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

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## 1. Introduction

### Background

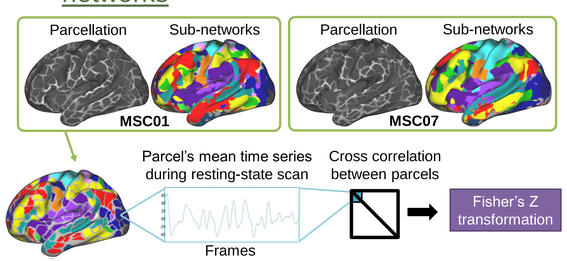
- Recent work in resting-state *f*MRI (rs*f*MRI) analysis can derive subject-specific parcellations and sub-networks.
- Standard approaches for rs*f*MRI:
  - **Graph/network analysis** accommodates different numbers of parcels/sub-networks.
    - Requires correction for multiple comparisons when examining 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 and sub-networks.**

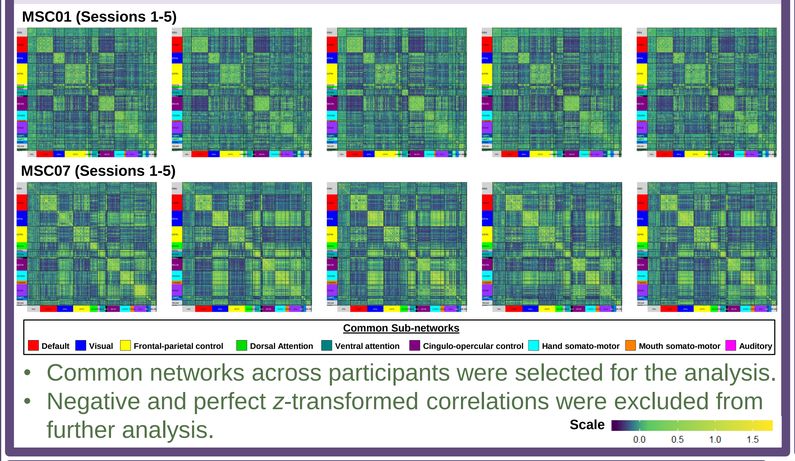
## 2. Resting-state data set

- **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



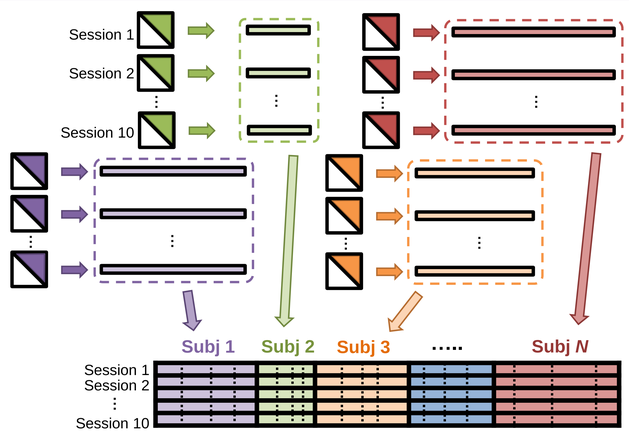

- Extract time series and create correlation matrix for each session of each subject

## 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:<br>  • Mean magnitudes of edges<br>• To equalize:<br>  • The contributions of subjects |
| | rows | x | |
| | columns | centered | |
| | edge tables | x | |
| | subject tables | MFA-normalized | |
| 2 | *z*-matrices | x | • To exclude:<br>  • Mean magnitudes of edges<br>• To equalize:<br>  • First the contributions of edges<br>  • Second the contributions of subjects |
| | rows | x | |
| | columns | centered | |
| | edge tables | HMFA-normalized (edge → subject) | |
| | subject tables | | |
| 3 | *z*-matrices | double-centered | • To exclude:<br>  • Mean magnitudes of regions<br>  • Mean magnitudes of edges<br>• To equalize:<br>  • The contributions of subjects |
| | rows | x | |
| | columns | centered | |
| | edge tables | x | |
| | subject tables | MFA-normalized | |
| 4 | *z*-matrices | x | • To exclude:<br>  • Mean magnitudes of regions<br>  • Mean magnitudes of edges<br>• To equalize:<br>  • First the contributions of edges<br>  • 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 data where the differences in both magnitudes and variances of rows are of interest (e.g., experiments).
- **The choices of these preprocessing steps should be optional and decided based on the research question.**

## 6. Results