Comment on Raine (2019) ‘The neuromoral theory of antisocial, violent, and psychopathic behavior’ [version 1; peer review: 1 approved]

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Abstract
Raine (2019) reviewed previous research on the neural correlates of antisocial, violent, and psychopathic behavior based on previous studies of neuroscience of morality. The author identified neural circuits associated with the aforementioned types of antisocial behaviors. However, in the review, Raine acknowledged a limitation in his arguments, the lack of evidence supporting the presence of the neural circuits. In this correspondence, I intend to show that this limitation can be addressed with additional evidence from recent neuroimaging research and the evidence can support the presence of the neural circuits of antisociality proposed by Raine.

Keywords
psychopathy, antisociality, morality, moral psychology, neuroscience

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A review article by Raine was published in *Psychiatry Research* in 2019 concerning neuromoral theory of antisocial, violent, and psychopathic behavior. The author proposed a comprehensive model of the neural network of morality and antisociality to explain the neural-level mechanisms of antisocial behavior. The author referred to previous neuroimaging studies and meta-analyses to identify the aforementioned neural networks and proposed that the prefrontal cortex, amygdala, insula, and anterior cingulate cortex are included in both networks, while the striatum is included in the antisociality network. The author stated two limitations regarding the network model that he proposed: first, the involvement of the insula and cingulate cortex regions in the neural networks could not be sufficiently supported by previous neuroimaging studies and meta-analyses; second, evidence that supports the involvement of the striatum in the morality network is insufficient.

Although Raine raised the aforementioned two concerns regarding the lack of supporting evidence, I suggest that recent research in the field of social neuroscience can address them. Herein, I introduce two supporting findings, one from online-based large-scale analysis of neuroimaging data, and the other from recent neuroimaging experiments focusing on brain circuits associated with morality. These recent research findings will be able to provide evidence of the involvement of the insula, cingulate cortex, and striatum regions in the neuromoral circuits.

First, a result from large-scale meta-analysis of previous neuroimaging studies provides evidence supporting Raine’s model. Thanks to the development of information technology, performing meta-analysis of large-scale neuroimaging data has become feasible. A recently invented web-based meta-analysis tool, NeuroSynth, is one example. NeuroSynth automatically gathers coordinate information that is reported in published neuroimaging articles and performs meta-analysis of the gathered information. A result from a meta-analysis of 87 studies and 2,806 activation foci that are associated with a keyword “moral” demonstrates that the left insula and anterior and posterior cingulate cortices show significant common activity across moral task conditions (see [http://neurosynth.org/analyses/terms/moral/](http://neurosynth.org/analyses/terms/moral/) for further details). This result provides evidence that supports the involvement of the insula and cingulate cortices in the neural network of morality based on large-scale data. In fact, the three meta-analysis articles that Raine reviewed meta-analyzed relatively fewer numbers of neuroimaging studies (references 1–3), so he could only tentatively propose the involvement of the insula and cingulate cortex regions in the neuromoral network. Hence, I suggest that the Raine’s argument is supported by large-scale neuroimaging data and the result from NeuroSynth analysis. Moreover, the reported involvement of the left insula may suggest the possibility of laterality effects that Raine mentioned in his review, although more research that directly focuses on the laterality effects should be conducted.

Second, recent neuroimaging studies by my research group suggest that the insula and striatum regions showed significant activation and interaction with prefrontal and cingulate regions, which were indicated as core regions in the neural network of morality by Raine, in moral task conditions. The author tentatively proposed that increasing evidence may suggest that the striatum can be included in the morality network as well as the antisociality network. The new neuroimaging studies may provide additional evidence that supports the involvement of the striatum in the morality network. Our neuroimaging study from 2014 reported that the insula, cingulate cortex, and striatum (e.g. caudate and putamen) were significantly activated when participants were solving moral dilemmas (see Table S1 in 6 for further details). Such findings were also supported by a recent reanalysis with Bayesian inference. Furthermore, our study from 2016 conducted psychophysiological interaction analysis and connectivity analysis based on Granger causality to examine interactions and connections among brain regions in moral task conditions. This study reported that the insula and striatum regions significantly interacted and were connected with other morality-related regions including the medial prefrontal and cingulate cortices. I suggest these findings can also support Raine’s argument regarding the role of the insula in the neural network of morality as well as his tentative proposal regarding the involvement of the striatum in the same network. In particular, the second study provides more direct evidence that supports the presence of the network because it used analysis methods that were designed to examine interaction and connectivity between different brain regions.

Given the aforementioned additional large-scale analysis and neuroimaging studies, the insula, cingulate cortex, and striatum regions can be considered as parts of the neural network of morality. I conclude that Raine’s argument about the neural network of antisociality that he proposed, with some reservations due to lack of evidence, can be well supported by the analyses that I introduce here.

**Data availability**

No data is associated with this article.

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**References**


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The current literature is a well written concise commentary. The title and the abstract precisely summarize the content of the article. The authors provided evidence supporting Raine’s model on the presence of the neural circuitry of antisociality. The concluding paragraph also clearly reflects the author's argument. This commentary would be useful to design or establish further research or hypothetical model regarding the insula, cingulate cortex, and striatum regions as parts of the neural network of morality or antisociality. (there are some typos (circuity) in the manuscript).

Is the rationale for commenting on the previous publication clearly described?
Yes

Are any opinions stated well-argued, clear and cogent?
Yes

Are arguments sufficiently supported by evidence from the published literature or by new data and results?
Yes

Is the conclusion balanced and justified on the basis of the presented arguments?
Yes

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Reviewer Expertise: Psychopathology, Social neuroscience.

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