Lateralization of language network in the human brain: A graph theory study

Poster No:

2101

Submission Type:

Abstract Submission

Authors:

Yinuo Liu[1], Chenghui Zhang[1], Haoyu Hu[1], Yuzheng Hu[1], Xiangzhen Kong[1]

Institutions:

[1]Zhejiang University, Hangzhou, Zhejiang

First Author:

Yinuo Liu
Zhejiang University
Hangzhou, Zhejiang

Co-Author(s):

Chenghui Zhang
Zhejiang University
Hangzhou, Zhejiang
Haoyu Hu
Zhejiang University
Hangzhou, Zhejiang
Yuzheng Hu
Zhejiang University
Hangzhou, Zhejiang
Xiangzhen Kong
Zhejiang University
Hangzhou, Zhejiang

Introduction:

Language is an important and complex function associated with multiple distributed brain regions. Typically, the left hemisphere shows greater involvement in language processing, also known as language lateralization. Previous work mainly focused on certain brain regions and investigated their individual roles in language. However, brain regions communicate and exchange information with each other. This study aims to examine how these language-related regions work together as a network. Specifically, graph theory was used to examine substantial lateralization in the topological properties and how they related to behaviors.

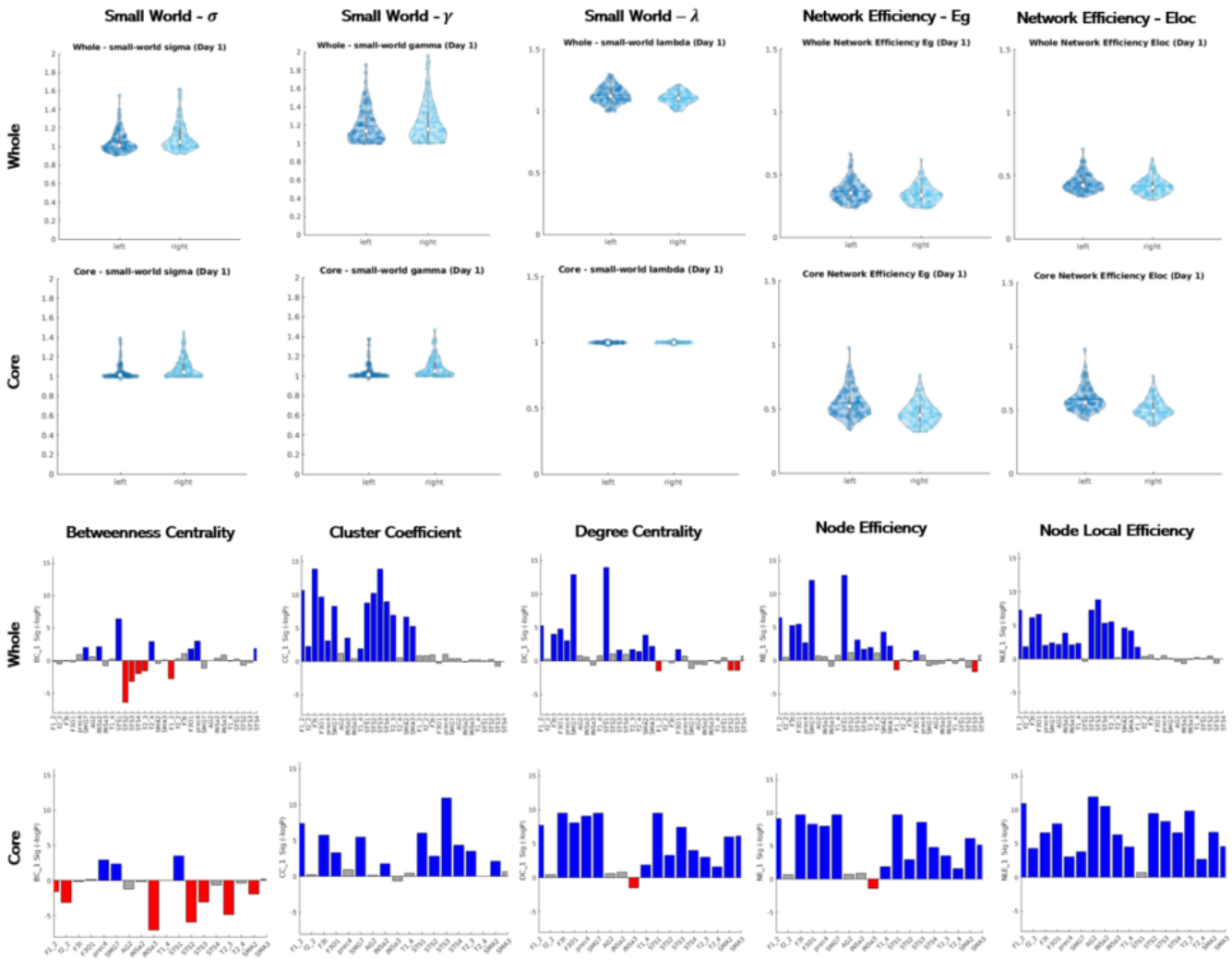
Methods:

One hundred unrelated subjects from the Human Connectome Project were involved (54 females; age: 29±3.7 years). In addition to the preprocessing performed by HCP, the first 10 volumes were removed, and spatial smooth, temporal detrend, nuisance regression, and band-pass filtering (0.071Hz~0.125Hz)

were conducted.
Language-related areas were defined based on the results of L. Labache et al. (2019). We ran the analyses for the general and the core language networks separately. The general network included 32 areas in each hemisphere, and the core 18 regions. Correlations between regions were calculated and Fisher-z transformed, resulting a functional connectivity matrix of each network for each subject. To remove spurious correlations, we set the connectivity value less than 0.20 to zero. We also repeated the analyses using various sparsity thresholds from 20% to 40%, and the results were similar.
At the network level, we calculated topographic metrics including small-world properties and network efficiency. At nodal level, we calculated betweenness centrality (BC), cluster coefficient (CC), degree centrality (DC), efficiency (NE), and local efficiency (NLE). We also investigated the correlations between these attributes with behavioral measures including reading, vocabulary, and handedness.

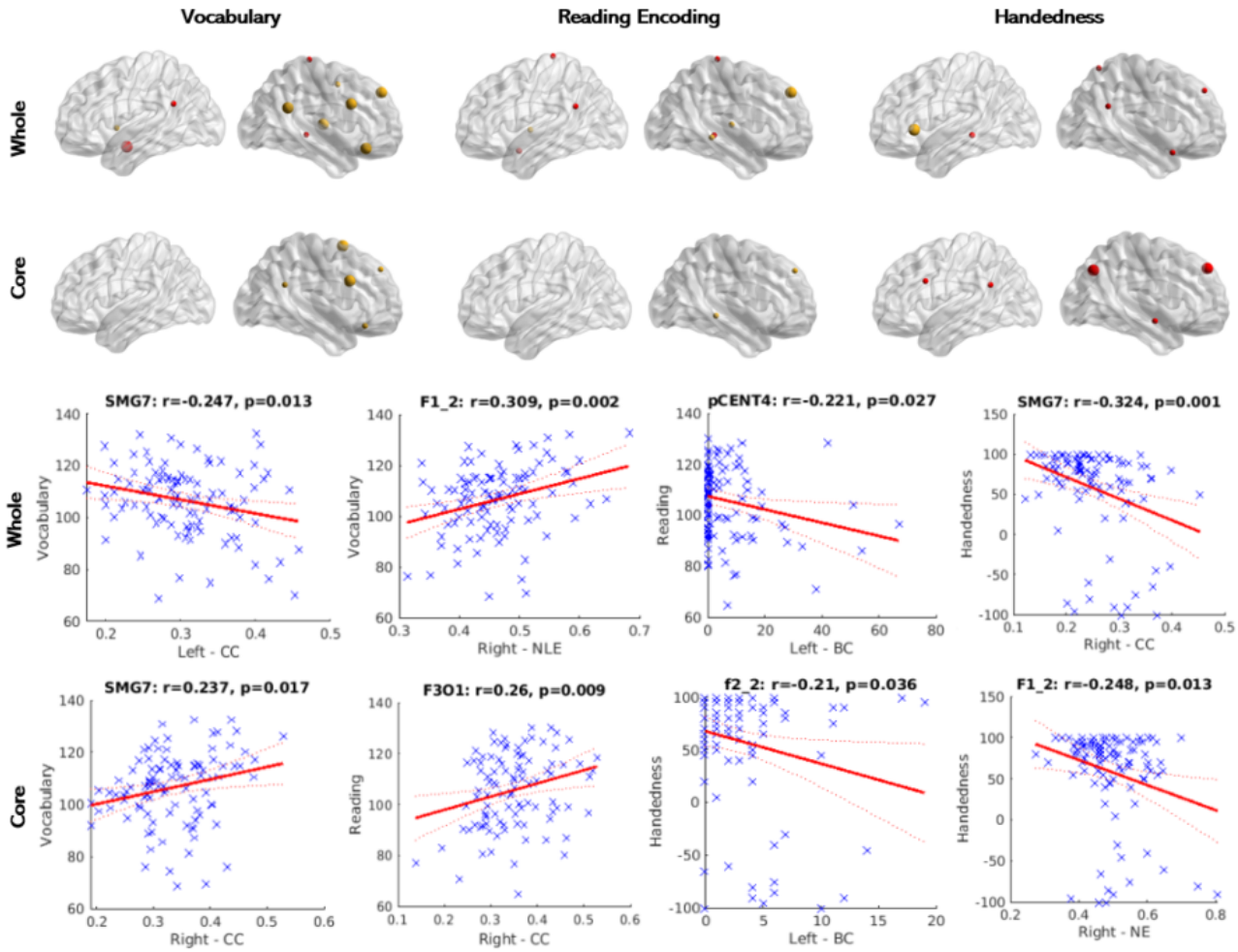
Results:

Network level results. The general language network of the left hemisphere showed higher network efficiency (Eloc: $p=0.011$) and smaller small-worldness δ ($p=0.006$) driven by larger λ ($p=0.002$). Similarly, left core network showed higher efficiency (Eg: $p<0.001$; Eloc: $p<0.001$) and smaller δ ($p<0.001$) but driven by smaller γ ($p<0.001$).
The λ of right core network showed significantly correlation with reading decoding ($r=-0.358$, $p<0.001$), while the γ and δ of left core network correlated with handedness (γ: $r=-0.228$, $p=0.025$; δ: $r=-0.216$, $p=0.031$).
Nodal level results. For the general network, most nodes showed higher DC, CC, NE and NLE on the left (Fig. 1). However, the numbers of dominant nodes in BC attribute on the two sides were almost equal. The core network showed similar patterns. For example, STS2 in both the general and core networks showed strong right asymmetry in BC (general: $t=-5.24$, $p<0.001$; core: $t=-4.98$, $p<0.001$). These nodal level attributes showed various correlations with behavioral measures, mainly in the right hemisphere (Fig. 2). For example, HIPP2 (BC) of the right general network significantly correlated with reading ($r=-0.373$, $p<0.001$). F1_2 (NE) of the core network in the right hemisphere significantly correlated with handedness ($r=-0.248$, $p=0.013$) and F3O1 (CC) with reading ($r=0.260$, $p=0.009$). Further replication of the behavioral correlations is needed.



(https://files.aievolution.com/prd/hbm2201/abstracts/abs_1962/figure1.png)

·Network-level properties for the whole left and right network (top), and nodal level properties' p-value for each node after paired t-test (bottom).



(https://files.aievolution.com/prd/hbm2201/abstracts/abs_1962/figure2.png)

·Nodes that have significant correlation(s) with behaviors (top), and scatter plots of some significant correlations (bottom)

Conclusions:

In sum, there are significant differences in the language networks between left and right hemispheres in terms of network properties at both network level and nodal level. Language network in left hemisphere has smaller small-worldness and higher efficiency, and the left nodes are also more efficient and clustered with higher degree centrality. Interestingly, we found that more nodes in right network show significant correlations with language-related behaviors.

Language:

Language Other [1]

Modeling and Analysis Methods:

fMRI Connectivity and Network Modeling [2]

Keywords:

Language
Other - Resting-state fMRI; Brain Network; Language Lateralization

[1|2]Indicates the priority used for review

My abstract is being submitted as a Software Demonstration.

No

Please indicate below if your study was a "resting state" or "task-activation" study.

Resting state

Healthy subjects only or patients (note that patient studies may also involve healthy subjects):

Healthy subjects

Was any human subjects research approved by the relevant Institutional Review Board or ethics panel? NOTE: Any human subjects studies without IRB approval will be automatically rejected.

Not applicable

Was any animal research approved by the relevant IACUC or other animal research panel? NOTE: Any animal studies without IACUC approval will be automatically rejected.

Not applicable

Please indicate which methods were used in your research:

Functional MRI
Behavior

For human MRI, what field strength scanner do you use?

3.0T

Which processing packages did you use for your study?

Other, Please list - GRETNA
SPM
FSL
Free Surfer

Provide references using author date format

[1] James M. Shine. (2016). The Dynamics of Functional Brain Networks: Integrated Network States during Cognitive Task Performance. Neuron, vol. 92, pp. 544-554.
[2] L. Labache. (2019). ASENtence Supramodal Areas AtlaS (SENSAAS) based on multiple task-induced activation mapping and graph analysis of intrinsic connectivity in 144 healthy right-handers. Brain Structure and Function, vol. 224, pp. 859-882.
[3] Xia M. (2013). BrainNet Viewer: A Network Visualization Tool for Human Brian Connectomics. PLoS ONE, 8(7): e68910.