Individual differences in fine-grained neural correlates of mental states

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Introduction

- Individual differences in mental states are probably encoded in fine-grained cortical activity.
- Such patterns are lost in analyzing anatomically-alignment fMRI data due to idiosyncratic anatomical architecture.
- Hyperalignment affords vast improvements in aligning cortical functional architecture (Haxby et al., 2011; Feilong et al., 2018)

Question: How does hyperalignment improve detection of fine-grained neural differences in individuals listening to similar yet distinct stories?

Methods

Stimulus and experimental procedure

- 36 subjects (18 per group) heard stories with identical grammatical structures but ~20% word changes while in the scanner (Yeshurun et al, 2017).
- Story 1 had a negative-to-positive story arc whereas Story 2 had a positive-to-negative arc.
- We applied connectivity hyperalignment (CHA) to anatomically normalized data and implemented all analyses in anatomically aligned (AA) and CHA data (Guntupalli et al., 2018).

Separating coarse- and fine- scale information

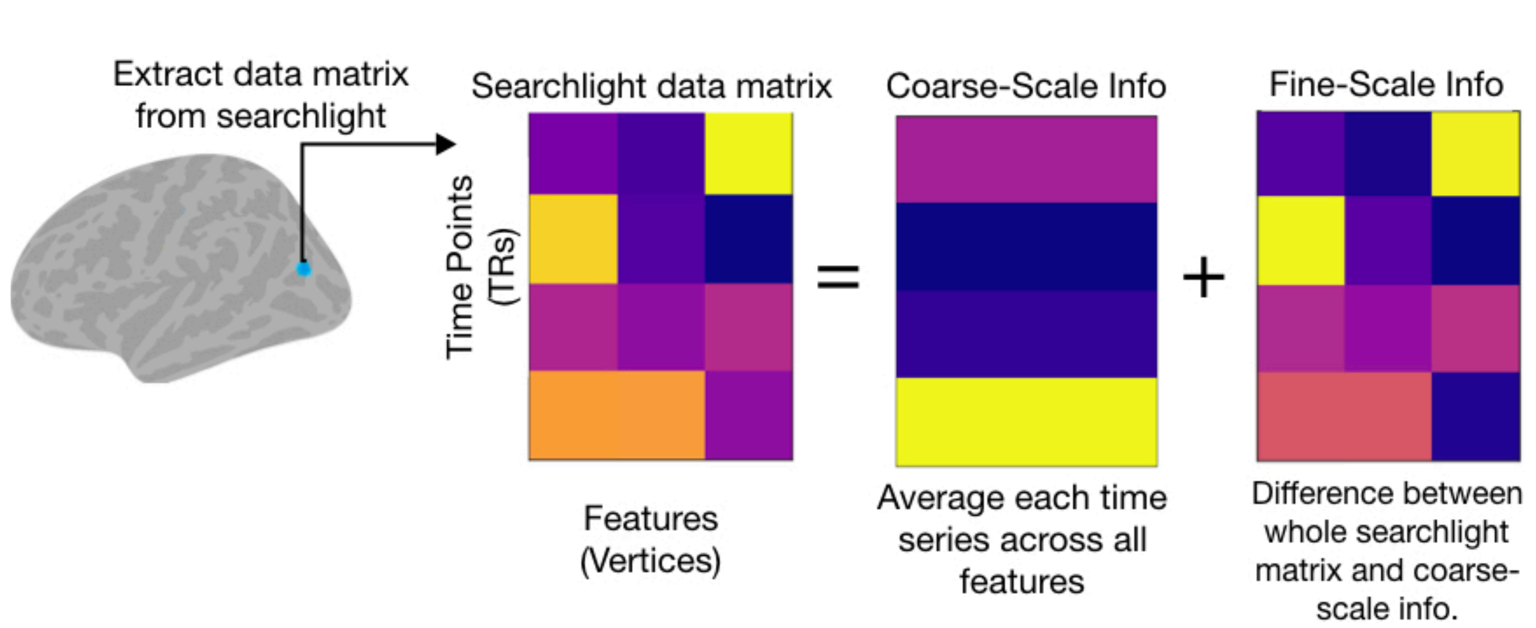

Figure 1: Schematic for separating coarse-scale and fine-scale information in a single searchlight.

Methods continued

Calculating ISC of response profiles

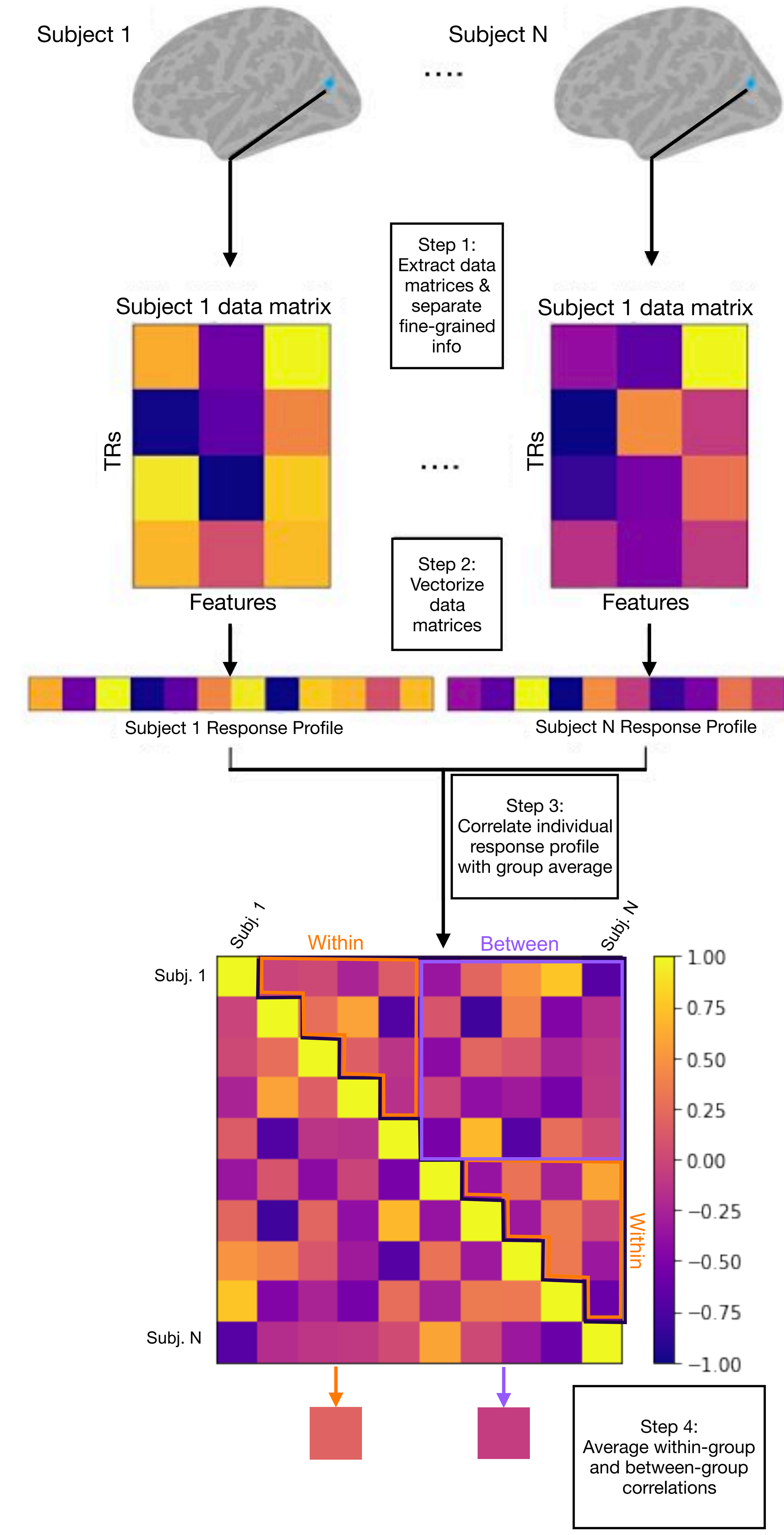

Figure 2: Schematic for calculating inter-subject correlations (ISCs) of local response profiles.

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Results

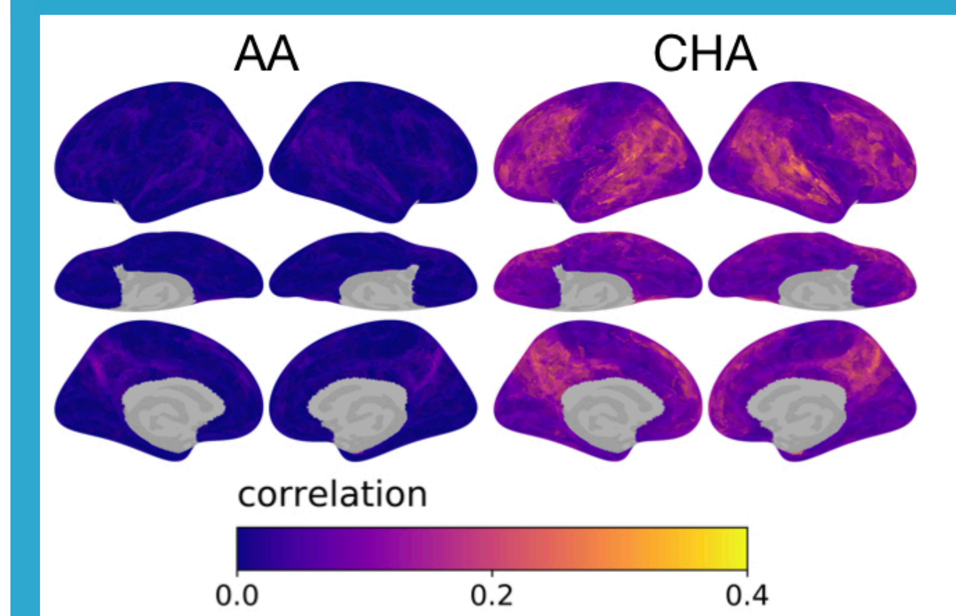

Figure 3: ISC of fine-grained information.
Averaged across within-and between-group ISC. CHA significantly improved ISC ($p < 1e-6$)
AA: M = 0.0132±0.0156
HA: M = 0.0978±0.0405

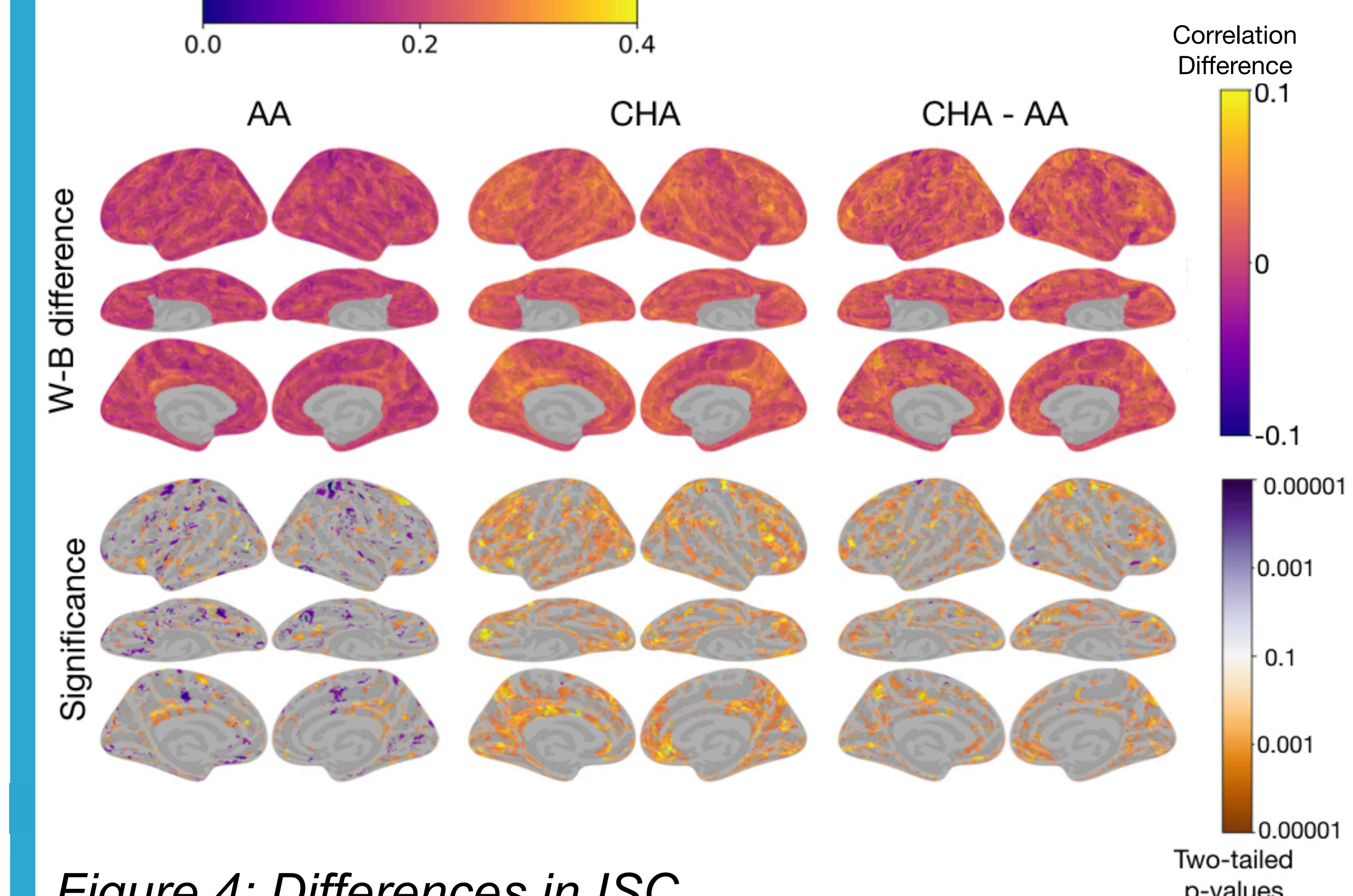

Figure 4: Differences in ISC.
Subtracted average BG from average WG correlation to find regions in which groups held distinct representations of the stimuli. Significance calculated with a permutation test (50K repetitions).

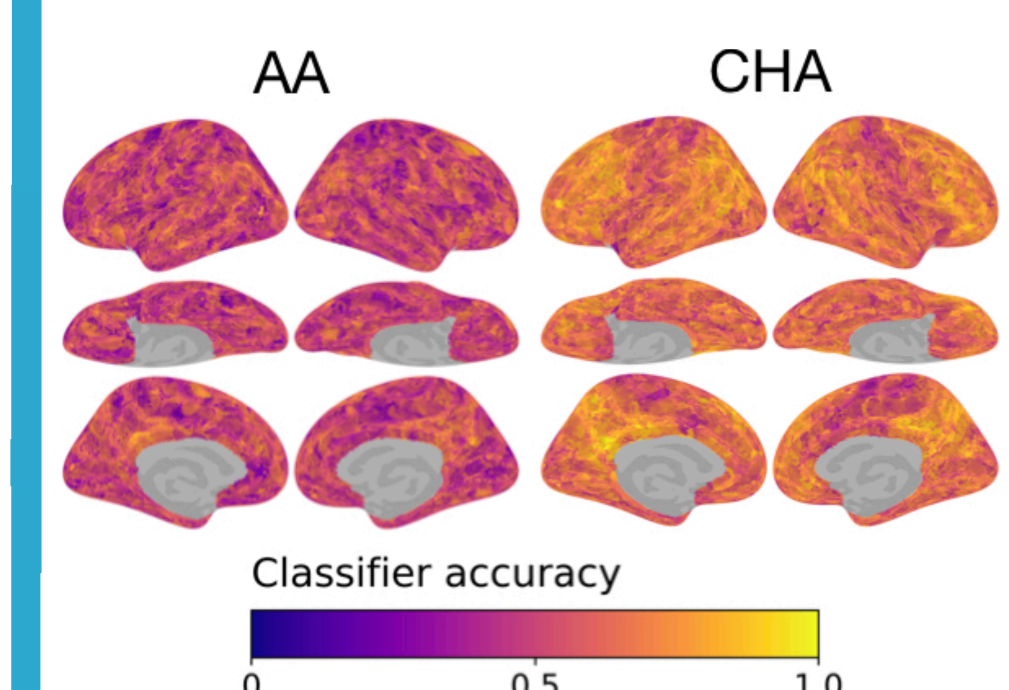

Figure 5: Classification analysis.
Accuracies of a classifier trained to predict which story a subject heard based on response similarity.

Accuracies:
AA: M=0.5220±0.1112
CHA: M=0.6619±0.1104
CHA improved classification ($p < 1e-6$).

Discussion

- CHA increases ISC of fine-grained information, revealing differences in TPJ, precuneus, and lateral prefrontal cortex.
- Classification accuracy is also highest in these regions, suggesting they encode information about distinct mental states in fine-grained response patterns revealed with hyperalignment.