

Increased DLPFC activity during moral decision-making in psychopathy

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Tassy, Oullier, Cermolacce, & Wicker¹ inquire as to whether psychopathy was associated with differential activity in the dorsolateral prefrontal cortex (DLPFC) in our study of moral decision-making in psychopathy². This is an important question that we had not considered previously. Tassy et al. also ask about behavioral responding and activity in another relevant brain region, the insula. Here we provide additional analyses of our data. We find that psychopathy is associated with *increased* activity in the dorsolateral prefrontal cortex during emotional moral decision-making. No significant relationship was observed between psychopathy and behavioral responses to the dilemmas. These findings, in conjunction with the reduced activity in emotion-related regions reported previously², suggest that psychopathic individuals may use alternative strategies to make moral judgments; alternative interpretations are also discussed.

Tassy et al. highlight the important role of the DLPFC in current theories regarding brain functioning in moral judgment. In particular, the DLPFC may play at least three distinctive roles: (1) to provide cognitive control to override prepotent social-emotional responses elicited by the dilemmas³, (2) to facilitate abstract reasoning (e.g. cost-benefit analyses),^{3,4} and (3) to generate self-centered and other-aversive emotions (e.g. anger, frustration, or moral disgust)⁵. Tassy et al. suggest that the examination of this region in our sample of individuals with varying degrees of psychopathic traits may help to clarify the role of the DLPFC in moral judgment.

We defined a new region of interest in the DLPFC (see Supplementary Methods) and performed the same correlational analysis as previously reported². Participants with higher psychopathy scores showed increased activity in the right DLPFC (Figure 1). Analyses of the four factors of psychopathy revealed that DLPFC activity was positively associated with Factor 3 (Impulsive lifestyle) and Factor 4 (Antisocial) of psychopathy (F3: 21, 60, 18; 46 voxels, T =

2.59, $p = .048$, corrected; F4: 21, 60, 21; 117 voxels, $T = 3.03$, $p = .024$, corrected); a trend-level relationship was observed for Factor 2 (Affective) (21, 60, 21; 26 voxels, $T = 1.98$, $p = .114$, corrected). No relationship was observed with Factor 1 (Interpersonal).

Tassy et al.¹ also inquired about activity in the insula, given its role in encoding disgust. No significant relationship was found between total or factor psychopathy scores and activity in the insula. Associations between insula activity and Factors 1 and 2 were in the negative direction, but did not survive correction for multiple comparisons ($p > .251$).

Finally, Tassy et al. asked whether psychopathic individuals give more utilitarian responses, as might be predicted based on the findings reported for patients with bilateral, adult onset damage to the VMPC⁶. Results from our sample, as well as from additional subjects from the same population, indicated that there was not a significant relationship between psychopathy scores and the proportion of “yes” (e.g. utilitarian) responses to the personal moral dilemmas⁷. This lack of behavioral differences in moral judgment appears to be consistent with forthcoming data from other groups (e.g. M. Hauser, personal communication).

Taken together, these findings suggest that more psychopathic individuals are able to provide relatively similar moral judgments to less psychopathic individuals, despite differences in activation in the amygdala and DLPFC. Such findings may lend support for a hypothesis that has been previously set forth—that in the absence of appropriate input from emotion-related regions, psychopathic individuals may make use of alternative cognitive strategies to process emotional information⁸. More psychopathic individuals, who show reduced amygdala activity when processing the emotionally salient moral dilemmas², may use abstract reasoning processes to a greater extent than less psychopathic individuals. Thus, these findings may provide support for the role of the DLPFC in abstract reasoning processes (Hypothesis 2 above), though not to

the exclusion of the other two hypotheses.

This finding of increased DLPFC activity in psychopathy is consistent with previous studies. Rilling et al.⁹ found increased activity in the DLPFC in more psychopathic individuals when choosing to cooperate with another individual, suggesting that psychopathic individuals may require more DLPFC activation to choose a morally appropriate option (see Supplementary Discussion). Similarly, increased activity in the DLPFC has been observed during emotional processing in both criminal psychopaths⁸ and undergraduates scoring higher in psychopathy¹⁰. In the moral dilemmas used in the present study, participants were asked whether a particular action was appropriate or not⁴; with less input from emotion-related regions, it is possible that psychopathic individuals rely more on abstract reasoning processes to determine whether specific actions are appropriate according to societal standards. Thus, although they may cognitively *know* the difference between right and wrong (i.e. the moral judgment), they may not have the *feeling* of what is right and wrong¹¹, and thus may lack the motivation to translate their moral judgments into appropriate moral behavior.

Alternatively, our findings of no differences in moral judgments of the more psychopathic individuals despite reduced activity in the amygdala may suggest that the emotional processes impaired in psychopathy may not be *necessary* for moral judgment, or more specifically, that the amygdala may not play a significant role in moral judgment despite its importance for emotional processing in other domains. Emotional processes that are impaired in psychopathy may play their most critical role in motivating morally relevant behavior once a judgment has been made¹². On this view, the deficit observed among psychopaths results from a failure to link moral judgment to behavior with appropriately motivating emotions.

We thank Tassy et al. for their inquiry and hope to have answered some of the questions

posed; however, many questions still remain. Our study is limited by a small sample size, so findings should be considered preliminary. Future studies will be necessary to further elucidate the role of the DLPFC and other regions both in moral decision-making and psychopathy.

References

- 1 Tassy S, Oullier O, Cermolacce M, & Wicker B. *Molecular Psychiatry* in press.
- 2 Glenn AL, Raine A, Schug RA. *Molecular Psychiatry* 2009; **14**: 5-9.
- 3 Greene JD, Nystrom LE, Engell AD, Darley JM, Cohen J. *Neuron* 2004; **44**: 389-400.
- 4 Greene JD, Sommerville RB, Nystrom LE, Darley JM, Cohen J. *Science* 2001; **293**: 2105-2108.
- 5 Moll J, de Oliveira-Sousa R. *Trends Cogn Sci* 2007; **11**: 319-321.
- 6 Koenigs M, Young L, Adolphs R, Tranel D, Cushman F, Hauser M, *et al.* *Nature* 2007; **446**: 908.
- 7 Young L, Glenn AL, Hauser M, Raine A, Schug R. Manuscript in preparation.
- 8 Kiehl KA, Smith AM, Hare RD, Mendrek A, Forster BB, Brink J. *Biol Psychiatry* 2001; **50**: 677-684.
- 9 Rilling JK, Glenn AL, Jairam MR, Pagnoni G, Goldsmith DR, Elfenbein HA, Lilienfeld SO. *Biol Psychiatry* 2007; **61**: 1260-1271.
- 10 Gordon HL, Baird AA, End A. *Biol Psychiatry* 2004; **56**: 516-521.
- 11 Raine, A, Yang, Y. *Soc Cogn Affect Neurosci* 2006; **1**: 203-213.
- 12 Huebner B, Dwyer S, Hauser M. *Trends Cogn Sci* 2009; **13**: 1-6.

Legend for Figure

Figure 1 Positive association between psychopathy total scores and activity in the right dorsolateral prefrontal cortex during emotional moral decision-making (MNI coordinates: 21, 60, 18; 36 voxels, $T = 2.15$, $p = .024$, corrected)

SUPPLEMENTARY MATERIAL

Reply to Tassy et al.: Increased DLPFC activity during moral decision-making in psychopathy

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Supplementary Methods

The DLPFC region of interest was defined as in previous studies^{S1} using the software WFU_PickAtlas (www.ansir.wfumc.edu) and intersecting the following parts: the middle frontal gyrus in the TD AAL (Automated anatomical labeling) atlas and the gray matter in the TD Type atlas. The insula region of interest for this area was defined by intersecting the insula in the TD AAL atlas, and the gray matter in the TD Type atlas.

Analyses of the DLPFC and insula regions of interest were performed using the same statistical analyses as previously reported^{S2}, using psychopathy scores as a covariate of interest in the second-level multiple regression model. Both positive and negative relationships were examined for all regions of interest.

The four factors of psychopathy^{S3} are as follows: Factor 1 (Interpersonal) involves manipulation, conning, superficial charm, and egocentricity. Factor 2 (Affective) involves lack of guilt, remorse, and empathy. Factor 3 (Lifestyle) involves impulsivity and stimulation-seeking. Factor 4 (Antisocial) involves criminal versatility and antisocial behavior at an early age.

Supplementary Discussion

Tassy et al. are correct that in the study by Rilling et al.^{S4}, subjects scoring higher in psychopathy had reduced DLPFC activation when deciding to defect during a socially interactive game. In that study, subjects scoring higher in psychopathy appeared to have a prepotent

response to defect, whereas lower-scoring subjects were found to have a prepotent response to cooperate. Thus, when deciding to defect, higher-scoring subjects did not have a prepotent response to override, and therefore demonstrated reduced DLPFC activity. However, when deciding to cooperate, Rilling et al.^{S4} found increased activity in the DLPFC in higher-scoring participants. Two possible explanations were offered—subjects scoring higher in psychopathy may be exerting effortful cognitive control to opt for the morally appropriate action (cooperating), or they may be using abstract reasoning processes to determine the response that would result in the greatest long-term benefit. Thus, it may be that psychopathic individuals require greater DLPFC involvement to choose a morally appropriate option; this finding could lend support for the hypotheses regarding cognitive control *or* abstract reasoning processes.

Although we raise the possibility that our findings of increased DLPFC may be indicative of increased reliance on abstract reasoning about the moral dilemmas, alternative explanations are certainly possible. Furthermore, our data do not contradict the role of the DLPFC in cognitive control during moral decision-making, a process which appears to be gaining evidence in recent literature.^{S5, S6}

Finally, our lack of significant findings in the behavioral responses to the moral dilemmas is in contrast to findings of increased utilitarian moral judgment in patients with lesions to the ventromedial prefrontal cortex or with frontotemporal dementia. Two important differences between psychopathic individuals and these patients should be noted. First, although there may be some overlap between brain regions that are disrupted in lesion patients and regions that have been implicated in psychopathy, there are many differences that exist in the regions involved in these two conditions and the corresponding emotional deficits likely differ. Second, the brain differences observed in psychopathy are much less pronounced than in patients who have brain

lesions, so it is likely that the emotional deficits are less severe, and may impact moral judgment to a lesser degree.

Supplementary References

- S1 Zhou, Y et al. *Neuroscience Letters* 2007; **417**: 297-302.
- S2 Glenn AL, Raine A, Schug RA. *Molecular Psychiatry* 2009; **14**: 5-9.
- S3 Hare RD. *Psychopathy Checklist—Revised (PCL-R)*, 2nd edn. Multi-Health Systems Inc.: Toronto, 2003.
- S4 Rilling JK, Glenn AL, Jairam MR, Pagnoni G, Goldsmith DR, Elfenbein HA, Lilienfeld SO. *Biol Psychiatry* 2007; **61**: 1260-1271.
- S5 Moore AB, Clark BA, Kane MJ. *Psychol Sci* 2008; 19: 549-557.
- S6 Greene JD, Morelli SA, Lowenberg K, Nystrom LE, Cohen JD. *Cognition* 2008; **107**: 1144-1154.

FIGURE 1

