Evaluation of functional brain parcellation methods using a multi-domain task battery

Da Zhi[1a,1b], Maedbh King[2], Carlos R. Hernandez-Castillo[1a], Richard B. Ivry[2], Jörn Diedrichsen[1a,1b,1c]

[a] Brain and Mind Institute, [b] Department of Computer Science, [c] Department of Statistical and Actuarial Sciences
[1] University of Western Ontario, [2] University of California, Berkeley

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Introduction

Brain parcellation is important for:
- Understanding the brain in terms different modules working together
- Defining regions-of-interest for subsequent analysis

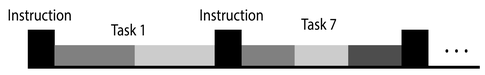
Aims of the current project
1) Provide a rich task data set to identify functional boundaries
2) Develop a new evaluation criterion to determine the quality of parcellations
3) Compare common brain parcellations for cortex
4) Develop new parcellation based on task-based data

Dataset: Multi-Domain Task Battery

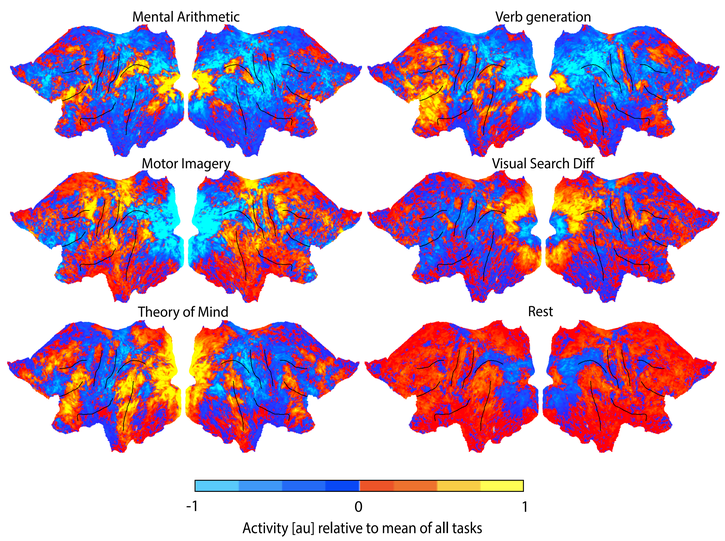
Multi-Domain Task Battery (MDTB)

Set A 29 Task Conditions	Set B 32 Task Conditions
No-Go	Theory of Mind
Go	Action Observation
Math	Video Knots
Digit Judgment	Finger Simple
Unpleasant Scenes	Finger Sequence
Pleasant Scenes	Object 0-Back
Objects	Object 2-Back
Sad Faces	Visual Search – easy
Happy Faces	Visual Search – med.
Interval Timing	Visual Search – hard
Motor Imagery	Spatial Imagery
Stroop Incongruent	Verb Generation
Stroop Congruent	Word Reading
Verbal 0-Back	Rest
Verbal 2-Back	
	Nature Movie
	Landscape Movie
	Animated Movie
	Spatial Map – easy
	Spatial Map – med.
	Spatial Map – hard
	Mental Rotation – easy
	Mental Rotation – med.
	Mental Rotation – hard
	Response Alt. – easy
	Response Alt. – med.
	Response Alt. – hard
	Biological Motion
	Scrambled Motion
	Permuted Rules
	True Prediction
	Violated Prediction
	Scrambled Prediction

- 47 unique task conditions
- Acquired in the same run with common baseline
- 24 Participants
- 4 Sessions (6 hrs) of data for each participant
- 2 Sessions for each task set
- Whole brain coverage



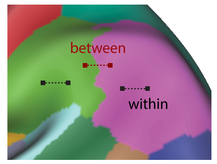
Example activity maps

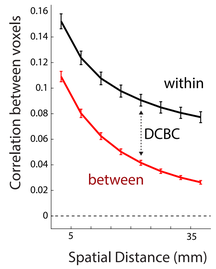


Evaluation Criterion: DCBC

Distance controlled boundary coefficient (DCBC)

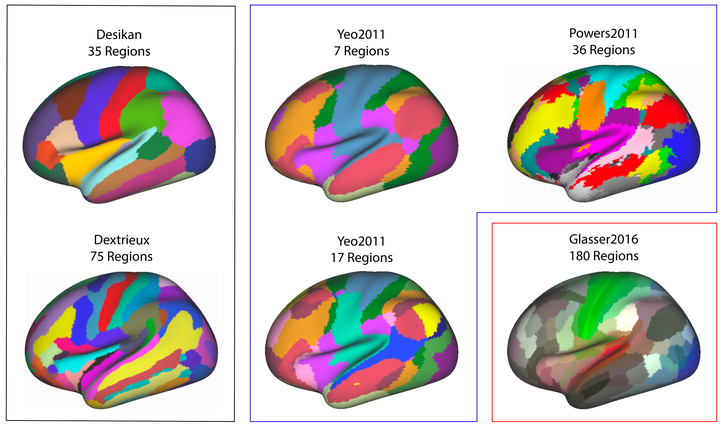
A good parcellation should result in
- High correlations between voxels within region
- Low correlations between regions

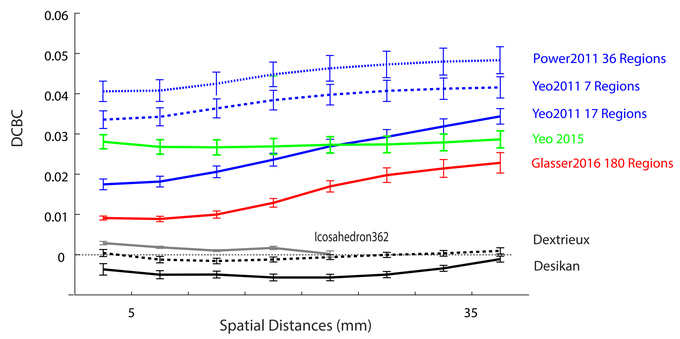




- Functional correlations fall off systematically with spatial distance of voxels
- Without control, any contiguous parcellation will do ok
- Distance controlled boundary coefficient (DCBC) is the difference between correlations for matched spatial distances.

Comparing existing parcellations





- Anatomical parcellations no better than chance
- Resting-state parcellations outperform others
- Glasser (2016) performs worse than pure resting-state parcellations

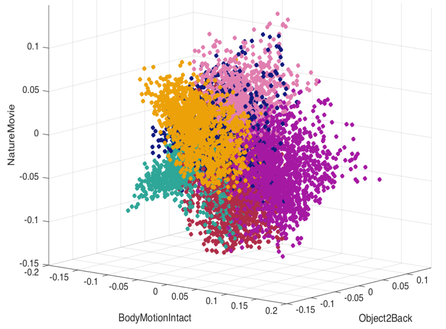
MDTB (task-based data) Parcellation

Clustering Algorithm

Spectral Clustering with cosine similarity matrix outperforms:

- Semi-nonnegative matrix factorization
- Spectral Clustering with euclidean distance affinity

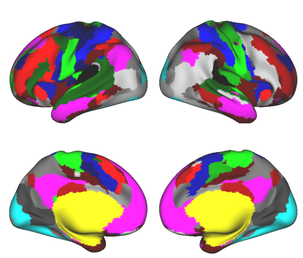
Activity profiles of each voxel on 3 exemplary conditions (of 47 conditions) reveals "star topology"



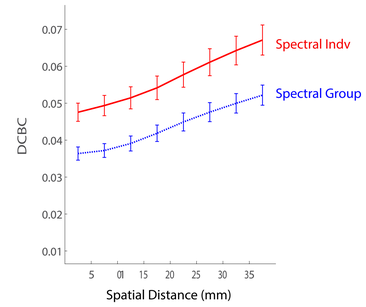
Individual vs group average

Parcellation derived from one task set
- Group averaged data (55hrs)
- Individual data (2.5hrs)

Evaluation is performed on the unique task of the other task set to avoid over-fitting



Spectral Clustering - 17 Regions



- The DCBC result shows individual parcellation outperforms group parcellation

Conclusion

1. Anatomical parcellations do not predict functional boundaries better than chance
2. Resting-state parcellations perform rather well in predicting task-based functional boundaries
3. Combined parcellation (Glasser) inferior to pure resting-state parcellations

Next steps:

Integrate individual with group task-based data to obtain optimal parcellations (transfer learn-

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