# ME-fMRI connectivity associations with behavior using group and individualized parcellation schemes

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## INTRODUCTION

- Two leading challenges to investigating brain-behavior relationships:
  1) accounting for non-neural signals (i.e., noise)
  2) individual differences in functional network structure
- Standard processing pipelines for rs-fMRI call for aggressive de-noising prior to analysis.
- Multi-echo (ME) fMRI acquisition can reliably dissociate neural (BOLD) from non-neural signals[1].
- Participant-specific functional parcellation schemes can be used to identify individualized network organization that may be obscured by group averaged parcellation schemes[2].
- **Aim:** Here we combine ME acquisition and individualized network parcellation schemes to evaluate their added impact on brain-behavior associations.

## METHODS

ME-fMRI data collected over two 10-minute resting state runs from 137 young adults (*M*=22.61y, *SD*=3.34y) in Ithaca, NY and Toronto, Canada. Fluid cognition was measured with the NIH Toolbox.

**Processing**

We compare multi-echo processing with standard single-echo processing.

•TE2 was used as a proxy for single-echo (SE) and was preprocessed using fMRIPrep v. 1.5.9[3] and xcpEngine v.1.0.1[4] using 36P+scrub design[5].
•ME data were minimally processed, optimally combined, and submitted to ME-ICA v. 3.2 beta[1]

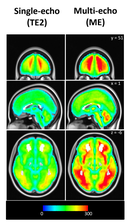



Figure 1. Group temporal signal-to-noise (tSNR) maps for single-echo and multi-echo processed data.

**Parcellation**

To compare the effect of parcellation choice on resting-state functional connectivity (rsfc) we used the following parcellation schemes:
•Group parcellation with 200-region Schaefer atlas[6]
•Individualized parcellation 200-regions[2]

**4 Pipelines:**

| | Group Parcellation (Schaeffer 200 atlas) | Individualized Parcellation (Chong et al., 2017) |
|---|---|---|
| **Single-Echo (TE2)** | SE group | SE indiv |
| **Multi-Echo** | ME group | ME indiv |

## What effects do processing and parcellation have on RSFC, network topology, and brain-behavior associations?

ANALYSES

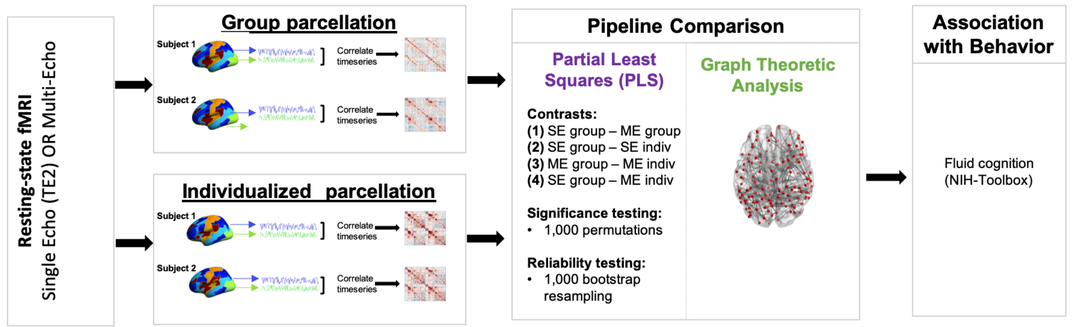
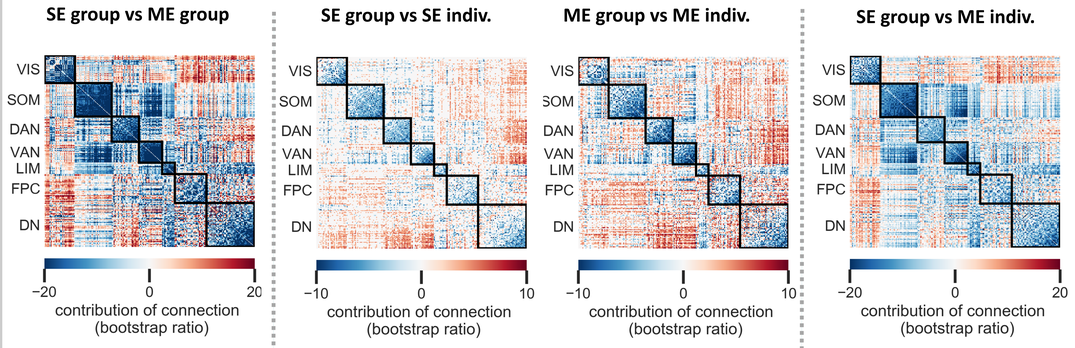



Figure 2. Analytic pipeline. After processing & de-noising, participants' resting-state data were parcellated in two ways: with a group atlas and using an individualized parcellation scheme. Resulting connectivity matrices were analyzed in PLS and with graph theoretic measures.

RESULTS




**Red** = Higher RSFC for ME group
**Blue** = Higher RSFC for SE group

**Red** = Higher RSFC for SE indiv
**Blue** = Higher RSFC for SE group

**Red** = Higher RSFC for ME indiv
**Blue** = Higher RSFC for ME group

**Red** = Higher RSFC for ME indiv
**Blue** = Higher RSFC for SE group

**Effect of ME processing.** Compared to SE, ME processing increases within-network connectivity overall and between-network connectivity in networks susceptible to tSNR loss (permutated $p < 0.001$).

**Effect of individual parcellation.** Individualized parcellation increases between-network connectivity compared to group parcellation in both SE processing and ME processing. The effects is magnified in ME processing. (SE group vs SE indiv: permutated $p < 0.001$; ME group vs ME indiv: $p < 0.001$).

**Combined effect of ME processing and individual parcellation.** Compared to standard SE approaches, the combined pipeline increases within-network connectivity overall and between-network connectivity in networks susceptible to low tSNR (permutated $p < 0.001$).

RESULTS

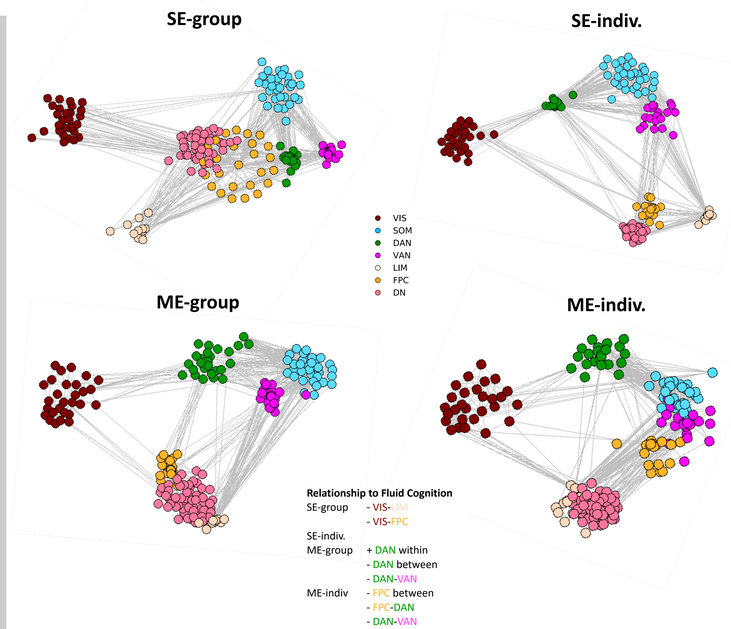



Figure 3. Network connectivity and associations with behavior are altered as a function of processing and parcellation scheme. Spring-embedded plots showing the 7-network solution (Yeo et al., 2011; 5% edge density) of the cohort's mean correlation matrices.

## CONCLUSIONS

- ME processing not only simplifies de-noising and boosts tSNR, but enhances rsfc within networks overall and between networks susceptible to dropout, like the limbic network.
- Individualized parcellation approaches increase between-network connectivity. Group atlases show higher within-network connectivity and segregation.
- Processing and parcellation choices alter network topology and associations with behavior.
  - Brain-behavior correlations are detectable in higher-order networks only with ME data
  - Individualized approaches are likely to yield more robust effects in more diverse samples

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