Brain Network: Innovation Points

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Methodological Issues

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NeuroImage
journal homepage: www.elsevier.com/locate/neuroimage

Optimising network modelling methods for fMRI

Usama Pervaiz [a,*], Diego Vidaurre [b,c], Mark W. Woolrich [b], Stephen M. Smith [a]
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[b] Oxford Centre for Human Brain Activity (OHBA), Wellcome Centre for Integrative Neuroimaging, Department of Psychiatry, University of Oxford, Oxford, OX3 7JX, United Kingdom
[c] Department of Clinical Medicine, Aarhus University, Denmark

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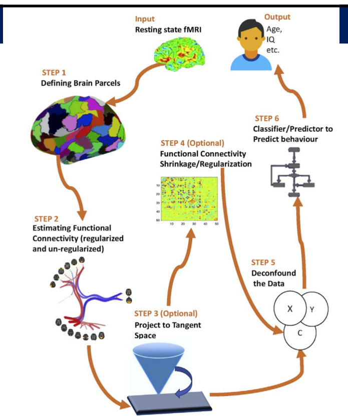

Fig. 1. Flow chart summarizing the six major steps of the methodology framework for rfMRI analysis.

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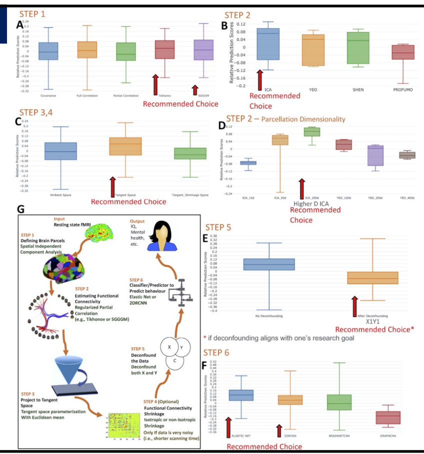

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Innovation Point 1

✓ Individual Parcellation >> Group Parcellation

✓ Functional Parcellation >> Anatomical Parcellation

✓ Surface Parcellation >> Volume Parcellation

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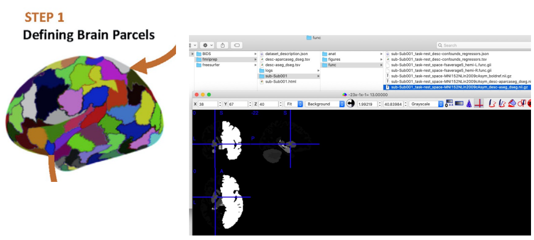
Innovation Point 1

✓ Individual Parcellation >> Group Parcellation



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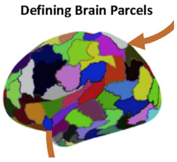
Innovation Point 1

✓ Functional Parcellation >> Anatomical Parcellation

STEP 1
Defining Brain Parcels



AAL ✕

❖ Smith SM, Miller KL, Salimi-Khorshidi G, Webster M, Beckmann CF, Nichols TE, et al. Network modelling methods for FMRI. Neuroimage. 2011;54(2):875-91.

❖ Sala-Llonch R, Smith SM, Woolrich M, Duff EP. Spatial parcellations, spectral filtering, and connectivity measures in fMRI: Optimizing for discrimination. Hum Brain Mapp. 2019;40(2):407-19.

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Innovation Point 1

✓ Functional Parcellation >> Anatomical Parcellation

nature neuroscience — ARTICLES
https://doi.org/10.1038/s41593-020-00711-6

Check for updates

Topographic organization of the human subcortex unveiled with functional connectivity gradients

Ye Tian[1], Daniel S. Margulies[2], Michael Breakspear[3,4] and Andrew Zalesky[1,5]

Brain atlases are fundamental to understanding the topographic organization of the human brain, yet many contemporary human atlases cover only the cerebral cortex, leaving the subcortex a terra incognita. We use functional MRI (fMRI) to map the complex topographic organization of the human subcortex, revealing large-scale connectivity gradients and new areal boundaries. We unveil four scales of subcortical organization that recapitulate well-known anatomical nuclei at the coarsest scale and delineate 27 new bilateral regions at the finest. Ultrahigh field strength fMRI corroborates and extends this organizational structure, enabling the delineation of finer subdivisions of the hippocampus and the amygdala, while task-evoked fMRI reveals a subtle subcortical reorganization in response to changing cognitive demands. A new subcortical atlas is delineated, personalized to represent individual differences and used to uncover reproducible brain–behavior relationships. Linking cortical networks to subcortical regions recapitulates a task-positive to task-negative axis. This new atlas enables holistic connectome mapping and characterization of cortico-subcortical connectivity.

Tian et al., 2020. Nat Neurosci

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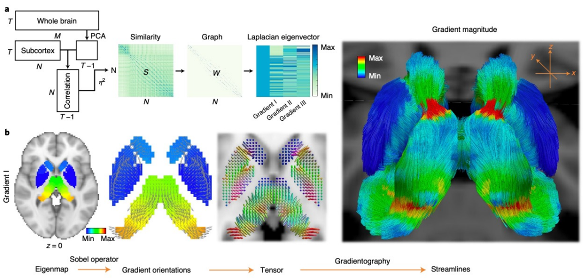
Innovation Point 1

✓ Functional Parcellation >> Anatomical Parcellation



Tian et al., 2020. Nat Neurosci

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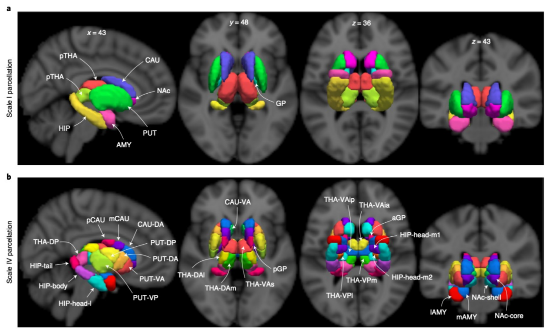
Innovation Point 1

✓ Functional Parcellation >> Anatomical Parcellation



Tian et al., 2020. Nat Neurosci

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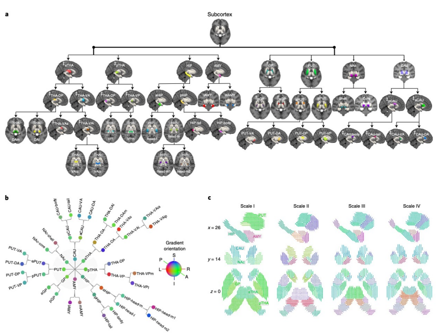
Innovation Point 1

✓ Functional Parcellation >> Anatomical Parcellation



Tian et al., 2020. Nat Neurosci

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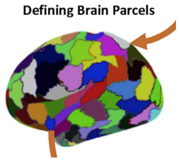
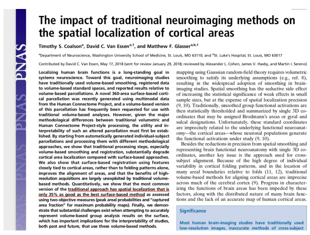
Innovation Point 1

✓ Surface Parcellation >> Volume Parcellation

STEP 1
Defining Brain Parcels





❖ Coalson TS, Van Essen DC, Glasser MF. The impact of traditional neuroimaging methods on the spatial localization of cortical areas. Proc Natl Acad Sci U S A. 2018;115(27):E6356-e65.

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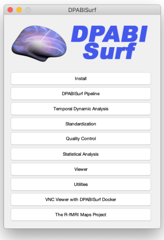
Innovation Point 1

✓ Surface Parcellation >> Volume Parcellation



❖ Coalson TS, Van Essen DC, Glasser MF. The impact of traditional neuroimaging methods on the spatial localization of cortical areas. Proc Natl Acad Sci U S A. 2018;115(27):E6356-e65.

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Innovation Point 1

✓ Surface Parcellation >> Volume Parcellation

ARTICLE

doi:10.1038/nature18933

A multi-modal parcellation of human cerebral cortex

Matthew F. Glasser[1], Timothy S. Coalson[1]*, Emma C. Robinson[2,3]*, Carl D. Hacker[4]*, John Harwell[1], Essa Yacoub[5], Kamil Ugurbil[5], Jesper Andersson[2], Christian F. Beckmann[6,7], Mark Jenkinson[2], Stephen M. Smith[2] & David C. Van Essen[1]

Understanding the amazingly complex human cerebral cortex requires a map (or parcellation) of its major subdivisions, known as cortical areas. Making an accurate areal map has been a century-old objective in neuroscience. Using multi-modal magnetic resonance images from the Human Connectome Project (HCP) and an objective semi-automated neuroanatomical approach, we delineated 180 areas per hemisphere bounded by sharp changes in cortical architecture, function, connectivity, and/or topography in a precisely aligned group average of 210 healthy young adults. We characterized 97 new areas and 83 areas previously reported using post-mortem microscopy or other specialized study-specific approaches. To enable automated delineation and identification of these areas in new HCP subjects and in future studies, we trained a machine-learning classifier to recognize the multi-modal 'fingerprint' of each cortical area. This classifier detected the presence of 96.6% of the cortical areas in new subjects, replicated the group parcellation, and could correctly locate areas in individuals with atypical parcellations. The freely available parcellation and classifier will enable substantially improved neuroanatomical precision for studies of the structural and functional organization of human cerebral cortex and its variation across individuals and in development, aging, and disease.

Glasser et al., 2016. Nature

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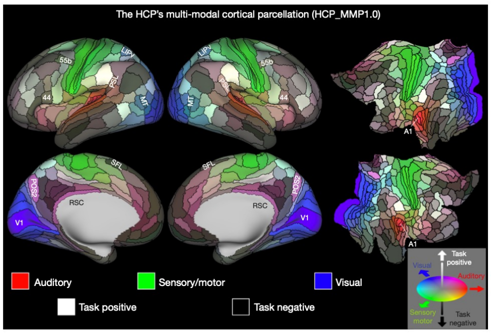
Innovation Point 1

✓ Surface Parcellation >> Volume Parcellation



Glasser et al., 2016. Nature

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Innovation Point 1

✓ Surface Parcellation >> Volume Parcellation

OXFORD

Cerebral Cortex, 2017; 1–20

doi: 10.1093/cercor/bhx179

Original Article

ORIGINAL ARTICLE

Local-Global Parcellation of the Human Cerebral Cortex from Intrinsic Functional Connectivity MRI

Alexander Schaefer[1], Ru Kong[1], Evan M. Gordon[2], Timothy O. Laumann[3], Xi-Nian Zuo[4,5], Avram J. Holmes[6], Simon B. Eickhoff[7,8] and B.T. Thomas Yeo[1,9,10]

[1]Department of Electrical and Computer Engineering, ASTAR-NUS Clinical Imaging Research Centre, Singapore Institute for Neurotechnology and Memory Networks Program, National University of Singapore, Singapore, [2]VISN 17 Center of Excellence for Research on Returning War Veterans, Waco, TX, USA, [3]Department of Neurology, Washington University in St. Louis, St. Louis, MO, USA, [4]CAS Key Laboratory of Behavioral Sciences, Institute of Psychology, Beijing, China, [5]University of Chinese Academy of Sciences, Beijing, China, [6]Yale University, New Haven, CT, USA, [7]Institute for Systems Neuroscience, Medical Faculty, Heinrich-Heine University Düsseldorf, Düsseldorf, Germany, [8]Institute of Neuroscience and Medicine, Brain and Behaviour (INM-7), Research Center Jülich, Jülich, Germany, [9]Martinos Center for Biomedical Imaging, Massachusetts General Hospital, Charlestown, MA, USA and [10]Centre for Cognitive Neuroscience, Duke-NUS Medical School, Singapore, Singapore

Schaefer et al., 2017. Cereb Cortex

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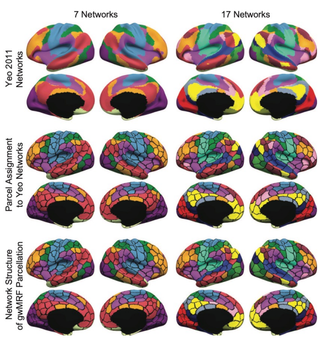
Innovation Point 1

✓ Surface Parcellation >> Volume Parcellation



Schaefer et al., 2017. Cereb Cortex

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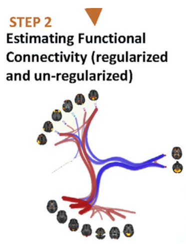
Innovation Point 2



✓ regularized partial correlation

> full correlation

e.g., Tikhonov and SGGGM

❖ Pervaiz U, Vidaurre D, Woolrich MW, Smith SM. Optimising network modelling methods for fMRI. Neuroimage. 2020:116604.

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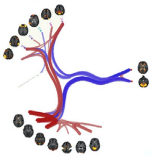
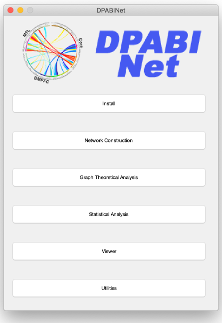
Innovation Point 2

STEP 2
Estimating Functional Connectivity (regularized and un-regularized)





- Pervaiz U, Vidaurre D, Woolrich MW, Smith SM. Optimising network modelling methods for fMRI. Neuroimage. 2020:116604.

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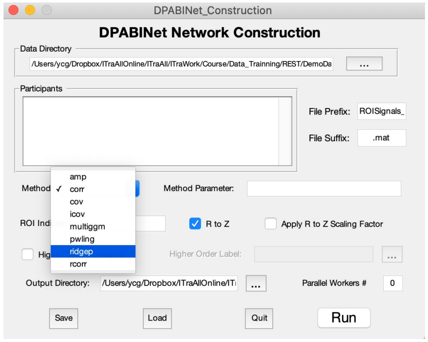
Innovation Point 2



'ridgep' - partial correlation using L2-norm Ridge Regression (aka Tikhonov)

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Further Help

The R-fMRI Course V3.0

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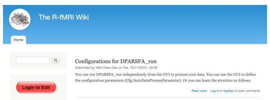
http://rfmri.org
The R-fMRI Lab
International Big-Data Center for Depression Research
Institute of Psychology, Chinese Academy of Sciences

http://rfmri.org/Course



http://rfmri.org/wiki

The R-fMRI Journal Club

Official Account: RFMRILab

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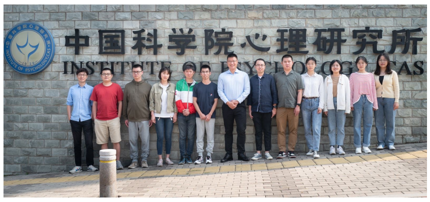
Acknowledgments



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Thanks for your attention!

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