Disentangling Neural Activation to Self and Others Using Structural Connectivity

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INTRODUCTION

Previous research has shown that the medial prefrontal cortex (MPFC) can often be split between the ventral MPFC and dorsal MPFC during self-referential tasks, with the former engaging in self-reference and the latter engaging in responses when thinking of others (Wagner, Haxby, & Heatherton, 2012). However, there remains substantial overlap in the brain regions that serve these processes. How can we begin to understand how the self is dissociated from others when they recruit the same regions of the brain?

The current study investigates whether diffusion tensor imaging (DTI) and probabilistic tractography can be utilized to distinguish self-other related activity from a trait-judgement fMRI task. We used machine learning and out-of-sample prediction to test whether structural connectivity measures could differentially predict self vs. other brain activation within the same subregion of the MPFC.

HYPOTHESIS

Can structural connectivity patterns predict activation values?

Can a learning algorithm model accurately predict activation values within the MPFC to differentiate self vs. other responses based on structural connectivity pattern weights?

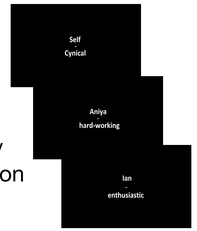
METHODS

Subjects

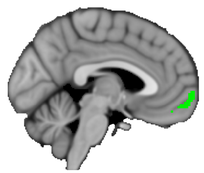
- One hundred and fourteen right-handed subjects (44 female) recruited from multiple close-knit groups within a variety of settings.
- Participants were composed within 20 groups, with 5-6 people per group.

fMRI Tasks

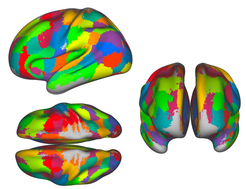
- Participants completed a standard self/other trait judgement task.
- An area within the MPFC of overlapping self/other related activity vs. baseline was used as a seed region for DTI analyses.



MPFC seed mask



Parcellation scheme



DTI

- Probabilistic tractography measured the structural connectivity from the seed region to a 100-parcel schematic via Neurosynth.
- 14 parcels remained in the predictive model after minimum connectivity thresholding of 10 streamlines.

ANALYSIS

Machine Learning

- Used weights of streamlines from 14 parcels as predictors for activation values of either self or other activity within the seed region using a random forest model.
- The model was trained on N = 85 subjects using a repeated 5-folds cross-validation procedure.
- Trained models were then tested out-of-sample in N = 29 subjects by comparing the predicted values from the model to the actual activation values for both self and other brain activation separately.

RESULTS

Out-of-sample prediction of variability in fMRI activation when thinking of the self.

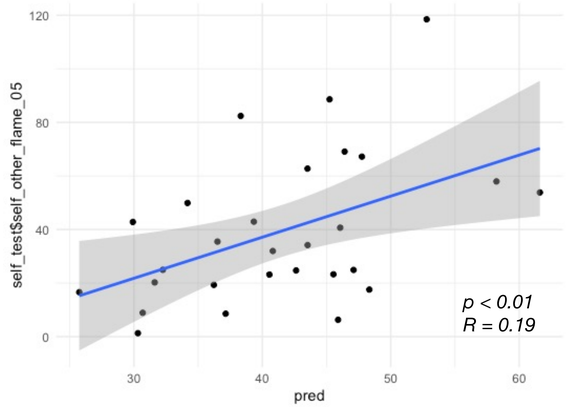


Figure 1. Correlation between the predicted functional values and the functional MRI values when participants were thinking of themselves.

Out-of-sample prediction of variability in fMRI activation when thinking of others.

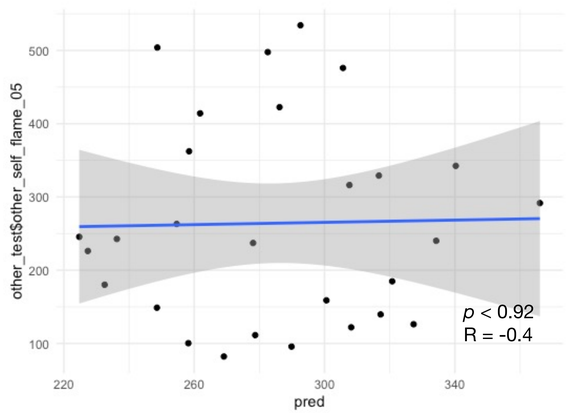
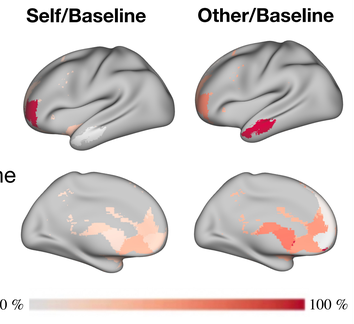


Figure 2. Correlation between the predicted functional values and the functional MRI values when participants were thinking of others.

Which parcels predicted variability best?

The corresponding figure provides the variable importance of each parcel during the self over baseline and other over baseline analyses. The frontal pole and lateral temporal gyrus show importance to self and other, respectively.



CONCLUSIONS

Our results indicate that a machine learning algorithm can better predict variability of fMRI activation values when participants thought of themselves than another participant, based on structural connectivity via DTI. Critically, these differences in predictive performance were found within an identical region of the MPFC that was active for both self and others in the fMRI data. These results demonstrate that overlapping activity for self/other processing can be differentiated based on connectivity patterns to other parts of the brain.

It may be inferred that variability within the self region of the MPFC is further connected with other parcels in the brain while the other region of the MPFC is less so connected. Furthermore, it may be possible that white matter tracts are more related or important during self tasks compared to other tasks. Such inferences could provide insight as to the inner workings of self-referential processes and the other brain systems involved during social cognition tasks. The variability within a subject's self/other fMRI data may serve as a proxy in the overall region's functional activity. While the model was unable to differentiate self vs. other currently, we aim to provide such an experiment in further analyses.

References

Chavez, R. S. & Wagner, D. D. (2020). The neural representation of self is recapitulated in the brains of friends: A round-robin fMRI study. *Journal of Personality and Social Psychology, 118*(3), 407.

Wagner, D. D., Haxby, J. V., & Heatherton, T. F. (2012). The representation of self and person knowledge in the medial prefrontal cortex. *Wiley Interdisciplinary Reviews: Cognitive Science*, *3*(4), 451-470.