Characterization of Individual Variability for the Improvement of Reliability

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Introduction:

Understanding individual variability is essential for characterizing test-retest reliability. How can one optimize the neuroimaging experiments to improve reliability, and how do changes in differing sources of variation (i.e., within, between) contribute to the improvement? Here we propose a reliability field map and its gradient flow to depict the impact of within- and between-individual variation on reliability (Fig 1). By situating reliability along the separable dimensions of within- and between-individual variation, we provide an explicit landscape of changes in reliability and their relations to these different sources of variations. We apply this approach to fMRI data and compare reliabilities for functional connectivity (FC) under four scan conditions: resting, naturalistic viewing of low engaging video (i.e., Inscapes), naturalistic viewing of higher engaging movies, and cognitive task performance (i.e. flanker). In addition, we assessed reliabilities for a 'hybrid' or 'general' FC (generated by combining four conditions in equal amounts) and compared them with those for FC driven solely from one condition.

Methods:

We introduce the reliability field and its gradient flow in the framework of test-retest intraclass correlation (ICC) definition (Fig 1). The gradient vector on the field map represents the maximal direction of ICC change on the respective axes of individual variability. For a given ICC change, we normalized its gradient and color coded the contributions of individual variability as compared to the optimal direction. We used the Serial Scanning Initiative (HBN-SSI) fMRI data, which was obtained from thirteen healthy adult participants (age: 29.8 ± 5.0 years). Each participant was repeatedly scanned under 4 conditions across 12 sessions (10 min x 4 conditions x 12 sessions). The hybrid data was concatenated with equal amounts of each fMRI condition. We split multiple sessions into 2 subsets for each of the five conditions and calculated the pairwise parcel-based FC. To calculate ICC, within- and between-individual variability were estimated in the linear mixed model for each FC. At each parcel, we compared the spatial patterns of FC and ICC across conditions and demonstrated in what manner that the individual variability contributes to the ICC differences between conditions.

Results:

Consistent with prior findings, FC showed substantial spatial similarity across four fMRI paradigms and the hybrid data appeared to capture the general FC, regardless of scan condition (Fig 2A). However, spatial patterns of ICC were relatively dissimilar between conditions (Fig 2A). Reliability gradient flow distinguished between the impact of within- and between-individual variability on the ICC differences (Fig 1B). When compared to rest, the ICC changes obtained for FC in the other conditions (movies, Inscapes, task, hybrid) were mostly in the optimal direction (Fig 1C, 59.9% ± 3.71%); these differences were attributed to between-individual variability more than within-individual variability across all the networks (between: 27.3%, within: 12.9%). Notably, increase in ICC were not a general phenomenon for each FC. Among 17.6% (±0.67%) of connections that exhibited significant differences ICC between rest and other conditions, (29.4% ± 1.61%) FC exhibited higher ICC for rest, with more between-individual variability contributions to these changes (e.g. Hybrid vs. Rest Fig 2B).

Conclusions:

The proposed reliability gradient flow was able to decode the contributions of within- and between-individual variability to reliability. We demonstrate the utility of the reliability gradient flow for comparing the reliability across fMRI conditions. Compared to rest, the engaged paradigms and hybrid FC offer an improvement of test-retest reliability. Our results suggested that reliability field map can serve as a general framework for characterizing the individual variabilities and provides insights into the neuroimaging design for optimizing the reliability.

Modeling and Analysis Methods:

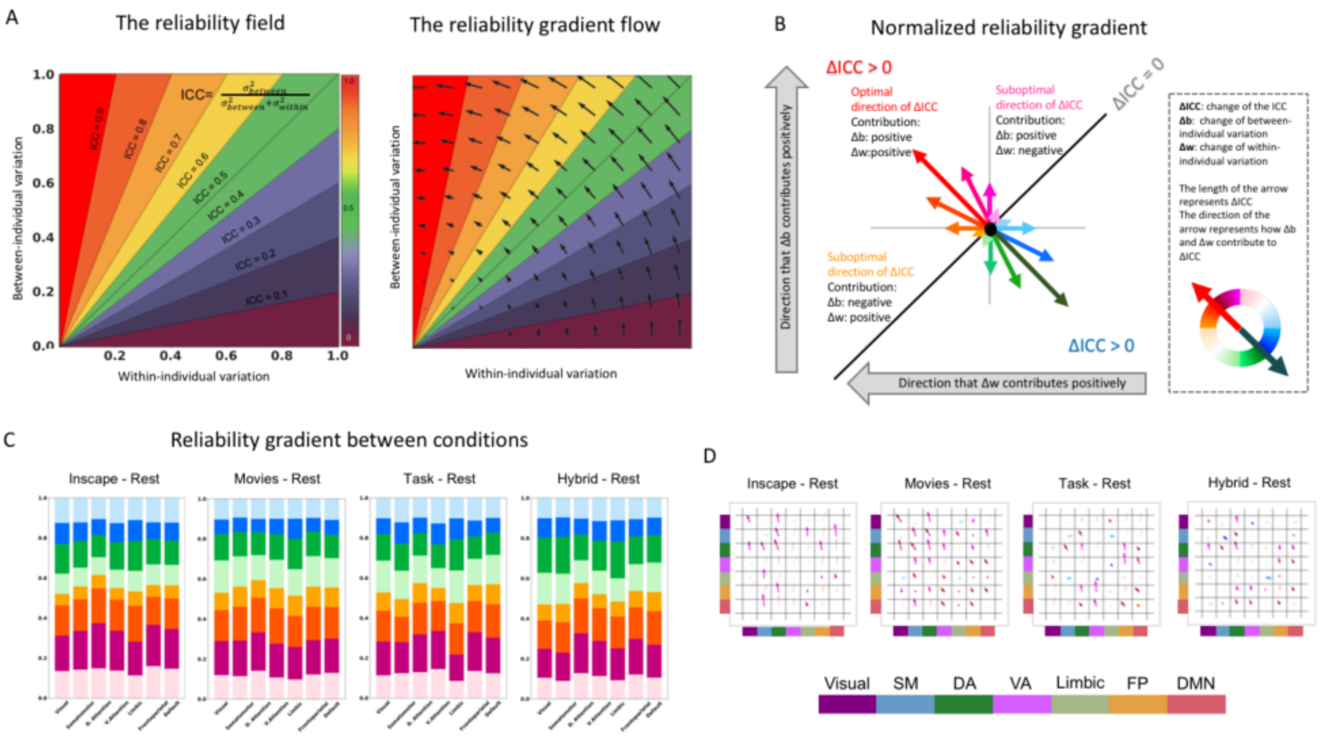
Connectivity (eg. functional, effective, structural) [2]
Methods Development [1]
Task-Independent and Resting-State Analysis

Keywords:

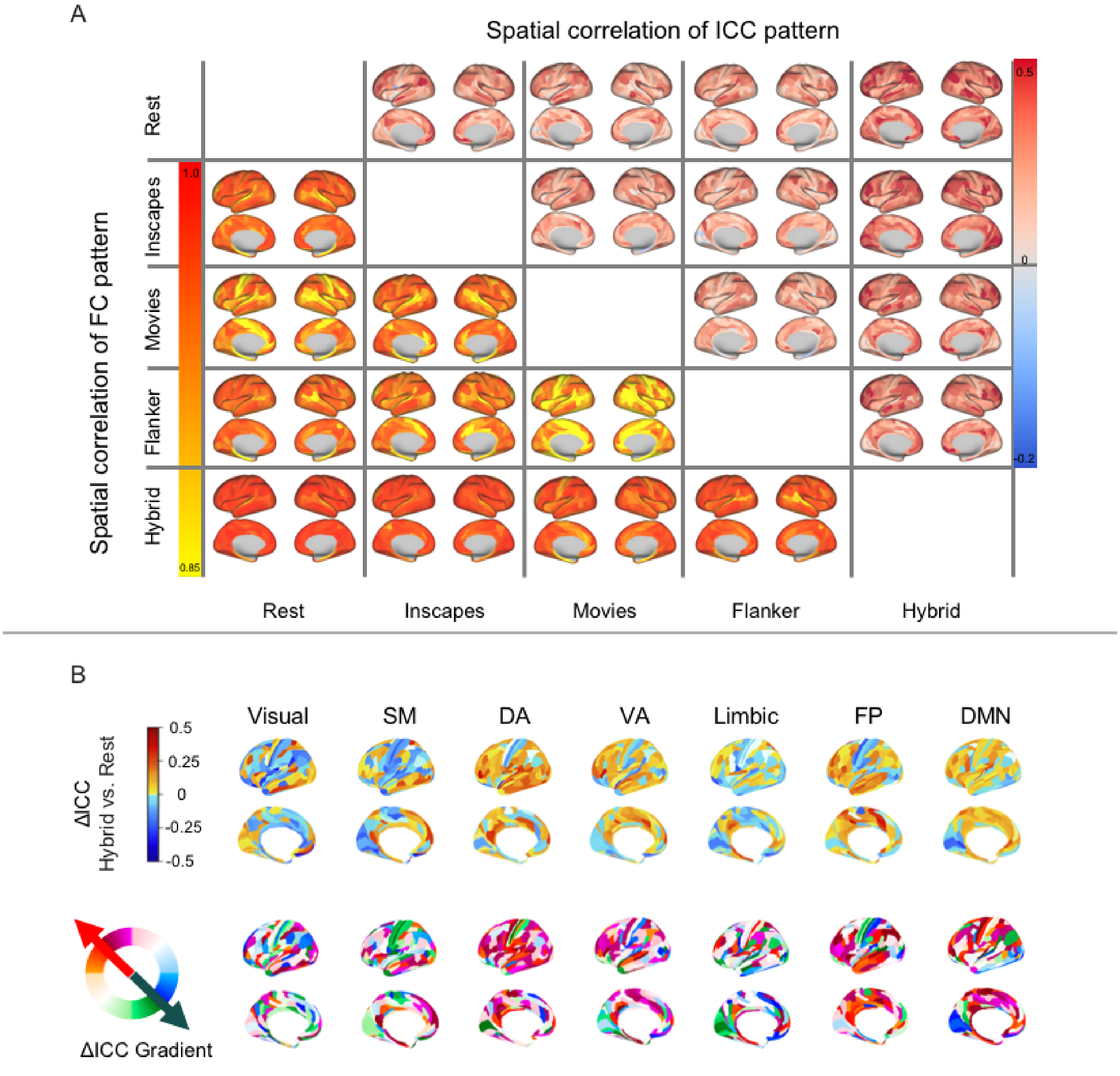
FUNCTIONAL MRI

Other - Reliability, General functional connectivity, Naturalistic viewing, Resting-state

[1|2]Indicates the priority used for review



·Figure 1



·Figure 2

My abstract is being submitted as a Software Demonstration.

No

Please indicate below if your study was a "resting state" or "task-activation" study.

Resting state
Task-activation

Healthy subjects only or patients (note that patient studies may also involve healthy subjects):

Healthy subjects

Are you Internal Review Board (IRB) certified? Please note: Failure to have IRB, if applicable will lead to automatic rejection of abstract.

Yes

Was any human subjects research approved by the relevant Institutional Review Board or ethics panel? NOTE: Any human subjects studies without IRB approval will be automatically rejected.

Yes

Was any animal research approved by the relevant IACUC or other animal research panel? NOTE: Any animal studies without IACUC approval will be automatically rejected.

No

Please indicate which methods were used in your research:

Functional MRI

For human MRI, what field strength scanner do you use?

3.0T

Provide references using author date format

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