Functional Connectivity Reliability and Individual Variability in Movie-Watching and Resting-State fMRI

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Introduction

- fMRI functional connectivity (FC) is used to characterize individual brain organization and holds promise as a biomarker.[1,2]

Resting-State (RS)	Movie-Watching (MW)
✓ Easy acquisition	✓ Easy acquisition
✗ Lack of control over cognitive state	✓ Naturalistic content
✗ Inflated inter-subject variability	✓ Synchronized neural activity across subjects
✗ Low biomarker sensitivity	✓ Recruitment of a variety of cognitive networks

- MW and RS yield different group-average FC patterns across the brain.[3]
- Sensitivity to individual differences (including abnormalities in clinical applications) increases with increased reliability of FC.[4]

Questions

1. What is the **within-subject reliability** of estimated FC patterns for MW and RS? What is their **group-level reliability**?
2. Are **individual deviations from group-average** FC patterns correlated in MW and RS?

Within-subject and group reliability of FC

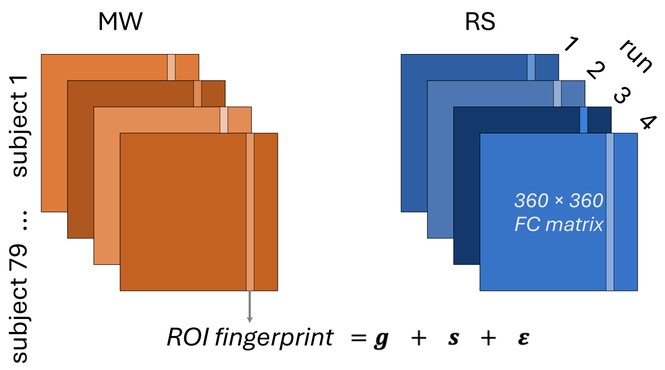
Methods

Data: Four ~15 min runs of MW and RS from 79 adults (ages 22-35, 41 female) in HCP S1200 7T, ICA-FIX denoised, MSMAll-aligned.[5,6]

Parcellation: 360 cortical ROIs from the Glasser atlas[7]; ROI timeseries: vertex-wise mean.

Functional connectivity: Pearson correlation between all ROI-pair timeseries → 360×360 FC matrix, Fisher z-transformed.

ROI FC fingerprint: each FC matrix column (vector) is the connectivity profile of one ROI.



Independent FC-model components

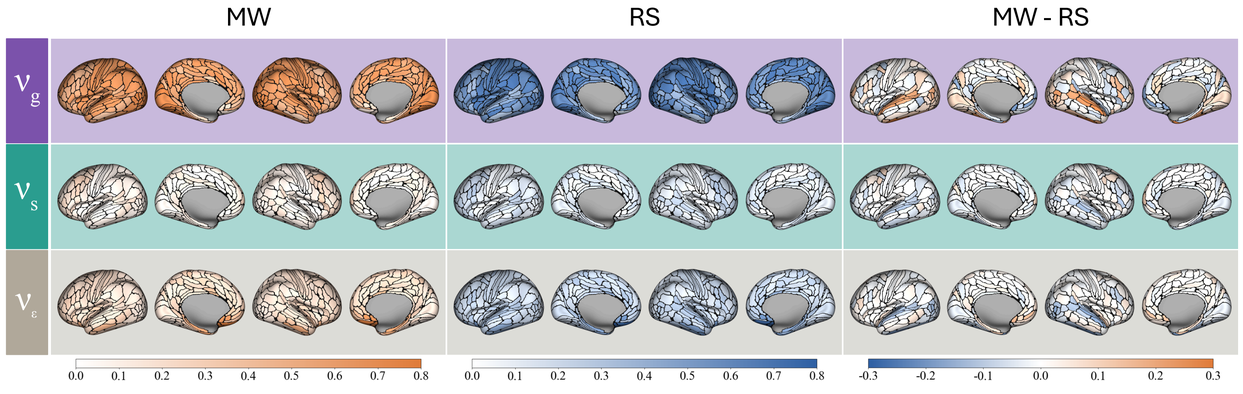
g *(group):* consistent FC across subjects and runs

s *(subject-specific):* consistent FC within each subject, across runs

ε: measurement noise

Variance of FC model components: estimated from cross-run and cross-subject inner products of mean-deducted fingerprints.

Within-subject reliability: $r_{subject} = \frac{v_g + v_s}{v_g + v_s + v_\varepsilon}$ Group reliability: $r_{group} = \frac{v_g}{v_g + v_s}$

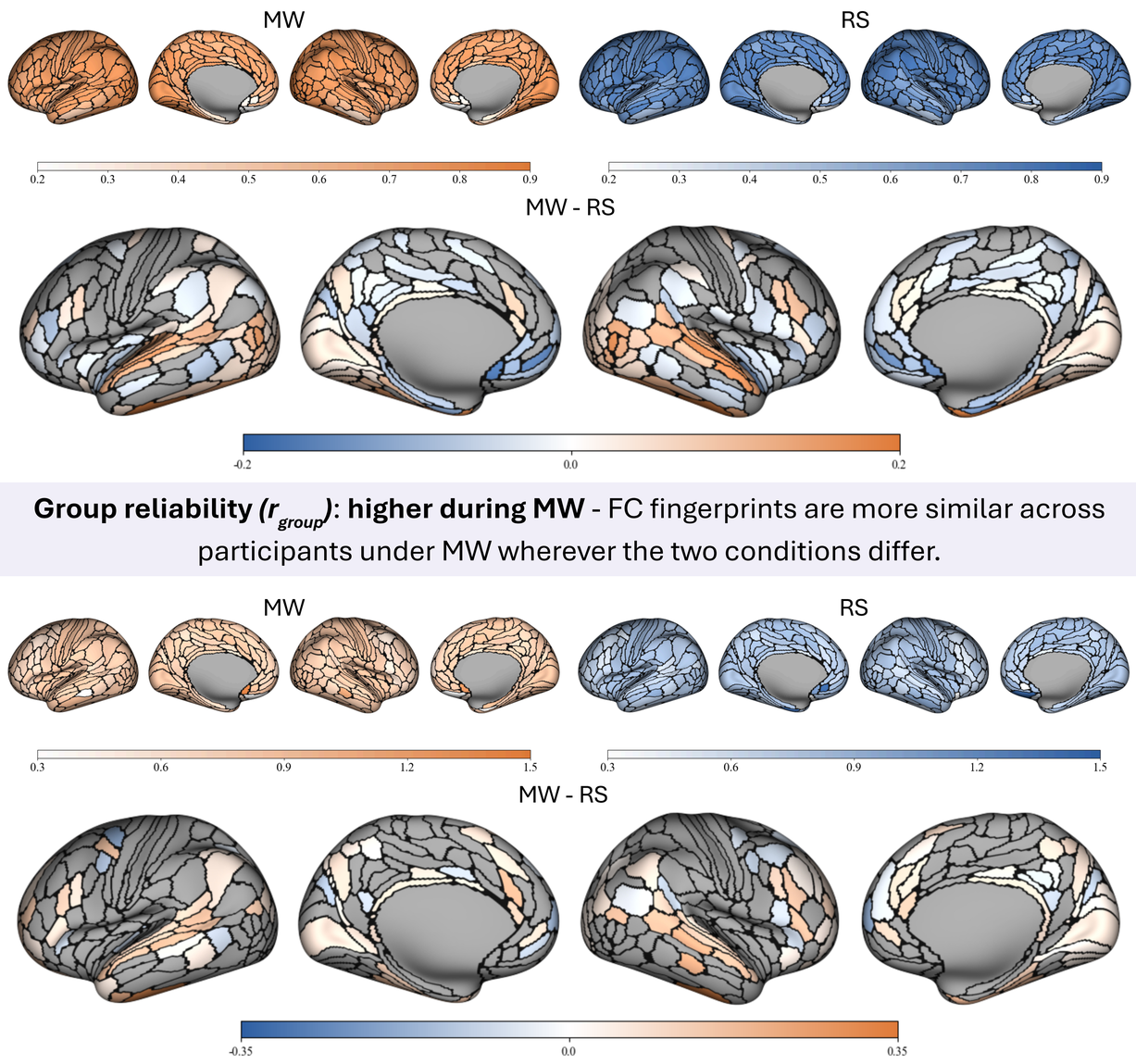


Results

All statistics: p<0.05; FDR-corrected, q < 0.05 (Benjamini–Hochberg)

Within-subject reliability ($r_{subject}$)

MW: more reliable in sensory regions; **RS:** more reliable in default-mode network.

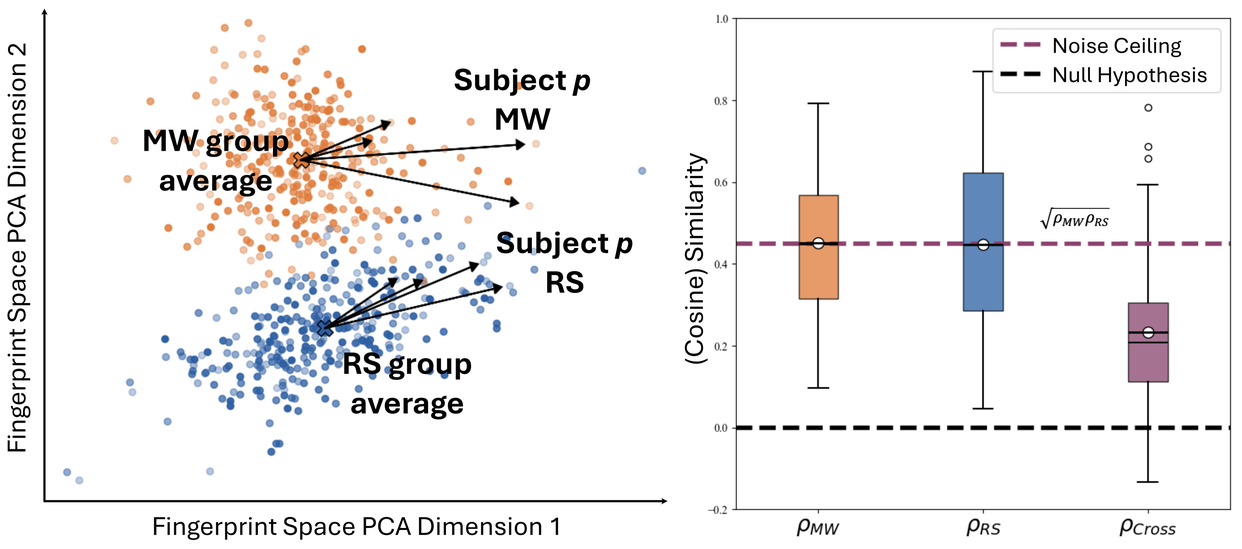


Group reliability (r_{group}): higher during MW - FC fingerprints are more similar across participants under MW wherever the two conditions differ.

Individual deviations from the group-average FC

Methods

An example ROI ($V1_L$)



Step 1

Computation of deviation (vector) from group-average for all runs and all subjects in both conditions.

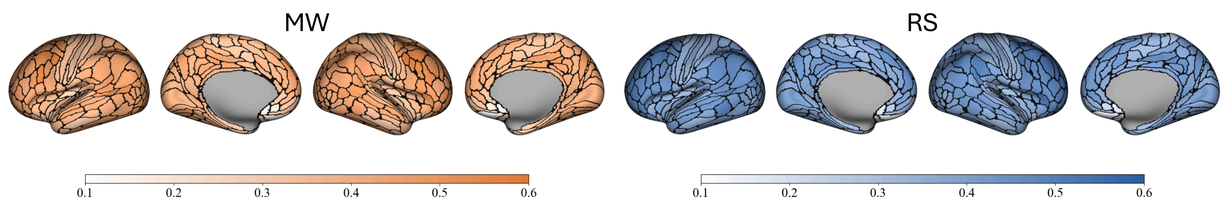
**Balck arrows: deviation vectors for an example subject (p).*

Step 2

Computation of deviation similarity within subjects for each condition (across runs), and across conditions (all MW-RS run pairs).

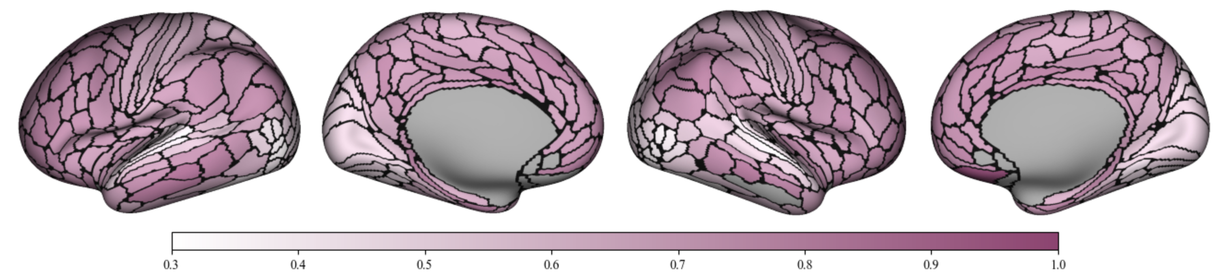
Results

Average within-condition similarity of individual deviations from the group-average



Individual patterns are correlated in MW and RS across the brain (normalized similarity>0.5 in 322 ROIs). In 10 ROIs (with low signal quality) they do not correlate at all.

Normalized cross-condition similarity ($\rho_{Cross}/\sqrt{\rho_{MW}\rho_{RS}}$)



Conclusions

1. Both MW and RS yield reliable FC fingerprints, **neither dominates across the entire brain.**

2. Higher MW group reliability suggests that the synchronized inter-subject BOLD timeseries similarity extends to the **covariance structure.**

3. Although MW and RS evoke different connectivity patterns on average, **individual patterns are somewhat correlated** across conditions; MW-RS differences are most pronounced in **auditory, sensorimotor, and visual cortices.**

References

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