Aberrant Individual Structural Connectivity Networks in Borderline Personality Disorder

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Introduction:

Borderline personality disorder (BPD) is characterized by pervasive pattern of instability in interpersonal relationships, identity, impulsivity, and affect, associated with long-term and severe impairments of emotion and behavior regulation[1]. These symptoms consistent across time and situations suggest stable aberrant large-scale brain connectivity in patients.

However little is known about whole brain structural connectivity of patients with BPD. In this study, we hypothesized that individual structural connectome (iSC) based on diffusion tractography may predict patients with BPD from healthy controls.

Methods:

3T T1 structural and diffusion weighted imaging (DWI) data from 16 patients with BPD and 16 age- and gender-matched healthy controls were employed in this study. After correcting motion artifact and eddy current noise, diffusion tensor model as well as fractional anisotropy (FA) and mean diffusivity (MD) were calculated out from 15 gradient directions and 1 B0 images.

Then deterministic fiber tracking was employed in native space[2,3,4], to extract fibers crossing or ending in any pair of whole brain's 108 ROIs, which were derived from Harvard-Oxford cortical and subcortical atlas and then transformed into native space by registering to T1 image and B0 image. Amount of fibers were counted and normalized by total number of whole brain fibers to get structural connectivity of Density. Other two iSCs were also constructed based on mean FA and MD for each subject.

Finally, combining feature selection based on information gain and three typical pattern classifiers (Support Vector Machine, Naive Bayes and k-Nearest Neighbor), classification accuracy was estimated in Leave-One-Out or 10-fold[5].

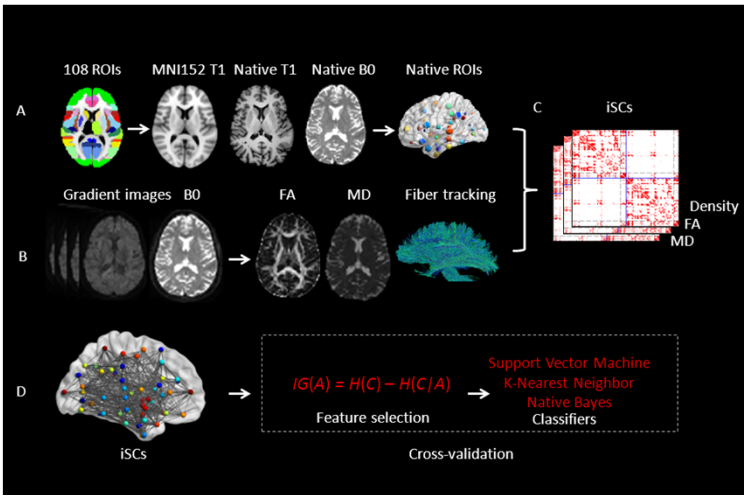

Figure 1. Flowchart of imaging data analysis.
(A) Brain parcellation and registration, resulting in 108 cortical and subcortical ROIs in native space. (B) Diffusion tractography. (C) Individual structural connectomes (iSCs) were constructed by combining brain parcellation and diffusion tractography for connection properties fiber density and integrity (FA, MD). (D) For each connection property separately, most distinctive connections of iSCs between groups were identified by feature selection, then classified by three different classifiers, and evaluated by cross-validation. Results were presented by classification accuracy scores.

Results:

Patients with BPD were separated from healthy controls with high accuracy (around 90%), which were consistent across different aspects of iSCs (fiber definition and property) and distinct methodological approaches of classification (classifier and cross-validation).

For example, scores of prediction accuracy using SVM for fiber Density, FA and MD in LOO were respectively 90.6%, 87.5% and 87.5%.

Furthermore, we found that most important brain regions for group separation overlapped with areas known to be relevant for emotion regulation such as medial prefrontal cortex, fronto-insular operculum, amygdala or striatum (Figure 2).

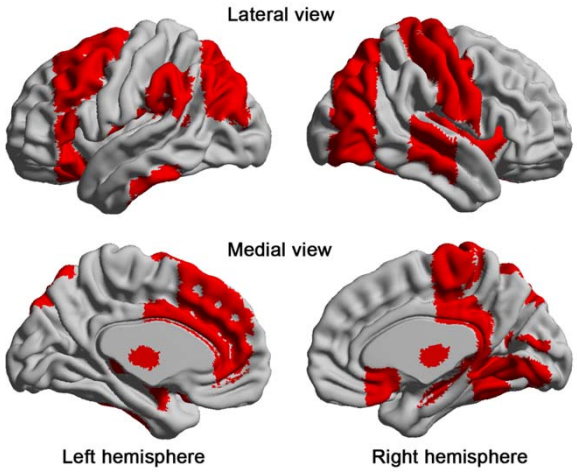

Figure 2. Most informative areas distinguishing patients with BPD from healthy controls.
Colored areas represent endpoints of connections that were consistently selected by information gain criterion (feature selection) in more than half of rounds of leave-one-out-cross-validation of support-vector machine-based classification concerning connection properties fiber density, fractional anisotropy and mean diffusivity. i.e. these areas are part of connections that are relevant for separating patients with BPD from controls. Areas are mapped on a human brain template and marked in red color using BrainNet Viewer.

Conclusion:

Our findings provides first evidence for aberrant individual structural connectivity networks in BPD. The results further suggest that circuits involved in emotion regulation may be most relevant for BPD.

References:

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