BrainNet Viewer: A Graph-Based Brain Network Mapping Tool

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Introduction: The human brain organizes naturally into a complex system represented as a structural connectome[1] of interconnected cortico-cortical axonal pathways and a functional connectome[2] of synchronized interregional neural activity. Mapping human brain connectome and uncovering the underlying organizational principles are fundamentally important in cognitive neuroscience and neuropsychology. Recent studies have suggested that the human brain connectome can be constructed using neuroimaging and neurophysiological data, and then analyzed by graph theoretical approaches. In the graph theory framework, the human brain can be modeled as graphs of a collective of nodes linked by edges. Through these methods, researchers have revealed many non-trivial topological properties of the brain such as small-worldness, modularity and highly connected hubs[3, 4]. Given the abstract nature of this methodology and the huge complexity of brain networks, it is important to visualize human brain connectomes and highlight their intrinsic topological organization. Here, we developed a flexible and rapid human brain network mapping tool, BrainNet Viewer, to visualize network analysis results friendly and intuitively.

Methods: We developed a brain network mapping tool termed as BrainNet Viewer, using Matlab (R2010b) as programming language, under Microsoft Windows environment. The visualization procedure of BrainNet Viewer can be summarized as four steps: file loading, visualization option setting, graph drawing and image saving. The BrainNet Viewer defined four kinds of import files: 1) Brain surface file is an ASCII file with suffix '.nv' which includes information of vertex and triangles of the brain surface. The 'pial' files generated by FreeSurfer (http://surfer.nmr.mgh.harvard.edu/, only hemisphere mesh was supported) and the 'mesh' files generated by BrainVISA (http://brainvisa.info/) are also supported. Besides, we provided a tool to merge left and right hemisphere surface files into one file. 2) Node file is an ASCII file with suffix '.node' containing an n×6 matrix including 3D coordinates, color index, size index and label information of network nodes. 3) Edge file is also an ASCII file with suffix '.edge' containing an n×n association matrix which is correlation matrix between each two nodes. 4) The 3D image files are NIFTI/Analyze files. Either single '.nii' file or paired files with suffix '.hdr' and '.img' are accepted. These files are loaded to be only used in mapping a volume-to-surface graph. Users are permitted to import the four kinds of files in different combinations to visualize a total of six different types of brain network maps, such as maps with only nodes or maps with both nodes and edges. We also provided an easy use panel for visualization options, in which user can change output details such as output layout, background color, surface transparency, nodal color and size, edge color and size or image resolution simply and flexibly. The BrainNet Viewer draws brain surface, nodes and edges in sequence and show in multi-views as user demanded. The figures can be exported to frequently-used image file formats for further usage.
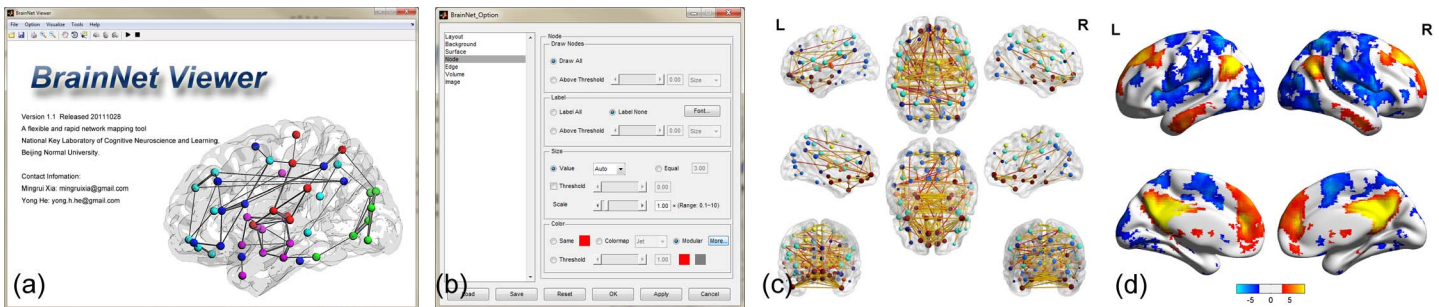

Figure (a) The main interface of BrainNet Viewer. (b) The option panel of BrainNet Viewer. (c) A functional brain network image saved in 'Full view'. (d) A volume-to-surface mapping image saved in 'Medium view'.

Results: The BrainNet Viewer can be downloaded freely on NITRC web site (www.nitrc.org/projects/bnv/), and also can be found in SPM (Statistical Parametric Mapping) extensions list (www.fil.ion.ucl.ac.uk/spm/ext/#BrainNetViewer). The latest version is 1.1, released on Oct 28th, 2011. BrainNet Viewer can mainly achieve the following functions: 1) Display brain network in multi-views. 2) Display several combinations of brain surface, nodes and edges. 3) Adjust nodal color and size in several manners. 4) Adjust edge color and size in several manners. 5) Extract edges from association matrix by setting correlation thresholds. 6) Map volume image to brain surface. 7) Support various kinds of image format exporting, including TIFF, BMP, JPEG, PNS and EPS. 8) Allow image resolution and DPI setting. 9) Provide interactive operations such as zoom and rotate.

Conclusion: The BrainNet Viewer is a brain network visualization tool, which can help researchers to visualize brain network with both nodes and edges from multi-views in a quick, easy and flexible way.

References: [1] Sporns et al, PLoS Comput Biol, 2005. **1**(4): p. e42. [2] Biswal et al., Mag Reson Med 1995. **34**(4): p. 537-541. [3] Bullmore and Sporns, Nat Rev Neurosci, 2009. **10**(3): p. 186-98. [4] He and Evans, Curr Opin Neurol, 2010. **23**(4): p. 341-50.