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Economic decision-making in psychopathy: A comparison with ventromedial prefrontal lesion patients

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ABSTRACT

Psychopathy, which is characterized by a constellation of antisocial behavioral traits, may be subdivided on the basis of etiology: "primary" (low-anxious) psychopathy is viewed as a direct consequence of some core intrinsic deficit, whereas "secondary" (high-anxious) psychopathy is viewed as an indirect consequence of environmental factors or other psychopathology. Theories on the neurobiology of psychopathy have targeted dysfunction within ventromedial prefrontal cortex (vmPFC) as a putative mechanism, yet the relationship between vmPFC function and psychopathy subtype has not been fully explored. In this study, we administered two laboratory decision-making tasks (the Ultimatum Game and the Dictator Game) to a group of prisoners ($n = 47$) to determine whether the different subtypes of psychopathy (primary vs. secondary) are associated with characteristic patterns of economic decision-making, and furthermore, whether either subtype exhibits similar performance to patients with vmPFC lesions. Comparing primary psychopaths ($n = 6$) to secondary psychopaths ($n = 6$) and non-psychopaths ($n = 22$), we found that primary psychopathy was associated with significantly lower acceptance rates of unfair Ultimatum offers and lower offer amounts in the Dictator Game. Moreover, primary psychopaths were quantitatively similar to vmPFC lesion patients in their response patterns. These results support the purported connection between psychopathy and vmPFC dysfunction, bolster the distinction between primary and secondary psychopathy, and demonstrate the utility of laboratory economic decision-making tests in differentiating clinical subgroups.

1. Introduction

For decades, psychopathy researchers have theorized that the extreme affective and behavioral traits that characterize the disorder could arise through different causal mechanisms. In other words, psychopaths may consist of "phenotypically similar, but etiologically distinct subtypes" (Lykken, 1957). Based on this etiological perspective, two classes of psychopaths have been proposed. In the "primary" subtype, psychopathy is presumed to arise directly from some fundamental intrinsic deficit, likely involving innate dysfunction in basic affective and attentional mechanisms. By contrast, "secondary" psychopathy is thought to arise as an acquired disturbance of social and affective processing—an indirect consequence of environmental or psychosocial factors such as parental abuse, socioeconomic disadvantage, poor intellect, substance abuse, or neurotic anxiety (Blackburn, Logan, Donnelly, & Renwick, 2008; Cleckley, 1976; Karpman, 1946, 1948; Lykken, 1995; Porter, 1996; Skeem, Johansson, Andershed, Kerr, & Louden, 2007). This theoretical distinction between primary and secondary psychopathy has profound implications for research on the neurobiological basis of the disorder. If there are indeed multiple, distinct causal mechanisms for psychopathy, then one may expect the different etiological subtypes to exhibit distinct psychological and neurobiological profiles within the context of similarly flagrant antisocial behaviors. The question, then, is how to differentiate primary psychopaths from secondary psychopaths for the purposes of research. In previous studies primary and secondary psychopaths have typically been differentiated based on levels of trait anxiety (Arnett, Smith, & Newman, 1997; Blackburn, 1975; Brinkley, Newman, Widiger, & Lyman, 2004; Fagan & Lira, 1980; Hiatt, Schmitt, & Newman, 2004). This practice is supported by ample theoretical and empirical work. In his seminal clinical descriptions, Cleckley stresses the importance of considering anxiety levels for the classification of psychopathy: "...[primary] psychopaths are sharply characterized by the lack of anxiety...I do not believe that [primary] psychopaths should be identified with the psychoneurotic group" (Cleckley, 1976). Following Cleckley's recommendation of distinguishing low-anxiety individuals from those with high (neurotic) levels of anxiety, a large and growing number of laboratory studies demonstrate abnormal behavioral

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results for low-anxious (primary) psychopaths but not necessarily for high-anxious (secondary) psychopaths (Arnett, Howland, Smith, & Newman, 1993; Arnett et al., 1997; Chesno & Kilmann, 1975; Fagan & Lira, 1980; Lykken, 1957; Newman, Kosson, & Patterson, 1992; Newman, Patterson, Howland, & Nichols, 1990; Newman, Schmitt, & Voss, 1997; O'Brien & Frick, 1996; Schmitt, Brinkley, & Newman, 1999; Skeem et al., 2007; Smith, Arnett, & Newman, 1992; Zeier, Maxwell, & Newman, 2009). In the present study, we seek to build on this experimental tradition to determine whether primary (low anxiety) and secondary (high anxiety) psychopaths differ in their behavior in the domain of economic decision-making. In addition, we compare the performance of each psychopathic subgroup to patients with focal damage to an area of the brain that plays a critical role in affective processing: the ventromedial prefrontal cortex (vmPFC).

The theorized connection between vmPFC dysfunction and psychopathy dates back decades in the field of behavioral neurology. Recognizing similarities between psychopaths and their patients with vmPFC lesions (lack of empathy, irresponsibility, poor decision-making), Blumer and Benson (1975) coined the phrase "pseudopsychopathy" to refer to the personalities of certain frontal lobe patients. Subsequent clinical and laboratory studies have continued to highlight similarities between psychopaths and vmPFC lesion patients (Damasio, Tranel, & Damasio, 1990; Eslinger & Damasio, 1985; Koenigs & Tranel, 2006). In the present study, we seek to determine whether the ostensible similarities between psychopaths and vmPFC lesion patients extend to laboratory tests of economic decision-making, namely the Ultimatum and Dictator Games. Moreover, we aim to test whether the vmPFC patients more closely resemble the primary or secondary subtype of psychopathy.

In the Ultimatum Game, two players are given an opportunity to split a sum of money. One player (the proposer) offers a portion of the money to the second player (the responder), and keeps the remainder for himself. The responder can either accept the offer (in which case both players split the money as proposed) or reject the offer (in which case both players get nothing). "Rational actor" models predict that the responder would accept any offer, no matter how low. However, relatively small offers (less than 20–30% of the total) are rejected about half the time (Bolton & Zwick, 1995; Guth, Schmittberger, & Schwarze, 1982). The "irrational" rejection of unfair offers has been correlated with feelings of anger (Pillutla & Murnighan, 1996), suggesting that the responder's ability to regulate anger and frustration plays a critical role in task performance. Patients with vmPFC lesions, who are known to exhibit irritability and poor frustration tolerance despite an otherwise generally blunted affect (Anderson, Barrash, Bechara, & Tranel, 2006; Barrash, Tranel, & Anderson, 2000), reject an abnormally high proportion of unfair offers (Koenigs & Tranel, 2007). Thus the first aim of this study is to determine whether either of the psychopathic subtypes (primary or secondary) also rejects an abnormally high proportion of unfair offers.

In the Dictator Game, there are again two players with an opportunity to split a sum of money. However, in this case the responder has no choice but to accept whatever split the proposer offers. Thus, the amount offered by the proposer in the Dictator Game is presumed to reflect a prosocial sentiment, such as empathy or guilt. Patients with vmPFC lesions, who are known to exhibit deficits in empathy and guilt (Anderson et al., 2006; Barrash et al., 2000), offer abnormally low amounts in the Dictator Game (Krajbich, Adolphs, Tranel, Denburg, & Camerer, 2009). Thus the second aim of this study is whether either of the psychopathic subtypes (primary or secondary) also offers abnormally low amounts in the Dictator Game.

2. Methods

2.1. Participants

Participants were male inmates recruited from a medium security Wisconsin correctional institution. Inmates were eligible if they met the following criteria: under 45 years of age, no history of psychosis or bipolar disorder, and not currently taking psychotropic medications. A total of 47 inmates met the inclusion criteria and participated in all study procedures. Informed consent was obtained both orally and in writing.

The Psychopathy Checklist – Revised (PCL-R) (Hare, 2003) was used to assess psychopathy. The PCL-R assessment involves a 60–90 min interview and file review to obtain information used to rate 20 psychopathy-related items as 0, 1, or 2, depending on the degree to which each trait characterizes the individual. A substantial literature supports the reliability and validity of PCL-R assessments with incarcerated offenders (Hare, 2003). To evaluate interrater reliability, a second rater who was present during interviews provided independent PCL-R ratings for 8 inmates. The intraclass correlation coefficient was 0.85. PCL-R Factors 1 and 2 scores were computed following procedures outlined in the PCL-R manual (Hare, 2003).

2.2. Participant groups

Participants were classified as psychopathic if their PCL-R scores were 30 or greater ($n = 12$) and non-psychopathic if their PCL-R scores were 20 or less ($n = 22$) (Hare, 2003). Following the convention of previous studies identifying psychopathy subtypes (Arnett et al., 1997; Brinkley et al., 2004; Hiatt et al., 2004; Lorenz & Newman, 2002; Newman et al., 1997; Schmitt et al., 1999), primary (low anxiety) psychopathy was differentiated from secondary (high anxiety) psychopathy based on a median split of Welsh Anxiety Scale (WAS) scores (Welsh, 1956). Thus, in our sample primary psychopathy was defined as having a PCL-R score of 30 or greater and a WAS score of 13 or less ($n = 6$), while secondary psychopathy was defined as having a PCL-R score of 30 or greater and a WAS score of 14 or greater ($n = 6$). The three participant groups (primary psychopaths, secondary psychopaths, and non-psychopaths; Table 1) did not significantly differ with respect to age, race, or estimated IQ. As expected, both psychopathic groups had significantly greater PCL-R total scores than the non-psychopathic group, and the primary psychopathy group had significantly lower anxiety scores than the other two groups. The psychopathic subgroups did not significantly differ in terms of overall incarceration duration (mean of 7.6 years for primary psychopaths, 7.4 years for secondary psychopaths).

2.3. Testing procedure

Participants first acted as responders in a series of 19 trials of the Ultimatum Game. In each trial (presented on individual sheets of paper), the participant read one offer and responded by circling "accept" or "reject" on the sheet. Before beginning, the task was explained to the participant. It was made certain that the participant understood that the participant and the proposer would receive payment (or not) based on the participant's decision, and that the participant's responses would not affect the rest of the offers. The participants were told that the 19 offers were made by 19 different inmates at a correctional institution in another state. The offers were in fact predetermined with each participant receiving the same offers in a fixed order. Because the participants' responses to unfair offers were of the greatest interest, offers were generated in the following frequencies: two offers of $5 (proposer keeps $5), two offers of $4 (proposer keeps $6), five offers of $3 (proposer keeps $7), five offers of $2 (proposer keeps $8), and five offers of $1 (proposer keeps $9). This procedure closely follows a previous study of Ultimatum Game responses (Koenigs & Tranel, 2007).

After completion of the Ultimatum Game responses the participant was asked to act as the proposer in the Ultimatum Game. Here it was explained that the participant would now make an offer like the ones he was previously given, that the

Table 1
Participant group characteristics. Cauc, Caucasian. Est IQ, estimated IQ based on the Shipley Institute of Living Scale (Zachary, 1986). WAS, Welsh Anxiety Scale. F1, Factor 1. F2, Factor 2. For each group, means are presented with standard deviations in parentheses. Groups did not significantly differ on age ($p = 0.46$), race ($p = 0.39$), or estimated IQ ($p = 0.38$).

	Age	Race (% Cauc)	Est IQ	PCL-R total	WAS	PCL-R F1	PCL-R F2
Primary psychopaths ($n = 6$)	30.3 (9.4)	83	91.6 (19.7)	32.3 (1.5)	6.2 (2.6)	12.5 (1.6)	17.3 (1.0)
Secondary psychopaths ($n = 6$)	30.0 (4.9)	83	98.2 (11.2)	31.0 (2.0)	22.7 (7.7)	10.4 (1.3)	17.3 (1.5)
Non-psychopaths ($n = 22$)	35.1 (6.9)	95	104.2 (11.2)	14.5 (3.3)	13.6 (9.6)	5.2 (2.1)	7.6 (3.6)

offer would be seen by inmates in another state, that the participant and the responder would be paid according to the responder's choice to accept or reject, and that the offer would be anonymous and the participant would have no other interaction with the responder. Participants were then asked to write their proposed split of $10 (whole dollar amounts only) on the provided sheet of paper. Participants were also asked to judge how likely they thought the responder would be to accept the offer on a 7-point scale ranging from −3 (definitely would not accept), 0 (not sure), to +3 (definitely would accept). Participants were then asked to fold the paper and submit it to the experimenter so the experimenter could not see their answers.

After completion of the Ultimatum Game proposal the participant was asked to act as the proposer in the Dictator Game. Before doing so it was made certain that the participant understood that however he wished to split the money is how it would be split; the other player would have no choice but to accept the offer. Again the participant was told to write how much he would keep and how much he would give to the other individual (whole dollar amounts only), and then to fold the paper and submit it to the experimenter.

Participants were paid based on a random selection of their responses in the tasks (minimum of $10, maximum of $21). Prisoners were able to spend this money at the prison canteen to obtain items such as food, clothes, personal hygiene products, and music.

3. Results

3.1. Ultimatum Game responses

First we computed the acceptance rates for each offer amount across the entire prison sample. As expected, the acceptance rates decreased for lower offer amounts. Acceptance rates were 98% for the $5 offers, 92% for the $4 offers, 83% for the $3 offers, 56% for the $2 offers, and 52% for the $1 offers. This overall pattern of acceptance rates is similar to previously reported Ultimatum Game responses in normal, healthy adults (Bolton & Zwick, 1995; Guth et al., 1982; Koenigs & Tranel, 2007; Sanfey, Rilling, Aronson, Nystrom, & Cohen, 2003).

To address the first aim of the study, we determined whether the primary and/or secondary psychopaths exhibited abnormally low acceptance rates for unfair Ultimatum offers (Fig. 1). Because of the small sample sizes and non-normal distribution of acceptance rates, we used the non-parametric Mann–Whitney *U* test to test for group differences. The secondary psychopaths and non-psychopaths exhibited similar acceptance rates for each level of unfair offer (all p values > 0.46). By contrast, the primary psychopaths' acceptance rates were lower than the secondary psychopaths' for the $3 offer ($z = -2.3$, $p = 0.02$), $2 offer ($z = -1.7$, $p = 0.08$), and the $1 offer ($z = -2.4$, $p = 0.02$). Similarly, the primary psychopaths' acceptance rates were lower than the non-psychopaths' for the $3 offer ($z = -2.4$, $p = 0.02$), $2 offer ($z = -1.8$, $p = 0.07$), and the $1 offer ($z = -2.1$, $p = 0.03$). These results indicate that primary, but not secondary, psychopathy is associated with decreased acceptance rates for unfair Ultimatum offers.

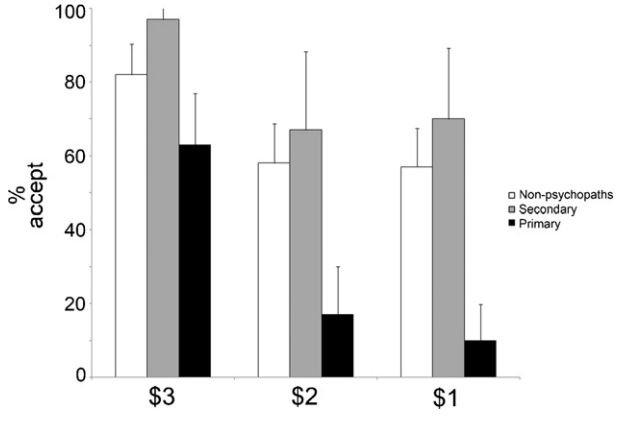

Fig. 1. Ultimatum Game responder data (with SE bars). Primary psychopaths accepted a lower percentage of unfair offers.

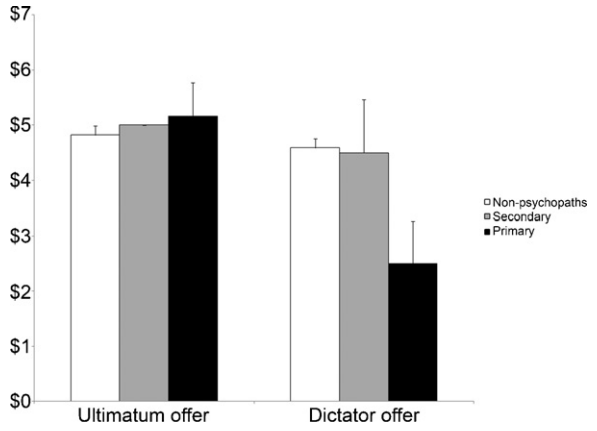

Fig. 2. Ultimatum and Dictator offer data (with SE bars). Primary psychopaths made comparable Ultimatum offers, but significantly lower Dictator offers than secondary psychopaths or non-psychopaths.

3.2. Ultimatum Game proposals

Although we had no specific hypotheses related to Ultimatum Game proposals (as vmPFC lesion patients do not exhibit abnormal performance in this portion of the task) (Krajbich et al., 2009), we still report here the results from each subject group (Fig. 2). The proposed offer amount of the primary psychopaths was similar to the secondary psychopaths ($z = -0.6$, $p = 0.53$) and non-psychopaths ($z = -0.04$, $p = 0.97$), who were also similar to each other ($z = -0.8$, $p = 0.45$). These results indicate that Ultimatum proposals did not significantly differ among groups.

3.3. Dictator Game proposals

To address the second aim of the study, we determined whether the primary and/or secondary psychopaths exhibited abnormally low Dictator offers (Fig. 2). In this group analysis (again conducted with Mann–Whitney *U* tests) the offer amount of the primary psychopaths was lower than both the secondary psychopaths ($z = -1.7$, $p = 0.08$) and non-psychopaths ($z = -2.9$, $p = 0.003$). The secondary psychopaths and non-psychopaths were not significantly different from each other ($z = -0.8$, $p = 0.40$). These results indicate that primary, but not secondary, psychopathy is associated with decreased offer amounts in the Dictator Game.

3.4. Comparison between psychopaths and vmPFC lesion patients

As described in Section 1, the ostensible similarities between psychopaths and vmPFC lesion patients motivated our questions about psychopaths' performance in the Ultimatum and Dictator Games. Indeed, in the present study we have found some interesting parallels. Primary psychopaths and vmPFC lesion patients were both less likely to accept unfair Ultimatum offers than their respective comparison groups (healthy adults and patients with non-vmPFC lesions in the case of the vmPFC lesion patients, secondary psychopaths and non-psychopathic inmates in the case of the primary psychopaths) (Koenigs & Tranel, 2007). Also, primary psychopaths and vmPFC lesion patients both offered less money than comparison groups in the Dictator Game, but similar amounts in the Ultimatum Game (Krajbich et al., 2009). While these qualitative comparisons between studies are intriguing, a statistical comparison of psychopaths' and vmPFC lesion patients' data would be even more informative. Here we directly compare the psychopaths to vmPFC lesion patients using economic decision-making data from previously published lesion studies (Koenigs & Tranel, 2007; Krajbich et al., 2009). First we examine whether

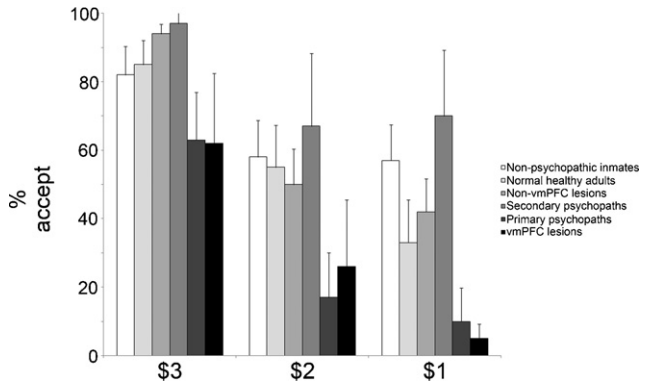

Fig. 3. Ultimatum Game responder data comparing psychopaths and brain lesion patients (with SE bars). Primary psychopaths and vmPFC lesion patients exhibited similar acceptance rates, which were lower than any of the comparison groups at each of the unfair offer amounts.

primary psychopaths and vmPFC lesion patients exhibit similar responses to unfair offers in the Ultimatum Game. For this analysis we used data from the Koenigs and Tranel (2007) study, as the testing procedure was nearly identical. In that study the vmPFC patients' acceptance rates for the $3, $2, and $1 offers were 62%, 26%, and 5%, respectively. In the present study the primary psychopaths' acceptance rates for the $3, $2, and $1 offers were 63%, 17%, and 10%, respectively (Fig. 3). The corresponding p-values (based on the Mann–Whitney U test) are 0.94, 0.44, and 0.77, indicating no significant difference between the vmPFC lesion patients and primary psychopaths in terms of Ultimatum Game responses. The secondary psychopaths' acceptance rates, on the other hand, were significantly higher than the vmPFC patients' (for $3 offers $z = -2.1$, $p = .04$; for $2 offers $z = -1.5$, $p = 0.14$; for $1 offers $z = -2.5$, $p = 0.01$).

To compare the vmPFC patients' and psychopaths' offers as proposers in the Ultimatum and Dictator Games, we used data from the Krajbich et al. (2009) study. Since the Ultimatum and Dictator offers in that study were based on a total sum of 50 points, rather than $10 as in the current study, we converted the offers in each study to a percentage of the total sum. For example, an offer of 25 points in the Krajbich study (50% of the total sum) would be equivalent to an offer of $5 in the present study (50% of the total sum). In the Krajbich et al. study, vmPFC patients made mean Ultimatum offers of 40% and Dictator offers of 9% (a difference of 27%), while in the current study the primary psychopaths made mean Ultimatum offers of 52% and Dictator offers of 25% (a difference of 31%). Neither the Ultimatum offers, Dictator offers, nor the differences were significantly different between the vmPFC lesion patients and primary psychopaths (p values of 0.07, 0.12, and 0.63 based on Mann–Whitney U test). By contrast, the vmPFC patients' Dictator offers were significantly lower than the secondary psychopaths' ($z = -2.2$, $p = 0.03$). These data demonstrate that primary psychopaths and vmPFC lesion patients are in fact quantitatively quite similar (and both distinct from the secondary psychopaths) in their behavior on the Ultimatum and Dictator Games. The similarities in economic decision-making between primary psychopaths and vmPFC patients are evident despite significant differences in age (mean age 58.9 for the vmPFC patients) and gender (4/7 vmPFC patients were female).

3.5. Supplementary analysis: Rational actors and even splits

In our original analyses, we divided the participant sample into groups on the basis of psychopathy subtype (primary psychopathy, secondary psychopathy, and non-psychopathy) and then determined whether these groups differed significantly in economic task performance. An alternative method of analysis would be to divide the participant sample on the basis of economic task performance, and then determine whether or not the different classes of economic decision-makers are distributed evenly among the psychopathy groups. As explained in Section 1, in the Ultimatum Game a theoretical "rational actor" would accept any offer, no matter how unfair. Among the sample of non-psychopaths, 12/22 (55%) were "rational actors," accepting all offers. Among the secondary psychopaths, 4/6 (67%) were "rational actors." By contrast, none of the primary psychopaths (0/6) were "rational actors." In other words, all primary psychopaths rejected at least one unfair offer. In this respect the primary psychopaths again mirror the vmPFC lesion patients: 0/7 vmPFC patients were "rational actors" (Koenigs & Tranel, 2007). Compared to the non-psychopaths and secondary psychopaths in the present study, the proportion of "rational actors" among the primary psychopaths is significantly lower ($p = 0.02$, Fisher's exact test). This result supports the original finding that primary psychopathy is associated with a reduced likelihood of accepting unfair offers.

In the Dictator Game, an even split of the money (i.e., $5 of the $10) is by far the most common response. Among the non-psychopaths 16/22 (73%) offered an even split. Among the secondary psychopaths 4/6 (67%) offered an even split. By contrast, only 1/6 (17%) of the primary psychopaths offered an even split, with the rest of the group keeping a majority of the sum for themselves. Again this pattern mirrors the vmPFC patients: 0/6 vmPFC patients offered an even split (Krajbich et al., 2009). Compared to the non-psychopaths and secondary psychopaths in the present study, the proportion of even splits among the primary psychopaths is significantly lower ($p = 0.02$, Fisher's exact test). This result supports the original finding that primary psychopathy is associated with reduced Dictator offers.

3.6. Supplementary analysis: Anxiety

The significant difference in anxiety levels between primary and secondary psychopaths ($p = 0.001$; Table 1) coupled with the significant difference in anxiety levels between primary psychopaths and non-psychopaths ($p = 0.04$; Table 1) raises the possibility that the observed group differences between primary psychopaths and the comparison groups (secondary psychopaths and non-psychopaths) may be driven solely by differences in anxiety levels, rather than by the combination of low anxiety and high psychopathy that defines primary psychopathy. Here we test the hypothesis that differences in anxiety, regardless of psychopathy severity, are sufficient to yield differences in performance on the Ultimatum and Dictator Games. To test this hypothesis, we divided the non-psychopathic sample (those participants with PCL-R of 20 or less) into high-anxiety and low-anxiety subgroups based on a median split of WAS scores, exactly as we did for the psychopathic sample. With these criteria we obtained 12 low-anxiety non-psychopaths and 10 high-anxiety non-psychopaths. As expected, WAS scores in the high-anxiety non-psychopaths were significantly greater than in the low-anxiety non-psychopaths ($z = 4.0$, $p < 0.001$) while PCL-R total scores were similar ($z = -0.8$, $p = 0.41$). Importantly, the difference in mean anxiety scores between the high-anxious and low-anxious non-psychopaths (21.8 vs. 6.8) was similar to the difference in mean anxiety scores between the secondary and primary psychopaths (22.7 vs. 6.2). Using Mann–Whitney U tests, we compared the two non-psychopathic groups' acceptance rates in the Ultimatum Game and proposal amounts in the Ultimatum and Dictator Games. We found no significant differences between groups on any of the measures ($p = 0.20$, $p = 0.76$, and $p = 0.76$ for acceptance of $3, $2, and $1 offers, respectively; $p = 0.26$ for Ultimatum proposals; $p = 0.26$ for Dictator proposals). The lack of significant economic decision-making differences between the high-anxiety and low-

anxiety non-psychopaths indicates that anxiety alone does not account for the unique performance of the primary psychopaths on the economic decision-making tests.

3.7. Supplementary analysis: Psychopathy factor scores

Although the focus of this study is on the primary/secondary distinction within psychopathy, here we also consider the economic decision-making results in terms of the conventional two-factor model of psychopathic symptomotology. The PCL-R is often divided into two clusters of symptoms based on a factor analysis (Factor 1 consisting of eight "interpersonal/affective" items and Factor 2 consisting of 10 "impulsive/antisocial" items) (Hare, 2003; Harpur, Hare, & Hakstian, 1989). As can be seen in Table 1, Factor 2 scores are nearly identical between the groups of primary and secondary psychopaths ($z = -0.2$, $p = 0.87$), and thus any significant group differences in economic task performance are likely not attributable to differences in Factor 2 scores. However, the Factor 1 scores of the primary psychopaths are significantly higher than those of the secondary psychopaths ($z = 2.1$, $p = 0.03$), raising the possibility that Factor 1 score may be a significant predictor of task performance. We explored this possibility with two analyses. For the first analysis we re-grouped the psychopaths strictly on the basis of Factor 1 scores—the six lowest in one group and the six highest in the other. If Factor 1 score is the critical determinant of economic task performance among psychopaths, then one would expect this grouping to result in group differences at least as large as those observed in the primary/secondary grouping. As expected, the Factor 1 scores of the "higher Factor 1 group" were significantly higher than the scores of the "lower Factor 1 group" ($z = 2.9$, $p = 0.004$), but this re-grouping resulted in no significant group differences on any of the economic task measures (acceptance of \$3 offers $z = -0.9$, $p = 0.18$; acceptance of \$2 offers $r = -0.5$, $p = 0.60$; acceptance of \$1 offers $r = -1.1$, $p = 0.26$; Ultimatum offers $r = -0.53$, $p = .60$; Dictator offers $r = -1.2$ $p = 0.21$). For the second analysis we used the entire prison sample ($n = 47$) to calculate the correlations between Factor 1 score and the economic task measures. We found no significant correlations (acceptance of \$3 offers $r = 0.23$, $p = 0.13$; acceptance of \$2 offers $r = -0.04$, $p = 0.81$; acceptance of \$1 offers $r = -0.08$, $p = 0.59$; Ultimatum offers $r = 0.18$, $p = .23$; Dictator offers $r = -0.26$, $p = 0.08$). Similarly, we found no significant correlations between Factor 2 score and any of the task measures (acceptance of \$3 offers $r = -0.15$, $p = 0.33$; acceptance of \$2 offers $r = -0.21$, $p = 0.17$; acceptance of \$1 offers $r = -0.20$, $p = 0.19$; Ultimatum offers $r = 0.16$, $p = .29$; Dictator offers $r = -0.14$, $p = 0.35$). The results of the analyses do not support Factor 1 or Factor 2 score as a significant predictor of economic task performance in this study. Rather, the results of this study suggest that deviant economic decision-making is characteristic of only a specific subset of inmates—those with high levels of psychopathy but low levels of anxiety, the "primary" psychopaths.

4. Discussion

In this study we sought to explore the putative behavioral parallels between psychopaths and vmPFC lesion patients using laboratory tests of economic decision-making. In particular, we addressed the possibility that etiologically distinct subtypes of psychopathy (primary and secondary) may exhibit characteristic patterns of economic decision-making, and that one or the other subtype may more closely resemble the vmPFC lesion patients in their task performance (reduced Ultimatum acceptance rates and Dictator offers). We found that, compared to non-psychopaths and secondary psychopaths, primary psychopaths exhibited significantly reduced Ultimatum acceptance rates as well as significantly lower Dictator offers. Secondary psychopaths did not significantly differ from non-psychopaths on any aspect of the Ultimatum or Dictator Games. On both tests, the primary psychopaths were statistically similar to the vmPFC lesion patients. The distinctive performance of the primary psychopaths in this study cannot be attributed to significant group differences in age, race, intelligence, overall psychopathy severity, or Factor 1/Factor 2 severities, nor can the results be explained solely on the basis of anxiety differences. These results converge to indicate that (1) primary and secondary psychopaths do in fact differ in their economic decision-making performance and (2) primary psychopaths closely match vmPFC lesion patients in their economic decision-making performance.

Given that the overall psychopathic sample size in our study was similar to the sample sizes reported in several recent behavioral studies of psychopaths (e.g., Mitchell, Richell, Leonard, & Blair, 2006; Mokros et al., 2008), but not as large as the sample sizes in other studies (e.g., Hiatt et al., 2004; Lorenz & Newman, 2002), we address here the role of sample size in our study. With respect to the primary/secondary distinction, we do not see the relatively small sample sizes ($n = 6$ in each group) as particularly problematic in our study for two reasons. First, the between-group differences were so strong that standard non-parametric tests appropriate for small samples (Mann–Whitney U test, Fisher's exact test) were able to clearly demonstrate statistically significant results. And second, the sample size of primary psychopaths in our study matches the sample sizes of vmPFC lesion patients in previously published studies using the same behavioral tasks (Koenigs & Tranel, 2007; Krajbich et al., 2009). Since we set out to test for comparable effects in psychopaths and vmPFC lesion patients on these same tasks, the sample size seems appropriate for the study.

We believe that the observed similarity in performance between primary psychopaths and vmPFC lesion patients is consistent with several lines of evidence. From a theoretical standpoint, primary psychopathy is thought to arise directly from some fundamental, innate deficit in basic affective and attentional processing, whereas secondary psychopathy is thought to arise as an indirect consequence of psychosocial or environmental factors (Blackburn et al., 2008; Cleckley, 1976; Karpman, 1946, 1948; Lykken, 1995; Skeem et al., 2007). If this is true, then the primary subtype of psychopathy may be associated with a characteristic psychological and neurobiological dysfunction, whereas secondary psychopaths may exhibit various psychological and/or neurobiological profiles. In the case of primary psychopathy, there is ample data to support speculation that vmPFC dysfunction may be part of the neurobiological mechanism. First is the seminal observation of primary psychopaths' conspicuous lack of anxiety and prosocial emotions such as empathy and guilt (Cleckley, 1976; Karpman, 1946). Studies of vmPFC lesion patients also highlight diminished anxiety, empathy, and guilt (Anderson et al., 2006; Barrash et al., 2000; Koenigs, Huey, Calamia, et al., 2008; Koenigs, Huey, Raymont, et al., 2008). We believe that the paucity of such emotions may underlie the abnormally low Dictator offers that were observed in both groups—presumably Dictator offers are determined at least in part by prosocial sentiment (e.g., empathy for the other player, guilt for treating him unfairly), as there is no financial self-interest in offering greater amounts. However, it is important to point out that neither vmPFC damage nor primary psychopathy is associated with a pervasive and complete blunting of emotion. In contrast to their lack of empathy and guilt, vmPFC patients typically exhibit exaggerated anger, irritability, and poor frustration tolerance (Anderson et al., 2006; Barrash et al., 2000; Grafman et al., 1996). A similar emotion regulation deficit has been noted for primary psychopaths: "For the initiation of such outbursts [the primary psychopath] does not, it seems, need any great anger. Moderate vexation usually suffices." (Cleckley, 1976; see also Blair, in press). We believe this common feature of the vmPFC patients and primary psychopaths may underlie the abnormally high Ultimatum rejection rates observed in both

groups. Since the "irrational" rejection of unfair offers has been correlated with feelings of anger (Pillutla & Murnighan, 1996), the responder's ability to regulate anger and frustration may play a critical role in task performance. Thus the similar economic task performance of vmPFC lesion patients and primary psychopaths appears to be consistent with their similar emotional profiles.

At first glance, the combination of results reported here may seem puzzling: on one hand the primary psychopaths and vmPFC patients seem to exhibit an element of hypoemotionality (diminished levels of anxiety, empathy, and guilt, corresponding to low Dictator offers), while on the other hand both groups seem to exhibit an element of hyperemotionality (exaggerated levels of anger and frustration, corresponding to low Ultimatum acceptance rates). How can these two concurrent features of vmPFC damage and primary psychopathy be reconciled? Is there a single underlying deficit that can engender both types of affective dysfunction? We believe the seemingly discordant results can be explained by an underlying deficit in "response modulation," the essence of which is the "temporary suspension of a dominant response set and a brief concurrent shift of attention from the organization and implementation of goal-directed responding to its evaluation" (Newman & Lorenz, 2003; Patterson & Newman, 1993). In the context of the decision-making tests considered in this study, we believe the concept of response modulation is applicable in terms of self-insight and self-reflection related to affective state. In situations of frustration or irritation (e.g., unfair Ultimatum offers), one might feel an impulse to respond aggressively or retributively (e.g., reject the offer). We suppose that psychologically and neurologically healthy individuals can recognize this impulse, reflect on the consequences of losing their cool in terms of social relationships or material considerations, and manage to modulate their response to some degree (e.g., accept the offer). Furthermore, we propose that the deployment of certain prosocial emotions, such as empathy and guilt (which are presumed to motivate Dictator offers), is also dependent on processes of self-insight and reflection. Each of these emotions is derived from a concern for one's actions relative to others—they are defined by their social nature. If one has no insight or reflection upon how his actions will affect others or be construed by others, then these prosocial emotions may appear conspicuously diminished (reflected by abnormally low Dictator offers). Thus we believe that a basic deficit in processes of self-insight and self-reflection could theoretically underlie both types of affective deficit (exaggerated anger/irritability and diminished empathy/guilt), and by extension the reduced Ultimatum acceptance rates and Dictator proposals, that characterize both primary psychopaths and vmPFC lesion patients.

An alternative interpretation is suggested by a recent study of Ultimatum Game behavior among vmPFC lesion patients (Moretti, Dragone, & di Pellegrino, 2009). In this study, as in the Koenigs and Tranel (2007) study, vmPFC patients exhibited substantially lower acceptance of unfair Ultimatum offers when financial gains were presented as abstract amounts to be received following the test. However, when the gains were visible and readily available, the vmPFC patients' acceptance of unfair offers was normal, suggesting that their irrational rejection of unfair offers could be due to a deficit in the representation of abstract reward (such as money promised at a later time), rather than an inability to regulate anger or frustration (Moretti et al., 2009). This interpretation contrasts with previous psychological research on the Ultimatum Game, which emphasizes the primary role of anger and frustration in motivating Ultimatum rejections (Pillutla & Murnighan, 1996). The relative contributions of emotion regulation and abstract value representation in decision-making among vmPFC patients and primary psychopaths warrant further investigation.

Our findings are not the first to demonstrate a parallel between vmPFC lesion patients and psychopaths. Following the initial clinical descriptions noting the similar personality characteristics between psychopaths and vmPFC lesion patients (Blumer & Benson, 1975; Eslinger & Damasio, 1985), there have been several laboratory paradigms that have yielded similar results for psychopaths and vmPFC lesion patients. Examples include reversal learning (Budhani, Richell, & Blair, 2006; Hornak et al., 2004), gambling tasks (Bechara, Damasio, Tranel, & Damasio, 1997; Mitchell, Colledge, Leonard, & Blair, 2002) (but see also Losel & Schmucker, 2004; Schmitt et al., 1999), smell identification (Jones-Gotman & Zatorre, 1988; Lapierre, Braun, & Hodgins, 1995), and physiological response to emotional stimuli (Damasio et al., 1990; Patrick, Bradley, & Lang, 1993; Patrick, Cuthbert, & Lang, 1994). However, our study is unique in two respects. Unlike the aforementioned literature, where qualitative comparisons were made across studies, ours is the only study to date that directly and quantitatively compares the performance of psychopaths and vmPFC lesion patients with statistical tests. More importantly, ours is the first study to compare vmPFC lesion patients with the specific subgroup of primary psychopaths. The majority of psychopathy research studies do not distinguish between primary and secondary subtypes, and these studies regularly associate psychopathy with characteristic laboratory findings related to decision-making (e.g., Blair, Leonard, Morton, & Blair, 2006; Budhani et al., 2006), psychophysiology (e.g., Birbaumer et al., 2005; Blair, Jones, Clark, & Smith, 1997), and neurobiology (e.g., Birbaumer et al., 2005; Glenn, Raine, Yaralian, & Yang, 2010; Kiehl et al., 2001; Yang, Raine, Narr, Colletti, & Toga, 2009). However, unless the primary and secondary psychopathy distinction is systematically evaluated in these paradigms, it is impossible to know whether the psychobiological correlates of psychopathy are specific to primary psychopathy, secondary psychopathy, or apply to both of these subtypes. We feel that this is a particularly noteworthy point, as primary and secondary psychopathy are presumed to reflect different etiologies (Blackburn, 1975; Cleckley, 1976; Hicks, Markon, Patrick, Krueger, & Newman, 2004; Karpman, 1946, 1948; Lykken, 1995; Skeem et al., 2007), and accordingly, may arise through distinct psychological or neurobiological mechanisms. It is important to note that the data reported here provide no direct evidence for vmPFC dysfunction as the neurobiological basis for primary psychopathy. Rather, we feel that the present results provide a compelling basis for future investigations into the neurobiological and psychological correlates of primary vs. secondary psychopathy.

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