# Developing a gradient flow framework to guide the optimization of reliability for the study of individual differences

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Most updated poster at www.github.com/jae7cho/ohbm2020

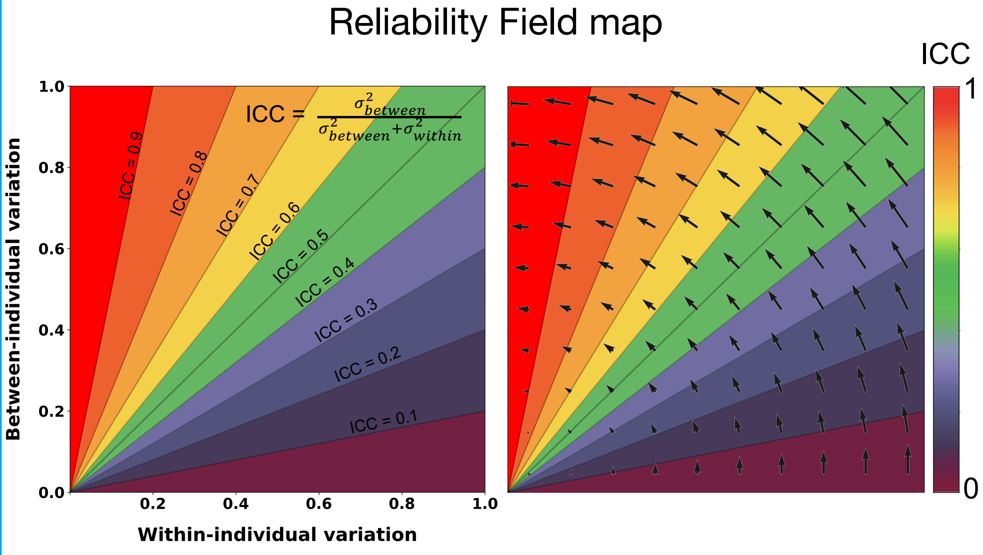
## Introduction

Understanding within- and between-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 (intraclass correlation [ICC]). 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 then apply this approach to fMRI data and compare reliabilities of functional connectivity (FC) under four scan conditions: task-free resting, naturalistic viewing of low engaging video (i.e., Inscapes), naturalistic viewing of higher engaging movies, and cognitive task performance (i.e. flanker task) as well as a 'hybrid' or 'general' functional connectivity (generated by combining four fMRI data in equal amounts).

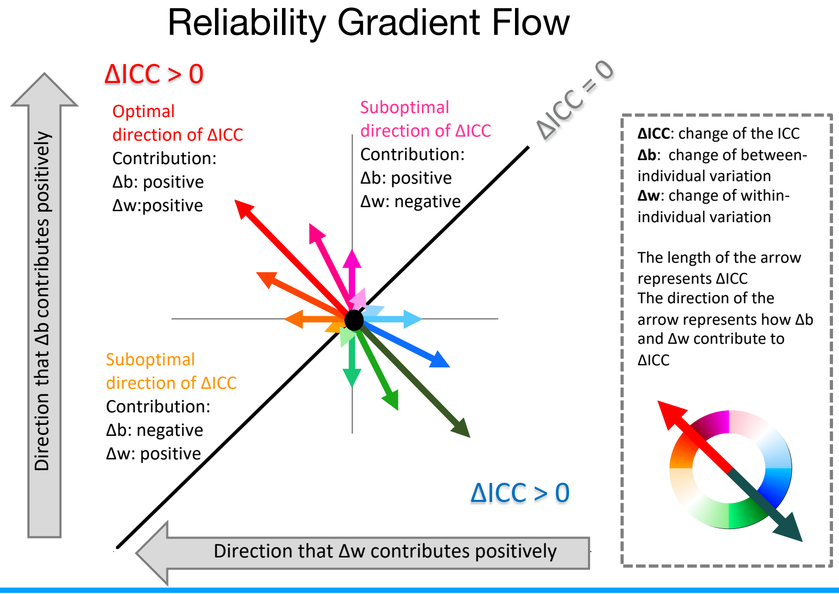
## Methods

We used the Serial Scanning Initiative (HBN-SSI) fMRI data, consisting of 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). Field maps were created by mapping the within- and between-individual variability along the x- and y-axis respectively. 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. To calculate ICC, within- and between individual variability was estimated in the linear mixed model for each FC edge.

## Figure 1

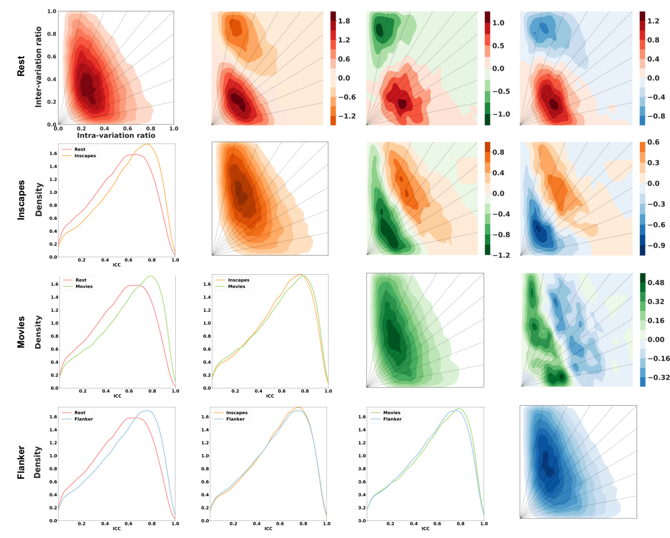



Left: Reliability field map is shown along with corresponding values of ICC. Right: An ICC increase of 0.05 is shown by arrows on the field map. The optimal direction for change in ICC with respect to increase in between-individual variation and decrease in within-individual variation is dependent on the original ICC.



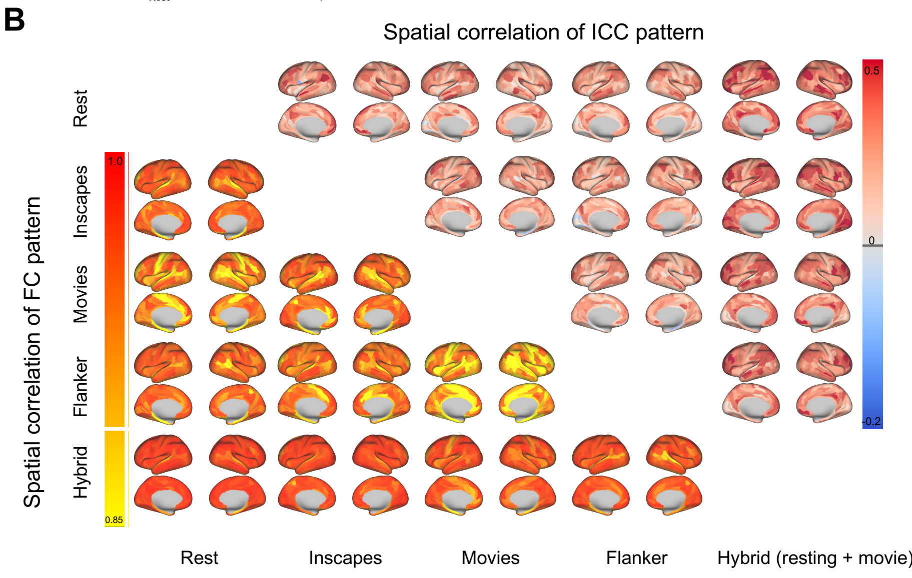

## Figure 2

**A** ICC distribution of FC across conditions



ICC of FC field map of each condition is plotted on the diagonal. Plotting both within- and between-individual variation show how these sources of variation affect differences in ICC between conditions (upper triangle). Differences in overall ICC between condition are shown in the lower triangle.

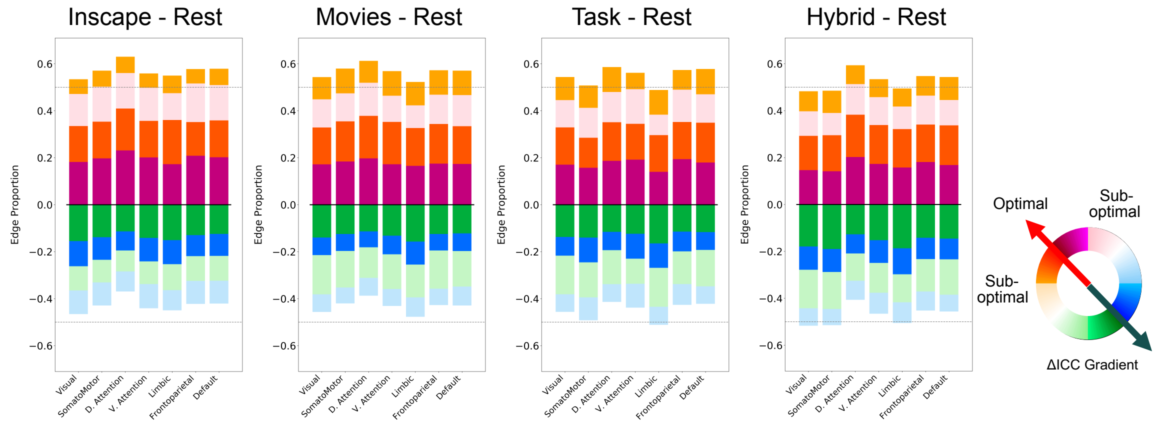
**B** Spatial correlation of ICC pattern



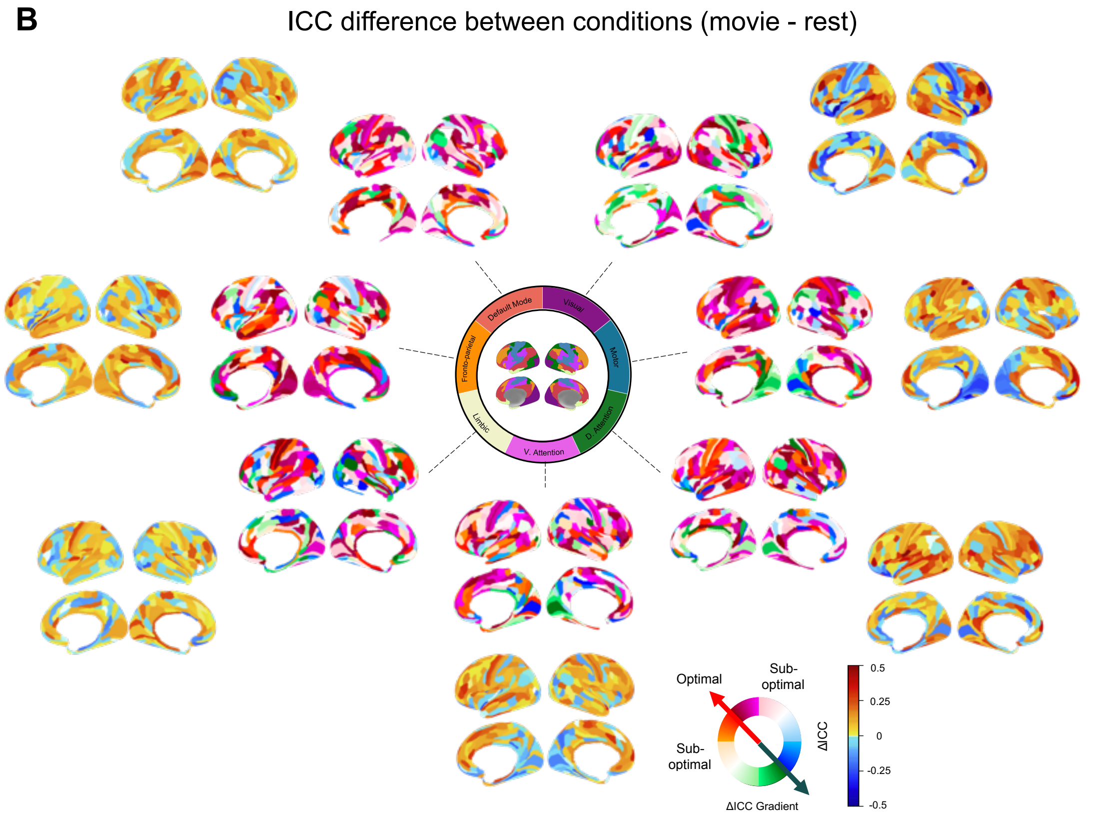

Spatial pattern of FC at each parcel (lower triangular) exhibited high similarities across conditions (*r>0.85*), while spatial pattern of ICC in FC (upper triangular) yielded a relatively low similarity across conditions (r<0.5)

## Figure 3

**A** Reliability gradient between conditions




**B** ICC difference between conditions (movie - rest)




## Results:

Field maps showing differences in ICC and within- and between-individual variation are shown in Figure 2A. Consistent with prior findings, FC showed substantial spatial similarity across four fMRI paradigms and the hybrid data appeared to capture the general FC (Fig. 2B), regardless of scan condition. However, spatial patterns of ICC were relatively dissimilar between conditions. Reliability gradient flow distinguished between the impact of within- and between-individual variability on the ICC differences. When compared to rest, the ICC changes obtained for FC in the other conditions (movies, Inscapes, task, hybrid) were mostly in the optimal direction as shown in Figure 3A (59.9% ± 3.71%); these differences were attributed to between-individual variability more than within-individual variability across all the networks (within: 27.3%, between: 12.9%). Notably, increase in ICC were not a general phenomenon for each FC. Among 17.6% (SD=0.67%) of connections that exhibited significant differences ICC between rest and other conditions, 29.4% (SD=1.61%) FC exhibited higher ICC for rest, with more between-individual variability contributions to these changes. Mean differences in gradient flow angle values along with ICC difference for each parcel are shown for movies vs resting conditions in Figure 3B.

## Conclusion

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.

**References**

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