Assessing functional connectivity beyond Pearson's correlation

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Background

Functional connectivity (FC) is defined as the temporal coincidence among neurophysiological events (Friston, 1994), which can be measured by the statistical dependency of recorded signals between two regions. In fMRI studies, Pearson's correlation is commonly used to measure the FC. In fact, it appears to have become the "synonym" of FC in the field. However, it is worth noting that Pearson's r is only one of many statistical dependency measures and it limits its ability to a linear relationship. Recently, a statistical model - Multiscale Graph Correlation (MGC) was developed for testing the dependency of time series (Vogelstein et al., 2019). Unlike Pearson's r MGC enables characterizing the linear and nonlinear relationship between two time series and provides the optimal scale to infer the linear and nonlinear dependency. Here, we used MGC as our dependency measurement to assess the FC and to examine the linear and nonlinear relation of fMRI signals in humans and macaque. We focus on homotopic connectivity as it is the general large scale phenomenon of brain organization across species.

Methods

We selected 22 participants from the Human Connectome Projects (HCP, resting-state fMRI 300 volumes) and one macaque sample including awake and various anesthetized states (720 volumes per state). We first parcellated the human and macaque data using Glasser et al. (2016) and Markov et al. (2014) parcellation, respectively. We used MGC and Pearson's r to measure the homotopic connectivity. Finally, we computed the optimal scale to examine the linear and nonlinear nature of homotopic FC in both human and macaque across multiple states

Results

Compared to Pearson's, the MGC-based homotopic connectivity showed similar spatial distribution across human and macaque cortex, suggesting the linear relationship might dominate the connection strength. The optimal scale of MGC in humans showed a local to global gradient along the anterior and posterior axis, indicating the nonlinear homotopic connection in the anterior brain. Intriguingly, the primary cortex (e.g. visual, auditory somatomotor) exhibited the nonlinear dependence in anesthetized states.

Conclusions

Using MGC, we characterized the linear and nonlinear homotopic functional connectivity in both human and macaque. Our results open up new directions to measure the FC and infer its linear and nonlinear relationships, facilitating our understanding of brain organization across different states and species.

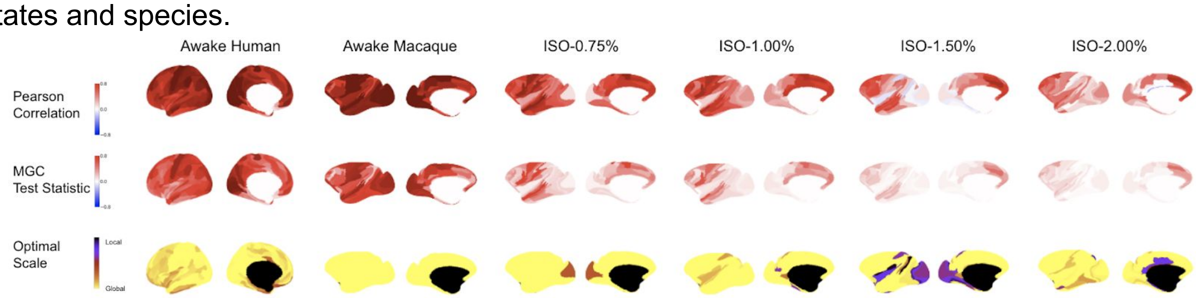

Figure1. Human and Macaque Homotopic Connectivity