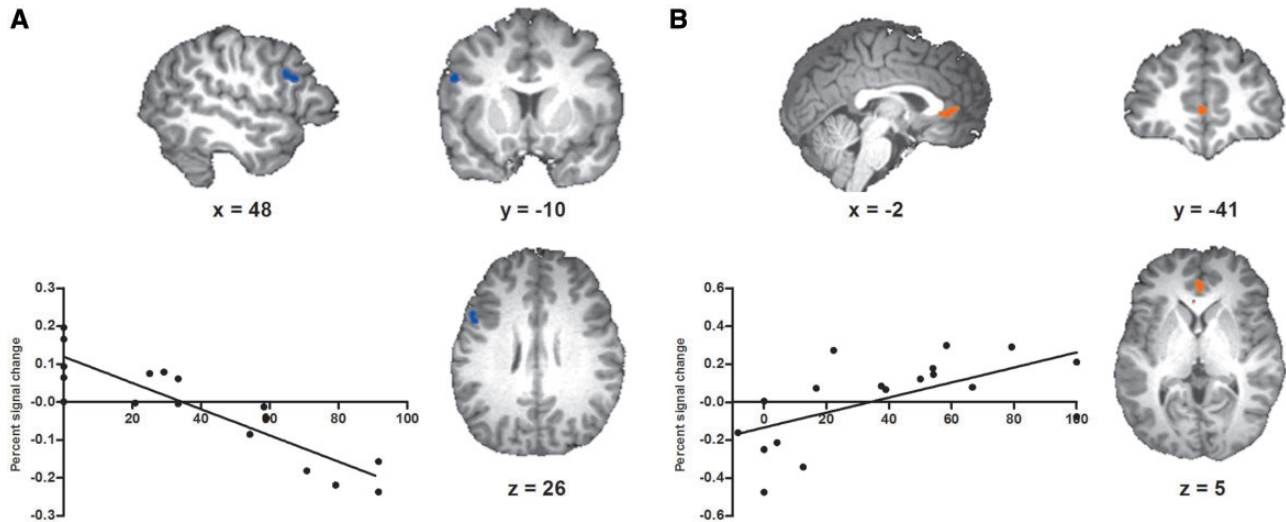


Fig. 3 Clusters identified by whole-brain linear regression analyses for the low (A) and high (B) psychopathy group in the Unfair > Fair contrast. (A) In the low psychopathy group, difference scores of acceptance rates were negatively associated with activity in the dlPFC, such that higher activation in this region was associated with increased acceptance of unfair offers. The scatter plot depicts the association between mean percent signal changes extracted from that cluster and difference scores. (B) In the high psychopathy group, difference scores of acceptance rates were negatively associated with activity in the rostral ACC/vmPFC, such that higher activation in this region was associated with increased rejection of unfair offers. The scatter plot depicts the association between mean percent signal changes in that cluster and difference scores.

offers. The vmPFC has been previously implicated in economic games (Rilling *et al.*, 2007; Baumgartner *et al.*, 2011; Suzuki *et al.*, 2011) and is known to have an important role in emotion regulation, especially in automatic emotional regulation processes (Phillips *et al.*, 2008). Damage in this region is associated with blunted affect and reduced tolerance to provocation or frustration (Barrash *et al.*, 2000; Bechara, 2004; Anderson *et al.*, 2006). Koenigs and Tranel (2007) demonstrated that vmPFC lesion patients with reported problems in emotion regulation made exaggerated irrational decisions in the UG, which was interpreted as the result of an angry reaction to the unfair treatment by another individual. A later study (Koenigs *et al.*, 2010) showed that the performance of individuals with elevated primary psychopathy scores was similar to that of vmPFC lesion patients. These findings are in line with models of vmPFC dysfunction in psychopathy, which suggest that abnormal vmPFC function is responsible for problems in stimulus reinforcement learning (e.g. Birbaumer *et al.*, 2005; Finger *et al.*, 2011) and reversal learning processes (e.g. Budhani *et al.*, 2006; Finger *et al.*, 2008). These problems compromise the ability to adapt to changing reinforcement contingencies and to obtain the desired outcomes, thus increasing the vulnerability to frustration in psychopathic individuals and, consequently, the risk for reactive aggression (Blair, 2010). Taking these findings into account, together with reports of increased vmPFC activity when individuals expect higher donations from others (Cooper *et al.*, 2010), we interpret the vmPFC activation observed in high psychopathy scorers as the result of the maintenance of high reward expectations throughout the game, with the conflict between such expectations and the unfairness of offers resulting in frustration and rejection. This interpretation is further supported by reports of reciprocal vmPFC and dlPFC activation in decision-making situations that vary in emotional saliency, with vmPFC being more active in 'hot' (emotionally salient) decisions and dlPFC in 'cold' (emotionally neutral) decisions (Goel and Dolan, 2003). In high psychopathy scorers it was also shown that, unlike in low scorers, no regions were involved in both acceptance rates and fairness ratings. The lack of overlap in the regions associated with UG responses and fairness perceptions further supports the hypothesis that in high psychopathy scorers UG decisions are not guided by fairness norm concerns.

Thus, in conjunction with the behavioral findings, these results lend support to the second set of hypotheses, suggesting that in high psychopathy scorers the response to unfair offers is probably not driven by a concern for fairness as normative preference for egalitarian divisions of resources, but instead may reflect an angry reaction to frustration for not obtaining the desired outcomes.

Although amygdala activity has been shown to be associated with a negative reaction to unequal divisions of resources (Haruno and Frith, 2010; Gaspic *et al.*, 2011; Osumi *et al.*, 2012), our results did not reveal amygdala activation to be a significant predictor of rejection rates in the low psychopathy group. This is consistent with the findings of Haruno and Frith (2010), who demonstrated that in healthy participants inequity aversion is only associated with amygdala activity in highly prosocial individuals (and not in subjects with a more individualistic social orientation). Within our groups, individual differences in social value orientation were not considered and no attempt was made to recruit unusually prosocial low-psychopathy participants, which could potentially explain why no effects were obtained in brain regions previously associated with negative reactions to unfairness, such as the amygdala, in the low psychopathy group.

Our findings should be interpreted in light of the fact that the study was conducted in a community sample (which was larger than that used in either of the two previous studies addressing UG responses in psychopathy), under the assumption that psychopathic traits are continuously distributed in the population (Markon *et al.*, 2011). Because we

used a recently developed self-report measure of psychopathy, the replication of the present findings using alternative instruments would be important to confirm the reported effects. This is particularly important given the absence of group differences in acceptance rates across groups, although this finding is not surprising considering the inconsistency of previous UG results in psychopathy, and the frequency with which distinct neural socio-affective processes are observed in high and low psychopathy scorers in the absence of overt behavioral differences (e.g. Harenski *et al.*, 2010; Sommer *et al.*, 2010; Pujol *et al.*, 2012). Replication will also be important in light of the fact that mean scores on the TriPM in community samples are not yet well established, such that we were unable to confirm how psychopathy scores in our sample compared with those of similar community samples.

In conclusion, this study was the first to adopt a linear regression approach in addition to the simple analysis of fMRI contrasts to directly investigate the neural mechanisms involved in economic decision making in individuals with varying psychopathic traits. Our findings may help to disambiguate previous findings by incorporating novel task features that clarify the relative influence of strategic and fairness considerations in the decisions made by each group. Our results also highlighted the role of the vmPFC in emotional regulation in social interactions, and implicate atypical functioning in this structure in the behavioral patterns of individuals with psychopathic traits. More importantly, they showed that similar behavioral responses can emerge from distinct underlying neural mechanisms, highlighting the importance of continuing to investigate the neural basis of adaptive and maladaptive social decision making in psychopathy.

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Conflict of Interest

None declared.

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Don't stand so close to me: psychopathy and the regulation of interpersonal distance

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Psychopathy is characterized by callous and unemotional personality traits, such as reduced empathy and remorse, and a tendency toward deviant interpersonal behaviors. It has been suggested that subtle behavioral cues in individuals with high levels of psychopathic traits may betray their personality during interpersonal interactions, but little research has addressed what these clues might be. In this study, we investigated whether psychopathic traits predict interpersonal distance preferences, which have been previously linked to amygdala functioning. 46 healthy participants performed a behavioral task in which the distance they preferred to maintain between themselves and an experimenter was measured across a series of trials. Psychopathic traits, including Coldheartedness, Fearless Dominance, and Self-centered Impulsivity were assessed using the Psychopathic Personality Inventory-Revised (Lilienfeld and Widows, 2005). Results demonstrated that Coldheartedness predicted preferred interpersonal distance, with more coldhearted participants preferring shorter distances. These findings suggest that interpersonal distance preferences may signal psychopathic traits, particularly callousness, supporting accounts of amygdala dysfunction in psychopathy.

Keywords: psychopathy, coldheartedness, interpersonal distance, approach/avoidance, amygdala

INTRODUCTION

Psychopathy is a personality variable characterized by callous and unemotional personality traits, such as lack of empathy and guilt, and antisocial behavioral tendencies, such as impulsiveness and aggression (Frick and White, 2008; Feilhauer and Cima, 2013). Given highly psychopathic individuals' penchant for deviant interpersonal behaviors, a troublesome feature of psychopathy is that individuals' outward appearance rarely betrays their affective and interpersonal deficits (Cleckley, 1988). Identifying observable behavioral cues that signal high levels of psychopathy would be highly desirable. That such cues exist is suggested by research showing observers can reliably detect psychopathic features from small samples, or "thin slices," of behavior (Fowler et al., 2009), although little evidence yet exists concerning what these cues might be.

In this study, we examined whether psychopathy predicts preferred interpersonal distance. The regulation of interpersonal distance appears to be supported by the amygdala. It was recently shown that a patient with selective bilateral amygdala lesions (SM) reported an abnormal lack of discomfort when standing very close to an experimenter and preferred interpersonal distances that were significantly shorter than the average preferred distance of controls (Kennedy et al., 2009). In the same study, fMRI results revealed that amygdala activity in healthy individuals was modulated by interpersonal distance, with activation increasing when subjects knew an experimenter was standing close to the scanner. This is consistent with research in animals showing that the amygdala is involved in regulating approach

and avoidance behaviors, such that monkeys with selective amygdala lesions show reduced avoidance of novel or naturally threatening objects (Machado et al., 2009), other monkeys in dyadic interactions (Emery et al., 2001), and human strangers (Mason et al., 2006).

These findings are in agreement with the possibility of aberrant interpersonal distance regulation in psychopathy, as robust evidence links psychopathy, particularly its affective component, to amygdala dysfunction. Both functional and structural amygdala abnormalities have been reported in high psychopathy scorers (Birbaumer et al., 2005; e.g., Kiehl et al., 2001; Gordon et al., 2004; Yang et al., 2010; Ermer et al., 2012; Marsh and Cardinale, 2014). Moreover, striking similarities between the behavior of psychopathic individuals and amygdala lesion patients have been observed. Both populations show facial, vocal, and postural fear recognition impairments (Adolphs et al., 1994; Scott et al., 1997; Blair et al., 2002; Munoz, 2009), reduced subjective experience of fear (Feinstein et al., 2011; Marsh et al., 2011), reduced startle modulation (Angrilli et al., 1996; Syngelaki et al., 2013), reduced anticipatory skin conductance response (Patrick et al., 1994; Bechara et al., 1995), and deficient aversive conditioning (LaBar et al., 1995; Rothemund et al., 2012).

No previous studies have investigated whether psychopathic traits affect the regulation of interpersonal distance during social interactions. Research on motoric approach/avoidance to social stimuli using a computer joystick task showed that high psychopathy scorers display less avoidance of social threats (angry faces; Von Borries et al., 2012), but it is unknown whether this would

extend to actual interpersonal distance regulation during social interactions. To investigate this question, we used a paradigm based on that developed by Kennedy et al. (2009) to assess interpersonal distance preferences in a community sample varying in psychopathy. In line with evidence showing amygdala dysfunction in psychopathy, we hypothesized that psychopathic traits would predict a preference for shorter interpersonal distances, paralleling what was observed with SM (Kennedy et al., 2009). Moreover, we were interested in investigating which psychopathic traits were most closely associated with interpersonal distance preferences. Recent reports linked reduced amygdala responsiveness specifically to the callous and unemotional components of psychopathy (White et al., 2012; Viding et al., 2013; Sebastian et al., 2014). Using the Psychopathic Personality Inventory-Revised (PPI-R; Lilienfeld and Widows, 2005), it has been demonstrated that Coldheartedness, which is associated with callousness, reduced empathy, and guiltlessness (Gaughan et al., 2009; Seibert et al., 2011), is associated with reduced amygdala activity to experimentally manipulated fearful faces (Han et al., 2011). In line with this evidence, we predicted that PPI-R Coldheartedness scores would most accurately predict preferred interpersonal distance.

MATERIAL AND METHODS

PARTICIPANTS

Forty-six participants (17 male; M age = 20.47, SD = 2.2, range 18–25) were recruited from the Georgetown University community and compensated for their participation. All participants reported not having any prior psychiatric or neurologic diagnoses, history of brain injuries or substance abuse, and not taking any psychotropic medication at the time of the study. The study was approved by the Institutional Review Board at Georgetown University, and all participants provided informed written consent in accordance with the Declaration of Helsinki.

PSYCHOPATHY MEASURES

Psychopathy was assessed using the PPI-R (Lilienfeld and Widows, 2005), a self-report instrument designed to measure psychopathic traits in a dimensional manner. This is consistent with the idea that psychopathy is a set of traits continuously distributed in the general population rather than a clinical taxon (Krueger et al., 2005; Skeem et al., 2011), and, like other personality disorders, it can be more reliably assessed using dimensional models of personality (Miller et al., 2001; Marcus et al., 2004). Although it was developed to assess psychopathic traits in community samples, the PPI-R and its predecessor correlate with psychopathy measures predominantly used in institutionalized samples, such as the PCL-R (Poythress et al., 2010). The PPI-R contains 154 items organized in eight subscales: social influence, fearlessness, stress immunity, Machiavellian egocentricity, rebellious non-conformity, blame externalization, carefree non-planfulness, and coldheartedness. These subscales, with the exception of coldheartedness, load into two higher-order factors, PPI-I or fearless dominance, and PPI-II or Self-centered impulsivity. Fearless dominance scores index interpersonal dominance and low anxiety (e.g., “When I’m in a frightening situation, I can “turn off” my fear almost at will”), and Self-centered impulsivity scores are

related to disinhibition and impulsive behavior (e.g., “I like to act first and think later”; Lilienfeld and Widows, 2005; Gaughan et al., 2009). Coldheartedness seems to be largely independent of both these factors, and is therefore regarded simultaneously as a subscale and a higher-order dimension (Skeem et al., 2011). Coldheartedness scores index callousness and lack of sympathy for others (e.g., “When someone is hurt by something I say or do, that’s their problem”; Lilienfeld and Widows, 2005; Gaughan et al., 2009).

INTERPERSONAL DISTANCE TASK

Following Kennedy et al. (2009), interpersonal distance preferences were measured across 32 trials for each participant, divided in two blocks. In the experimenter-walking block, participants began by standing with their toes on a mark on the floor. The experimenter stood four meters away and then began walking toward the participant at a natural gait (approximately 1 m/s). Participants were instructed to tell the experimenter to stop at their preferred distance (i.e., the distance at which they felt “the most comfortable”). This was then fine-tuned by allowing the participant to ask the experimenter to move slightly forward or back after she had stopped. Distance between the chins of the experimenter and participant was then measured using a digital laser tape measure (Bosch, model DLR130). In the participant-walking block, participants walked toward the experimenter and stopped upon reaching their preferred distance, also followed by adjustments after stopping if they desired. The order of the blocks was counterbalanced across participants. Within each block, trials varied in terms of *eye contact* (with or without) and *approach/withdrawal* (in approach trials the participant or experimenter started apart and walked forward, in avoidance trials they started close, with their toes approximately 2–3 cm apart, and walked backward). This resulted in eight different trial types, each repeated four times, with the order of trials being randomized within each block.

All participants were tested in the same room by two experimenters, one who gave task instructions and made distance measurements, and another who walked or stood. The experimenter who walked/stood maintained a neutral facial expression throughout the task and refrained from showing any signs of discomfort upon approaching or being approached by the participant.

RESULTS

We calculated the average preferred distance per participant, across and for each trial type. The distribution of values obtained across trials ranged from 0.41 to 1.58 m (M = 0.80, SD = 0.30; **Figure 1**), a distribution very similar to that reported by Kennedy et al. (2009) using the same task ($t(32) = 0.45$, $p = 0.65$).

Exploration of PPI-R total and factor scores revealed only minor deviations from normality, namely in the symmetry of the distributions (**Table 1**). Skewness values were < 1.0 for all variables and thus not indicative of significant deviations from normality (Field, 2005; Blanca et al., 2013). In order to be conservative, however, we log-transformed PPI-R total and factor scores and ran the analyses using both raw and log-transformed variables. These transformations did not affect the significance of any effects, so we

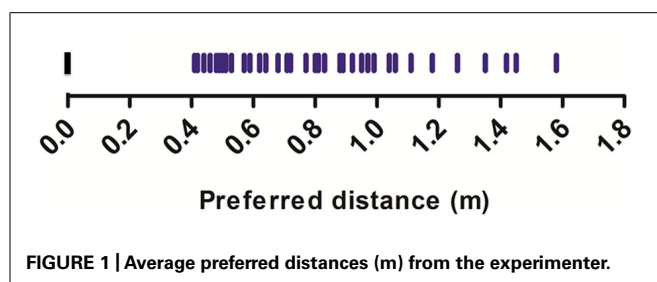


Table 1 | Sample characterization in terms of psychopathy scores (PPI-R total and factor scores).

	Cronbach's α	M (SD)	Min–Max
PPI-Total	0.95	303.79 (44.69)	228–426
Coldheartedness	0.83	29.78 (6.94)	17–52
Fearless dominance	0.94	128.41 (24.98)	63–171
Self-centered impulsivity	0.92	145.40 (24.10)	105–223

Table 2 | Correlation coefficients indexing the associations between overall preferred distance (m) and PPI-R total and factor scores.

	PPI-R total	C	FD	SCI
Overall preferred distance	−0.11	−0.29*	−0.07	−0.05

* $p < 0.05$. C = Coldheartedness; FD = Fearless Dominance; SCI = Self-centered Impulsivity.

present results obtained using non-transformed values in order to facilitate interpretation of findings.

We first examined the associations between overall preferred distance and PPI-R total and factor scores. Results revealed that overall preferred distance was only significantly associated only with Coldheartedness scores, with higher scorers preferring shorter distances (Table 2).

Follow-up correlations with preferred distance in each trial type showed that the strongest associations between Coldheartedness and distance were obtained in approach trials with eye contact, irrespective of person walking (experimenter-walking: $r = -0.35$, $p = 0.018$; participant-walking: $r = -0.35$, $p = 0.018$; Table 3; Figure 2), although the difference between the magnitude of the correlation coefficients across trial types was not significant.

To confirm the link between preferred distance and Coldheartedness, we computed the average preferred distance in approach trials with eye contact by collapsing experimenter-walking and participant-walking trials, and performed linear regression analysis with the three PPI-R factors as predictors, and co-varying out age, sex, and the match between experimenter and participant sex. Results revealed that Coldheartedness was the only significant predictor of preferred distance, with higher scores associated with preference for shorter distances (Table 4). Consistent effects were obtained using the overall preferred distance as dependent variable (Table 4).

To rule out possible effects of cultural variability within our sample, we repeated the correlation analyses after excluding subjects who were not born in the United States ($n = 10$). We also replicated the regression analyses with the total sample, adding nationality as a predictor of no interest. All observed associations between Coldheartedness and preferred distance remained significant.

Finally, we split the sample into quartiles according to Coldheartedness scores to compare the average preferred distance in approach – eye contact trials between highest and lowest scorers. T -test results ($t(24) = 2.04$, $p = 0.053$; $d = -0.78$) showed that the highest quartile of Coldheartedness scorers ($M = 0.67$ m, $SD = 0.21$) preferred shorter interpersonal distances than the lowest quartile ($M = 0.98$ m, $SD = 0.52$; Figure 3), with the middle quartiles showing intermediate values ($M = 0.71$ m, $SD = 0.23$; $M = 0.80$ m, $SD = 0.14$).

DISCUSSION

This study investigated whether psychopathic traits influence the distance individuals prefer to maintain between themselves and others in social interactions. Consistent with our hypothesis, results showed that PPI-R coldheartedness scores, which index interpersonal callousness (Gaughan et al., 2009), significantly predicted preferred distance, with more callous participants showing a preference for shorter distances. These patterns persisted even after potentially confounding variables, such as cultural background and sex, were accounted for in the analysis.

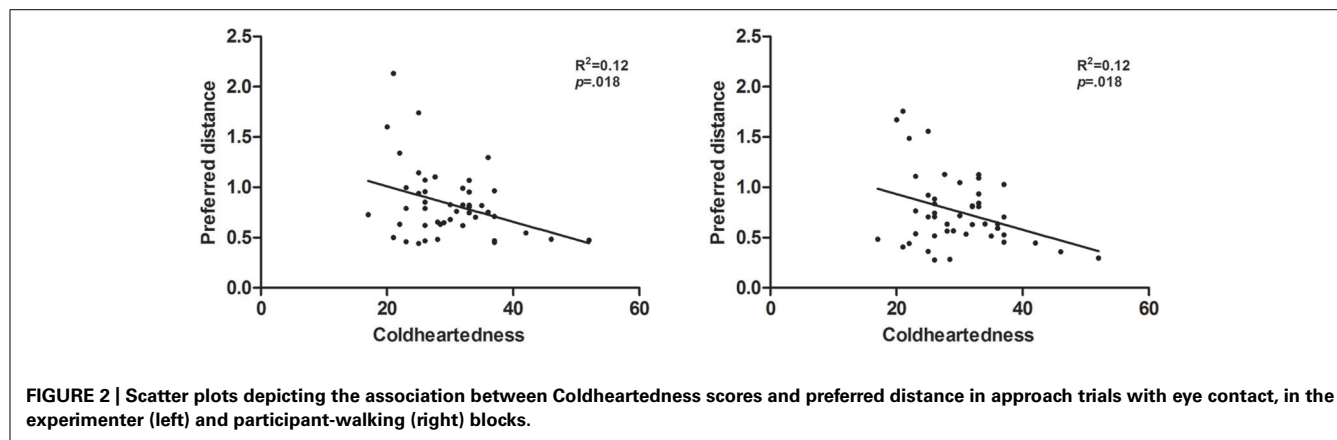
In his seminal work, Cleckley (1988) described psychopathy as a profound affective deficit that results in impaired patterns of interpersonal functioning. Nonetheless, he believed that individuals with psychopathic traits display a “mask of sanity” that gives them an appearance of normality, charm, and good intelligence. Fowler et al. (2009) argued that despite this “mask,” psychopaths’ lack of insight into their own deficits leads them to give away clues about their personality during interpersonal interactions. These clues, mainly non-verbal, may be picked up even from thin slices of behavior, and used by lay observers to make relatively reliable and accurate assessments of psychopathy, although the question of how these assessments are achieved remained unanswered by their study. Our results suggest that one clue that predicts the presence of heightened psychopathic traits, particularly callousness, is preferred interpersonal distance.

By demonstrating an association between coldheartedness and interpersonal distance regulation, a mechanism previously shown to be under the control of the amygdala (Kennedy et al., 2009), our results support the association between callous personality traits and amygdala dysfunction. This is in line with previous research linking atypical amygdala function to these traits more than to other features of psychopathy (Patrick et al., 1993; Marsh et al., 2008; Jones et al., 2009; White et al., 2012). Moreover, it is consistent with recent studies that specifically linked the PPI-R coldheartedness subscale to abnormal amygdala activity in response to social stimuli (Han et al., 2011). Finally, these results are in line with prior reports that psychopathic traits are associated with reduced avoidance of social stimuli (Von Borries et al., 2012). It should be noted, however, that contrary to Von Borries

Table 3 | Correlation coefficients indexing the associations between preferred distance (m) in each trial type and PPI Coldheartedness scores.

	Experimenter walking				Participant walking			
	Approach eye contact	Approach no eye contact	Withdrawal eye contact	Withdrawal no eye contact	Approach eye contact	Approach no eye contact	Withdrawal eye contact	Withdrawal no eye contact
C	−0.35*	−0.28	−0.27	−0.21	−0.35*	−0.28	−0.22	−0.07
FD	−0.04	−0.06	−0.1	−0.01	−0.15	−0.00	−0.20	−0.10
SCI	−0.05	−0.03	−0.05	−0.02	−0.09	−0.06	−0.05	−0.01

* $p < 0.05$. C = Coldheartedness; FD = Fearless Dominance; SCI = Self-centered Impulsivity.

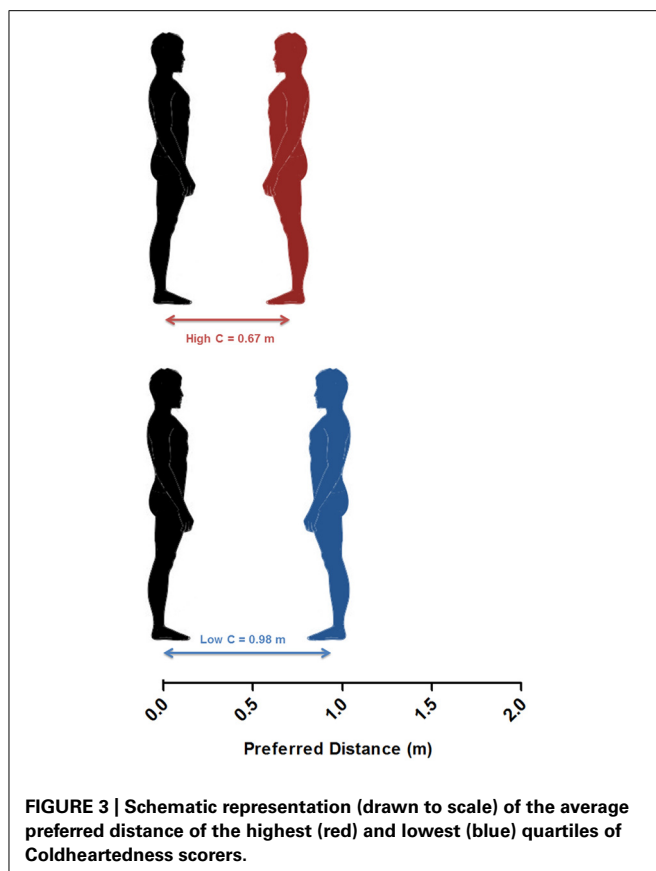
**Table 4 | Regression analysis results.**

Preferred distance in approach trials with eye contact	B	Wald Chi-Square (1 df)	p
Coldheartedness	−0.021	6.53	0.01
Self-Centered Impulsivity	0.001	0.33	0.95
Fearless Dominance	0.000	0.00	0.57
Overall preferred distance			
Coldheartedness	−0.016	4.68	0.03
Self-Centered Impulsivity	0.001	0.34	0.56
Fearless Dominance	0.000	0.01	0.93

Significant results highlighted in bold.

et al. (2012) our effects were specific for callous traits and not overall psychopathy. Moreover, we did not assess approach/avoidance behavior to threatening social stimuli. Despite these methodological differences, the fact that our results and those reported by Von Borries et al. (2012) were in the same direction further supports the association between psychopathic traits, especially callousness, and an atypical pattern of social approach/avoidance, which may extend to both threatening and non-threatening interactions. Our confidence in the present findings also relies on our sample size, which was larger than that used in the studies conducted by Kennedy et al. (2009), Han et al. (2011), and Von Borries et al. (2012), and yielded results that were in accordance with those studies.

One of the questions arising from our findings is why highly callous individuals would prefer to stand closer to other people, and whether this preference is related to other interpersonal behavioral patterns associated with psychopathy. Our trial-specific findings may help to address this question. Results showed that coldheartedness best predicted preferred distance when subjects were approached by or approached another person. These experimental conditions are the ones that best approximate a real-life aggressive encounter, suggesting that perhaps the regulation of interpersonal distance in highly callous individuals may relate to their demonstrated propensity for aggression in general and, particularly, for instrumental aggression (e.g., Viding et al., 2009; Walsh et al., 2009; Thornton et al., 2012). Although the link between personal space (i.e., the area maintained around oneself in social interactions; Sommer, 1959), and aggression has been investigated previously (e.g., Curran et al., 1978; Walkley and Gilmour, 1984), the personality traits mediating such association have never been systematically explored. It seems reasonable to assume that, for two people facing one another, shorter interpersonal distances would facilitate aggression by putting individuals within arm's reach. Interestingly, the average frontal arm reach – around 90 cm for males and 82 cm for females (Parker et al., 1996) – is shorter than the preferred distance of low coldheartedness scorers, but longer than the preferred distance of high coldheartedness scorers in our study, suggesting that more callous participants tended to prefer distances that put the experimenter within their reach. In light of these data, we speculate that interpersonal distance preferences of highly callous individuals may



mediate the relationship between callous traits and aggression, by producing behaviors that facilitate aggressive behavior. Although plausible and consistent with demonstrations that in high psychopathy scorers the decreased avoidance of threatening social stimuli is correlated with levels of instrumental aggression (Von Borries et al., 2012), this interpretation requires further testing. Furthermore, it would be important to confirm whether high and low coldheartedness scorers are equally able to detect if they are or not within the reach of another person to validate this interpretation.

An alternate explanation of our findings relates to the practical realization that those who maintain shorter interpersonal distances put themselves within others' reach and, therefore, become more vulnerable to aggression. In fact, classical accounts of personal space assigned it a protective function against potentially unpleasant or threatening situations (Dosey and Meisels, 1969). In addition to instrumental aggression, Von Borries et al. (2012) found an association between decreased social avoidance and inability to experience personal distress in psychopathic individuals. This interpretation is consistent with previous reports of reduced fearfulness in high psychopathy scorers (e.g., Marsh et al., 2011), which has been linked to atypical amygdala function in this population. In sum, it is possible that preference for shorter interpersonal distances in highly callous individuals reflects deficient social avoidance mechanisms, which could result from deficits in fear experience as a consequence of amygdala dysfunction. However, our results are not entirely congruent

with this interpretation, given that we did not find any significant effects of the PPI fearless dominance component (which among other traits indexes fearlessness) on preferred interpersonal distance.

In sum, this study demonstrated that the callousness component of psychopathy is associated with a preference for maintaining shorter distances in social interactions, a pattern that is likely to be linked to abnormal amygdala functioning. By identifying an observable behavior that potentially signals high callous traits, this study adds a novel finding to the literature concerning interpersonal behavior in psychopathy. In future research, the inclusion of additional measurements in the same paradigm, such as assessing the participant's walking pace and the number of adjustments necessary to choose the preferred distance, as well as explicitly manipulating the threat level and familiarity of the interactions, would enable a more precise characterization of the interpersonal behavioral styles associated with psychopathic traits. Furthermore, given prior research demonstrating a relationship between psychopathic traits and difficulties in recognizing emotional expressions of distress (e.g., Blair et al., 2001), it would be relevant to investigate whether interpersonal distance preferences in highly callous individuals are associated with difficulties in identifying signs of discomfort in others, or with the disregard of those signs. Even though it is not likely that our findings were driven by these potential deficits (as we tried to minimize displays of discomfort by the experimenter during the task), the possible relation between emotional recognition deficits and interpersonal distance preferences in individuals varying in psychopathic traits should be investigated in future studies. Finally, further research is needed to address the putative associations between interpersonal distance preferences, fear, and aggression as a function of psychopathic personality traits, and to directly investigate its neural basis.

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Discussion

1. Summary of findings

This work investigated the influence of psychopathic traits on social behavior, with the objective of answering two main questions:

1. How do psychopathic traits affect interpersonal behavior and decision-making in social interactions?
2. What are the neural mechanisms driving interpersonal behavior and social decisions in individuals with varying psychopathic traits?

Overall, results obtained in two separate studies suggested that psychopathic personality traits in healthy individuals are associated with atypical patterns of neural activity, which may affect social behavior. The first study showed that individuals who vary in psychopathic tendencies recruited divergent neural mechanisms to make decisions in the ultimatum game. In low psychopathy scorers, decisions were affected by subjective evaluations of the fairness of offers, and therefore, as previously suggested (e.g. Gaspic et al., 2011; Sanfey et al., 2003), the acceptance of unequal proposals required additional cognitive effort, indexed by activity in the dorsolateral prefrontal cortex (dlPFC). Conversely, amongst high psychopathy scorers, decisions did not appear to be motivated by fairness considerations. Instead, results suggested that rejections were induced by frustration, which resulted from abnormal processing of the reward value of offers, and was indexed by ventromedial prefrontal cortex activity (vmPFC). The second study demonstrated that individuals scoring higher in callous traits (PPI-R coldheartedness) displayed abnormal approach/avoidance behavior in social interactions. Specifically, our results showed that more callous participants demonstrated a preference for shorter interpersonal distances, a pattern that is probably associated with amygdala dysfunction (Kennedy et al., 2009). Taken together, these findings highlight some of the neural vulnerabilities that may give rise to dysfunctional patterns of social interaction in individuals with high psychopathic tendencies, and are consistent with accounts that specifically link psychopathy with abnormal functioning of the vmPFC and amygdala (Blair, 2007a, 2008, 2013; Koenigs, 2012; Marsh, 2013).

2. Implications for neurobiological models of psychopathy

2.1. vmPFC

Results obtained in the first study revealed that in individuals scoring higher in psychopathy social decisions were predicted by activity in the vmPFC, specifically in a cluster within the rostral ACC, with higher activation in this region being associated with increased rejection of unfair offers.

It has been suggested that the vmPFC is implicated in linking potential decision outcomes with somatic states based on previous reward and punishment experiences (Damasio, 1996), in representing the value of rewards and goal-directed actions (Levy & Glimcher, 2012), in regulating emotional states (Phillips, Ladouceur, & Drevets, 2008), and also in facilitating social emotions, such as embarrassment or guilt, through its role in self-reflection (Beer, John, Scabini, & Knight, 2006). Research suggests psychopathy is associated with vmPFC dysfunction, with neuroimaging studies demonstrating both structural (e.g. Yang et al., 2010; Yang et al., 2005) and functional (e.g. Finger et al., 2008; Sommer et al., 2010; Veit et al., 2009) vmPFC abnormalities in psychopathy. This is further supported by studies reporting comparable deficits in vmPFC lesion patients and psychopaths in tasks involving response reversal (Budhani, Richell, & Blair, 2006; Hornak et al., 2004; Mitchell, Colledge, Leonard, & Blair, 2002), moral judgment (Koenigs et al., 2012; Koenigs et al., 2007), and social decision-making (Koenigs et al., 2010). Previous studies reporting atypical vmPFC function in psychopathic individuals during tasks that require stimulus reinforcement learning (Birbaumer et al., 2005; Finger et al., 2011) and response reversal (Budhani et al., 2006; Finger et al., 2008) are particularly relevant for the interpretation of our findings. Overall, these studies demonstrated that subjects higher in psychopathy show difficulties in adapting their responses to changing reinforcement contingencies, and that those difficulties are associated with atypical functioning of the vmPFC. These previous findings suggest that the increased vmPFC activity observed in high psychopathy scorers in our study could be related to abnormal processing of the reward value of offers. Specifically, we argued that increased vmPFC activity in high psychopathy scorers indexes the anticipation of gains during the task, with the violation of reward expectations by the unfairness of some offers resulting in frustration-induced rejection. This interpretation is consistent with a number of studies reporting

that activity within the rostral ACC/vmPFC increases with the expectation of rewards (e.g. Glascher, Hampton, & O'Doherty, 2009; Kim, Shimojo, & O'Doherty, 2011; Levy & Glimcher, 2011; Lin, Adolphs, & Rangel, 2012; Marsh, Blair, Vythilingam, Busis, & Blair, 2007) (Figure 4). It is also in agreement with recent studies suggesting that adolescents with psychopathic traits have difficulties in coding expected value information, and that those difficulties are probably associated with abnormal vmPFC activation (White, Brislin, et al., 2013; White, Pope, et al., 2013).

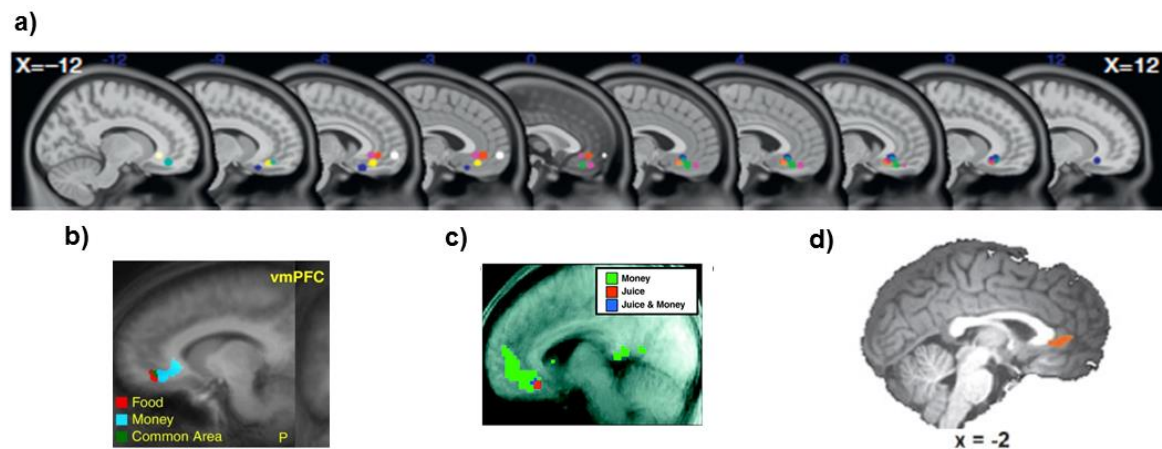


Figure 4: Role of the vmPFC in the codification of the reward value of stimuli. a) vmPFC clusters representing value-related signals in 13 imaging studies reviewed by Levy and Glimcher (2012) (reprinted from Current Opinion in Neurobiology, Volume 22, Issue 6, Levy & Glimcher, The root of all value: a neural common currency for choice, 1027-1038, Copyright 2012, with permission from Elsevier); b) and c) clusters with activation specifically associated with expected value of different reward types (Kim et al., 2011; Levy & Glimcher, 2011, respectively) (Kim et al, Overlapping Responses for the Expectation of Juice and Money Rewards in Human Ventromedial Prefrontal Cortex, Cerebral Cortex, 2011, 21(4), 769-776, by permission of Oxford University Press; Levy & Glimcher, 2011, The Journal of Neuroscience, 12 October 2011, 31(41):14693-14707; doi:10.1523/JNEUROSCI.2218-11.2011, reprinted with permission of the Journal of Neuroscience). d) Cluster predicting rejection of unfair offers in Study 2 (Vieira et al, Distinct neural activation patterns underlie economic decisions in high and low psychopathy scorers, Social Cognitive and Affective Neuroscience, 2013, epub ahead of print, by permission of Oxford University Press).

Our findings are interpretable within leading neurobiological models of psychopathy. In his model, Blair (2010, 2013) proposed that impairments in learning stimulus-reinforcement associations and representing reinforcement expectations driven by vmPFC dysfunction compromise decision-making in psychopathic individuals, often preventing them from obtaining

the desired outcomes. The mismatch between desired and obtained outcomes heightens the vulnerability to frustration, increasing the risk for reactive aggression, one of the troubling antisocial correlates of psychopathy. Our study supports this hypothesis and demonstrates its applicability to social decisions among individuals with psychopathic traits.

2.2. Amygdala

The amygdala has been consistently implicated in the pathophysiology of psychopathy. By investigating the relation between psychopathic traits and interpersonal distance, our study indirectly tested the involvement of the amygdala in psychopathy. Fowler and colleagues (2009) suggested that psychopathic individuals might give away subtle clues about their personality during social interactions, enabling quick and accurate assessments of psychopathy from “thin slices” of interpersonal behavior. Our results suggested that the preference for shorter interpersonal distances may be one of those clues. More importantly, we argue that this behavioral manifestation probably reflects an amygdala dysfunction in individuals with high callous traits.

The observed pattern of interpersonal distance regulation is akin to what was reported with SM, a patient with selective bilateral amygdala lesions (Kennedy et al., 2009). This similarity adds to a number of previous studies reporting parallel deficits in psychopathic individuals and amygdala lesion patients in laboratory tasks. Specifically, both groups have shown deficits in facial, vocal and postural fear recognition (Adolphs, Tranel, Damasio, & Damasio, 1994; Blair et al., 2002; Dawel, O'Kearney, McKone, & Palermo, 2012; Munoz, 2009; Scott et al., 1997; Sprengelmeyer et al., 1999), reduced subjective experience of fear (Feinstein, Adolphs, Damasio, & Tranel, 2011; Marsh, Finger, Schechter, et al., 2011), reduced startle modulation (Angrilli et al., 1996; Patrick et al., 1993), reduced anticipatory skin conductance response (Bechara et al., 1995; Patrick, Cuthbert, & Lang, 1994), and deficient aversive conditioning (LaBar, LeDoux, Spencer, & Phelps, 1995; Lykken, 1957; Rothmund et al., 2012). Our interpretation of the findings is also in agreement with a solid body of neuroimaging research pointing to amygdala abnormalities in psychopathic subjects. Structural imaging studies have shown anomalies in amygdala structure and volume (Ermer et al., 2012; Fairchild et al., 2013; Yang et al., 2010). Functional imaging

studies demonstrated that psychopathic individuals display atypical amygdala activity in response to both fearful faces (Gordon et al., 2004; Jones, Laurens, Herba, Barker, & Viding, 2009; Marsh et al., 2008; White, Williams, et al., 2012) and fear-evoking statements (Marsh & Cardinale, 2012b), during emotionally charged moral dilemmas (Glenn et al., 2009), when assessing the severity of moral violations (Harenski et al., 2010), in response to negative social outcomes (Rilling et al., 2007), and during fear conditioning (Birbaumer et al., 2005). Moreover, the reported abnormalities seem to be specifically associated with callous-unemotional personality traits and not with the behavioral tendencies that characterize the disorder (Han et al., 2011; Jones et al., 2009; Marsh et al., 2008; White, Marsh, et al., 2012), which is congruent with our coldheartedness-specific effects.

The hypothesis that psychopathy is associated with an amygdala dysfunction is shared by several models of psychopathy (Blair, 2007a; Fowles & Dindo, 2006; Marsh, 2013; Patrick, 1994). Marsh (2013) argues that individuals with high psychopathic tendencies have a fundamental deficit in amygdala-based fear processing. A solid body of empirical data, obtained in both animal and human subjects, indicates that the amygdala and its efferent projections are essential for threat processing and the generation of fear (Davis & Whalen, 2001; Pare & Duvarci, 2012; Phan, Wager, Taylor, & Liberzon, 2002; Sehlmeier et al., 2009). Furthermore, it has been demonstrated that the amygdala's role in the regulation of approach and avoidance behaviors to threatening stimuli extends to social contexts (Adolphs, 2010) (Figure 5). Research with monkeys showed that animals with selective amygdala ablations not only show reduced avoidance of novel or naturally threatening objects (Machado, Kazama, & Bachevalier, 2009), but also of other monkeys in dyadic interactions (Emery et al., 2001), and human strangers (Mason, Capitanio, Machado, Mendoza, & Amaral, 2006). Similarly, in human patients, amygdala lesions are associated with lack of avoidance of threatening stimuli (Feinstein et al., 2011) and lack of discomfort in response to violations of personal space during dyadic interactions (Kennedy et al., 2009). This evidence is consistent with what has been described in psychopathic individuals. In addition to fear conditioning (Birbaumer et al., 2005) and passive avoidance deficits (Newman & Schmitt, 1998), psychopathic traits have been shown to be associated with reduced avoidance of social threats (specifically, angry faces) (Von Borries et al., 2012) and, according to our own results, with a preference for shorter distances in interpersonal interactions.

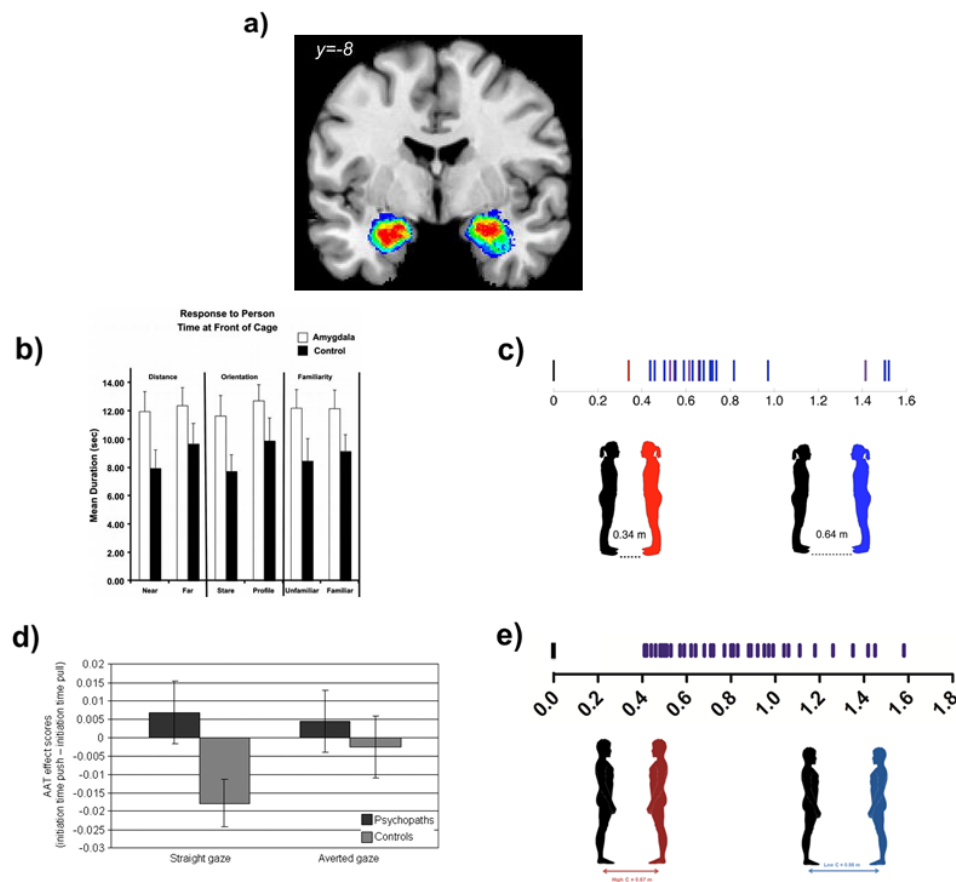


Figure 5: Role of the amygdala in social approach/avoidance behavior. a) Probabilistic maps of the amygdala, hippocampus and entorhinal cortex in anatomical MNI space (the color scale indicates the overlap of anatomical structures in a sample of 10 brains) (Anatomy and Embryology, 210(5-6), 2005, 343-352, Cytoarchitectonic mapping of the human amygdala, hippocampal region and entorhinal cortex: intersubject variability and probability maps, Amunts et al., figure 2, copyright 2005, reprinted with kind permission from Springer Science and Business Media). b) Monkeys with amygdala lesions show less avoidance of human strangers, which reflects on the amount of time they spend at the front of the cage when there is an unfamiliar person standing near the cage (reprinted with permission from Mason et al., Amygdalectomy and responsiveness to novelty in rhesus monkeys (*Macaca mulatta*): generality and individual consistency of effects, *Emotion*, 6(1), 73-81, 2006, APA). c) Overall preferred distance (m) from experimenter (back) by SM (red) and 20 control subjects (blue and purple)(reprinted by permission from Macmillan Publishers Ltd: *Nature Neuroscience*, Kennedy et al., 2009, copyright 2009). d) Psychopaths display reduced avoidance of angry faces in a motoric approach-avoidance task (reprinted from *Psychiatry Research*, 200(2-3), Von Borries et al., Psychopaths lack the automatic avoidance of social threat: relation to instrumental aggression, 761-766, Copyright 2012, with permission from Elsevier). e) Overall preferred distance (m) from experimenter (black) in a sample of 46 participants from Study 2, with the highest coldheartedness scorers preferring significantly shorter distances (adapted from Vieira & Marsh, 2013).

Models of amygdala dysfunction in psychopathy have also emphasized how this neural deficit reflects on antisocial behavioral patterns, particularly instrumental aggression (Blair, 2007a; Marsh, 2013). Marsh (2013) suggested that amygdala-driven difficulties in experiencing fear in psychopathic individuals compromise empathy for fearful others (Marsh et al., 2013; Marsh et al., 2008), and therefore cause difficulties in judging the acceptability of, and inhibiting behaviors that cause fright or distress to others (Marsh & Cardinale, 2012a, 2012b). Although not tested directly, our data suggested that social approach/avoidance problems in highly callous individuals may facilitate instrumental aggression in this population, in line with what was reported in a previous study (Von Borries et al., 2012). In sum, our findings provide further support to the hypothesis of amygdala dysfunction in psychopathy, and demonstrate how this neural vulnerability may translate in abnormal patterns of interpersonal behavior.

3. Concluding remarks

3.1. *Main conclusions*

This work adopted a neuroscientific approach to the study of social behavior in psychopathy, adding to a growing body of research that has tried to shed light on the mechanisms that underlie the emotional, interpersonal and behavioral problems that are consistently observed in individuals with high psychopathic traits.

One main conclusion arising from this set of studies is that particular patterns of social behavior associated with high psychopathic traits seem to result from specific neural abnormalities, namely in the vmPFC and amygdala. Importantly, our findings show that those neural abnormalities sometimes lead to behavioral impairments that may be subtle and remain undetected in some experimental tasks. For instance, results obtained in the first study showed that individuals with high psychopathic traits produced social responses that were comparable to those produced by low psychopathy scorers. Despite the absence of differences in explicit behavioral responses, a deeper exploration of the neurocognitive processes involved revealed that the implicit reasons driving those responses were probably divergent, as high and low scorers valued fairness and reward differently when making decisions. This is consistent with

previous literature showing differential neural processes in subjects scoring high and low in psychopathy during socio-affective tasks, in the absence of overt behavioral differences (Glenn et al., 2009; Gordon et al., 2004; Pujol et al., 2012; Sommer et al., 2010). Conversely, results of our second study suggested that some neural abnormalities that underlie high psychopathic traits, namely in the amygdala, result in observable alterations in interpersonal behavior. Specifically, this study identified for the first time a potential behavioral cue (the preference for shorter interpersonal distances) that may signal high callous traits in interpersonal interactions, while proposing its putative neural cause.

Overall, our findings seem to mirror Cleckley's (1988) description of psychopathic individuals, which emphasized how they are often able to display apparently adaptive social behavior while concealing severe emotional and interpersonal impairments, therefore rendering it sometimes extremely difficult to detect their true deficits:

"Despite the extraordinarily poor judgment demonstrated (...) in the actual living of his life, the psychopath characteristically demonstrates unimpaired (sometimes excellent) judgment in appraising theoretical situations. In complex matters of judgment involving ethical, emotional, and other evaluational factors (...) he also shows no evidence of a defect. So long as the test is verbal or otherwise abstract, so long as he is not a direct participant, he shows that he knows his way about. (...) When the test of action comes to him we soon find ample evidence of his deficiency" (p.346).

As suggested in this quote, one of the factors that may determine the extent to which psychopathic individuals manifest their deficits in social scenarios is related to the nature of the task or situation at hand. This idea may help to explain why we found overt behavioral differences as a function of psychopathic traits in one study, but not in the other, although there is evidence of alterations in the neural mechanisms recruited by both tasks. The ultimatum game is a decision-making paradigm, implying therefore a higher level of abstraction and computational demands. In terms of the neural processes involved, performance in this task recruits a network of regions, including the vmPFC, which are implicated in representing the value of different responses and outcomes. As demonstrated by our and previous research, psychopathic traits are associated with impairments in these processes. Importantly, these

impairments are believed to be primarily associated with the disinhibition component of psychopathy, and partially shared with other externalizing disorders (e.g. ADHD) (Blair, 2013). On the other hand, the interpersonal distance task requires “action”, assessing more automatic approach/avoidance behavior, and being expected to specifically recruit the amygdala. There is ample evidence that amygdala dysfunction is linked to psychopathy, particularly to its callous-unemotional component (e.g. Han et al., 2011), as supported by our coldheartedness-specific findings. In sum, it is possible that the somewhat divergent findings obtained in the two studies were due to differences in task demands, and consequently in the neural mechanisms recruited. Moreover, the psychopathy-related effects were probably driven by different psychopathic traits: in the first study, the deficits found were possibly more associated with externalizing psychopathic traits, and determined by vmPFC dysfunction, whereas deficits found in the second were driven by callous-unemotional traits, which are rooted in amygdala dysfunction. It is worth noting that there are reports implicating the amygdala in ultimatum game performance as well (Gospic et al., 2011). However, as discussed in the first study, our results showed amygdala activity did not predict decisions in the task, even within the low psychopathy group, which is consistent with previous investigations (e.g. Sanfey et al., 2003).

3.2. *Directions for future research*

To enable a more precise characterization of the patterns of social behavior manifested by psychopathic individuals, future research should strive to develop tasks that enable the investigation of both implicit and explicit responses, so that even subtle behavioral deficits may be more easily detected and investigated. Additionally, the relative contribution of different psychopathic traits (in addition to overall psychopathy) in task performance should be assessed, in line with the idea that psychopathy represents a constellation of phenotypic dimensions, rather than a unitary construct (Patrick et al., 2009). Finally, the pattern of functional and structural brain alterations associated with different psychopathic features should be investigated. In an on-going voxel-based morphometry (VBM) analysis of the anatomical data collected in study 1, we are exploring volumetric alterations associated with different psychopathic traits. Consistent with existing reports (see section II.1), our preliminary data

suggests that total psychopathy scores are associated with reduced gray matter volumes in a network of regions comprising the amygdala, hippocampus and parahippocampal gyrus, and orbitofrontal and superior temporal cortices. Furthermore, boldness was associated with volume reductions in the insula, fusiform gyrus and orbitofrontal cortex, whereas meanness predicted reductions in the hippocampus and parahippocampal gyrus, amygdala, fusiform gyrus, and superior and medial prefrontal cortices. Finally, disinhibition scores were associated with alterations within the striatum, inferior temporal cortex and precuneus. These findings, although preliminary, seem to support theoretical accounts concerning the neurobiological bases of boldness, meanness and disinhibition-related traits. More importantly, they represent one of the first attempts to identify the structural brain alterations that predict distinct psychopathic personality traits in healthy individuals.

The characterization of the neural correlates of psychopathy may carry important advantages for social, clinical and legal settings. In fact, such knowledge could help to elucidate the pathophysiology of psychopathic traits and identify putative neural markers that could be used to detect individuals with heightened psychopathic tendencies, in addition to representing potential targets for pharmacological interventions. Yet, it should be noted that applied outcomes such as these are still fairly remote, and that more research is needed to identify consistent and unequivocal neural correlates of psychopathic traits. Irrespective of its applicability to legal and clinical contexts, basic research on psychopathy, as well as on other clinical and subclinical populations that present social and affective impairments (e.g. autism, alexithymia), has the potential to make significant contributions to the understanding of the neurobiological bases of emotion and social cognition, providing valuable insights into the mechanisms that subserve processes such as empathy and aggression.

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Appendices

Appendix 1:

Triarchic Psychopathy Measure (Patrick, 2010)

Directions: This questionnaire contains statements that different people might use to describe themselves. Each statement is followed by four choices: ☐ T ☐ t ☐ f ☐ F. The meaning of these four different choices is as follows:

☐ T = True ☐ t = somewhat true ☐ f = somewhat false ☐ F = False

For each statement, fill in the bubble for the choice that describes you best. There are no right or wrong answers; just choose the answer that best describes you.

Like this: ☒ Not like this: ☒ ☒ ☒

Remember: Fill only one bubble per item. If you make a mistake cross out the incorrect answer with an X and fill in the correct option. Answer all of the items. Please work rapidly and do not spend too much time on any one statement.

- | | | | | | |
|-----|--|---|---|---|---|
| 1. | I'm optimistic more often than not. | T | t | f | F |
| 2. | How other people feel is important to me. | T | t | f | F |
| 3. | I often act on immediate needs. | T | t | f | F |
| 4. | I have no strong desire to parachute out of an airplane. | T | t | f | F |
| 5. | I've often missed things I promised to attend. | T | t | f | F |
| 6. | I would enjoy being in a high-speed chase. | T | t | f | F |
| 7. | I am well-equipped to deal with stress. | T | t | f | F |
| 8. | I don't mind if someone I dislike gets hurt. | T | t | f | F |
| 9. | My impulsive decisions have caused problems with loved ones. | T | t | f | F |
| 10. | I get scared easily. | T | t | f | F |
| 11. | I sympathize with others' problems. | T | t | f | F |
| 12. | I have missed work without bothering to call in. | T | t | f | F |
| 13. | I'm a born leader. | T | t | f | F |
| 14. | I enjoy a good physical fight. | T | t | f | F |
| 15. | I jump into things without thinking. | T | t | f | F |
| 16. | I have a hard time making things turn out the way I want. | T | t | f | F |
| 17. | I return insults. | T | t | f | F |
| 18. | I've gotten in trouble because I missed too much school. | T | t | f | F |

19.	I have a knack for influencing people.	T	t	f	F
20.	It doesn't bother me to see someone else in pain.	T	t	f	F
21.	I have good control over myself.	T	t	f	F
22.	I function well in new situations, even when unprepared.	T	t	f	F
23.	I enjoy pushing people around sometimes.	T	t	f	F
24.	I have taken money from someone's purse or wallet without asking.	T	t	f	F
25.	I don't think of myself as talented.	T	t	f	F
26.	I taunt people just to stir things up.	T	t	f	F
27.	People often abuse my trust.	T	t	f	F
28.	I'm afraid of far fewer things than most people.	T	t	f	F
29.	I don't see any point in worrying if what I do hurts someone else.	T	t	f	F
30.	I keep appointments I make.	T	t	f	F
31.	I often get bored quickly and lose interest.	T	t	f	F
32.	I can get over things that would traumatize others.	T	t	f	F
33.	I am sensitive to the feelings of others.	T	t	f	F
34.	I have conned people to get money from them.	T	t	f	F
35.	It worries me to go into an unfamiliar situation without knowing all the details.	T	t	f	F
36.	I don't have much sympathy for people.	T	t	f	F
37.	I get in trouble for not considering the consequences of my actions.	T	t	f	F
38.	I can convince people to do what I want.	T	t	f	F
39.	For me, honesty really is the best policy.	T	t	f	F
40.	I've injured people to see them in pain.	T	t	f	F
41.	I don't like to take the lead in groups.	T	t	f	F
42.	I sometimes insult people on purpose to get a reaction from them.	T	t	f	F
43.	I have taken items from a store without paying for them.	T	t	f	F
44.	It's easy to embarrass me.	T	t	f	F
45.	Things are more fun if a little danger is involved.	T	t	f	F
46.	I have a hard time waiting patiently for things I want.	T	t	f	F

47.	I stay away from physical danger as much as I can.	T	t	f	F
48.	I don't care much if what I do hurts others.	T	t	f	F
49.	I have lost a friend because of irresponsible things I've done.	T	t	f	F
50.	I don't stack up well against most others.	T	t	f	F
51.	Others have told me they are concerned about my lack of self-control.	T	t	f	F
52.	It's easy for me to relate to other people's emotions.	T	t	f	F
53.	I have robbed someone.	T	t	f	F
54.	I never worry about making a fool of myself with others.	T	t	f	F
55.	It doesn't bother me when people around me are hurting.	T	t	f	F
56.	I have had problems at work because I was irresponsible.	T	t	f	F
57.	I'm not very good at influencing people.	T	t	f	F
58.	I have stolen something out of a vehicle.	T	t	f	F

