A multivariate resting-state *f*MRI technique for subject-specific parcels and sub-networks

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1. Introduction

Background

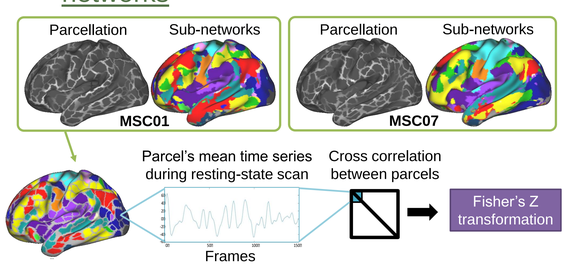
- Recent work in resting-state *f*MRI (rs*f*MRI) analysis can derive subject-specific parcellations and sub-networks.
- Standard approaches for rs*f*MRI:
  - **Graph/network analysis** accommodates different numbers of parcels/sub-networks.
    - Requires correction for multiple comparisons when examining sub-networks.
  - **Multivariate analysis** (e.g., MDS, DISTATIS) requires the same number of parcels/sub-networks.
    - Usually achieved by using a shared template.
    - Biases against individuals that vary greater from the target template.
- The above issues from standard approaches are particularly problematic for studies involving subjects that exhibit larger variance in brain structure and function (e.g., elderly, lesion patients, children).

Aim

To develop a new multivariate technique that allows different numbers of parcels/sub-networks.

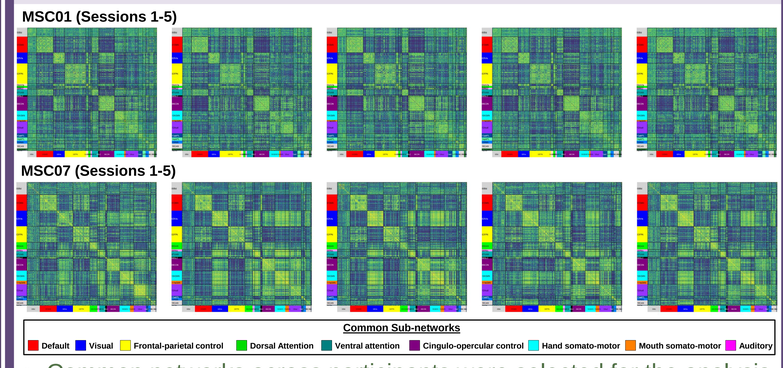
2. Resting-state data set

- **Midnight Scan Club (MSC; Gordon et al, 2017)**
  - Resting-state *f*MRI (30 minutes)
  - 10 participants x 10 sessions
  - Subject-specific parcellations and sub-networks



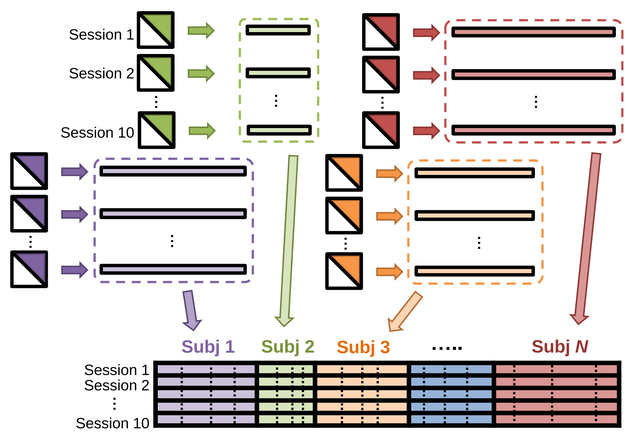
- Extract time series and create correlation matrix for each session of each subject

3. Examples of connectivity matrices



- Common networks across participants were selected for the analysis.
- Negative and perfect *z*-transformed correlations were excluded from further analysis.

4. Proposed method



- **Centering:** exclude the effect of magnitudes
  - **Double-centering the *z* matrix:** exclude the magnitudes of regions
- **Normalization:** exclude units
- **MFA-normalization (divide each table by its first singular value):** equalize contributions of tables to the first component

Preprocessed

SVD

5. Choices of preprocessing steps

	Dimensions	Preprocessing	Aims

1	*z*-matrices	x	• To exclude:
			  • Mean magnitudes of edges
			• To equalize:
			  • The contributions of subjects

	rows	x	
	columns	centered	
	edge tables	x	
	subject tables	MFA-normalized	

2	*z*-matrices	x	• To exclude:
			  • Mean magnitudes of edges
			• To equalize:
			  • First the contributions of edges
			  • Second the contributions of subjects

	rows	x	
	columns	centered	
	edge tables	HMFA-normalized (edge → subject)	
	subject tables		

3	*z*-matrices	double-centered	• To exclude:
			  • Mean magnitudes of regions
			  • Mean magnitudes of edges
			• To equalize:
			  • The contributions of subjects

	rows	x	
	columns	centered	
	edge tables	x	
	subject tables	MFA-normalized	

4	*z*-matrices	x	• To exclude:
			  • Mean magnitudes of regions
			  • Mean magnitudes of edges
			• To equalize:
			  • First the contributions of edges
			  • Second the contributions of subjects

	rows	x	
	columns	centered	
	edge tables	HMFA-normalized (edge → subject)	
	subject tables		

Justifications and thoughts

- Normalizations were not applied to rows or columns because their units are the same.
- The rows were unprocessed because we want to apply this technique to the data where the differences in both magnitudes and variances of rows are of interest.
- **The choices of the preprocessing steps should be optional and decided based on the research question.**

6. Results