Optimal Distances for Edge-Wise Reliability in the Functional Connectome

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Summary

Background: Functional connectivity is one of the most important measurement techniques of the human brain. Recently, the field of neuroimaging has focused issues of reliability and reproducibility of the functional connectome[1]. While Pearson's correlation is the commonly used to assess the relationship between the functional timeseries in different parts of the brain[2], relatively little is known about its reliability compared to other commonplace distance metrics.

Current work: In the current work we conducted an extensive evaluation of the univariate reliability of eight commonplace distance metrics. We assessed the differences in reliability of these distance metrics across a different atlas resolutions, scan times, and sparsity levels. We examined the cortical spatial variability of functional connectivity and ICC between the 10 atlases for each distance metrics as well.

Results: We found that Pearson's correlation had significantly lower edge-wise ICC than other distance metrics, and these differences were exacerbated by higher numbers of regions in an atlas, greater scan time, and thresholding all but the top 5% of edges.

Conclusions: Spatial distribution of mean connectivity and ICC is highly conserved across distances. Pearson's correlation seems suboptimal for maximizing edge-wise ICC. Further evaluation is required.

Approach

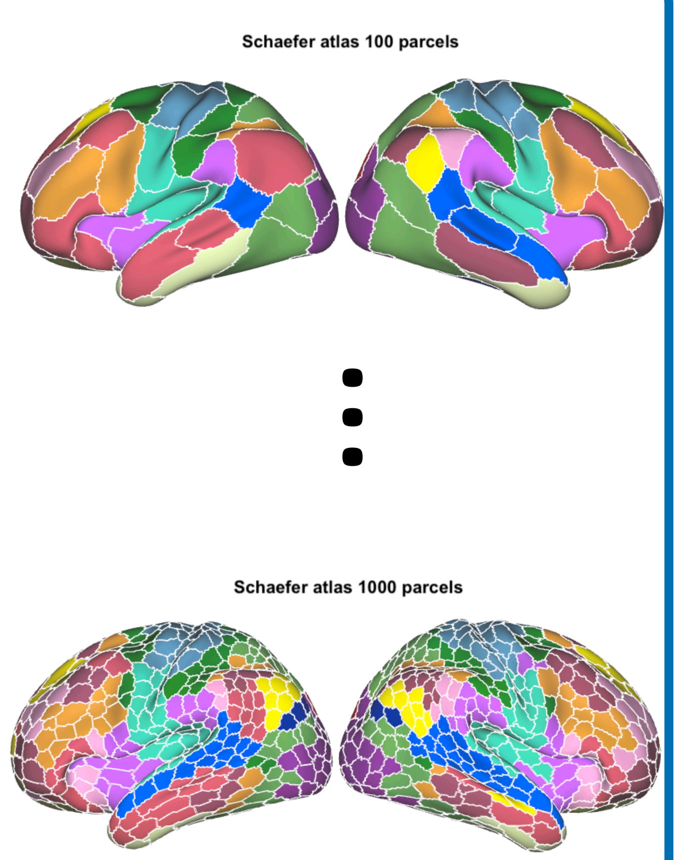
Data: HNU1 Test Retest[3]: 30 young adults; Ten, 10 min rs-fMRI.

C-PAC Preprocessing: Skull stripping with AFNI. preprocessed to 2mm, White matter and CSF regression. No GSR, bandpass filtering 0.01-0.1, CompCor- 5 component. White matter and CSF regression, Spike regression.

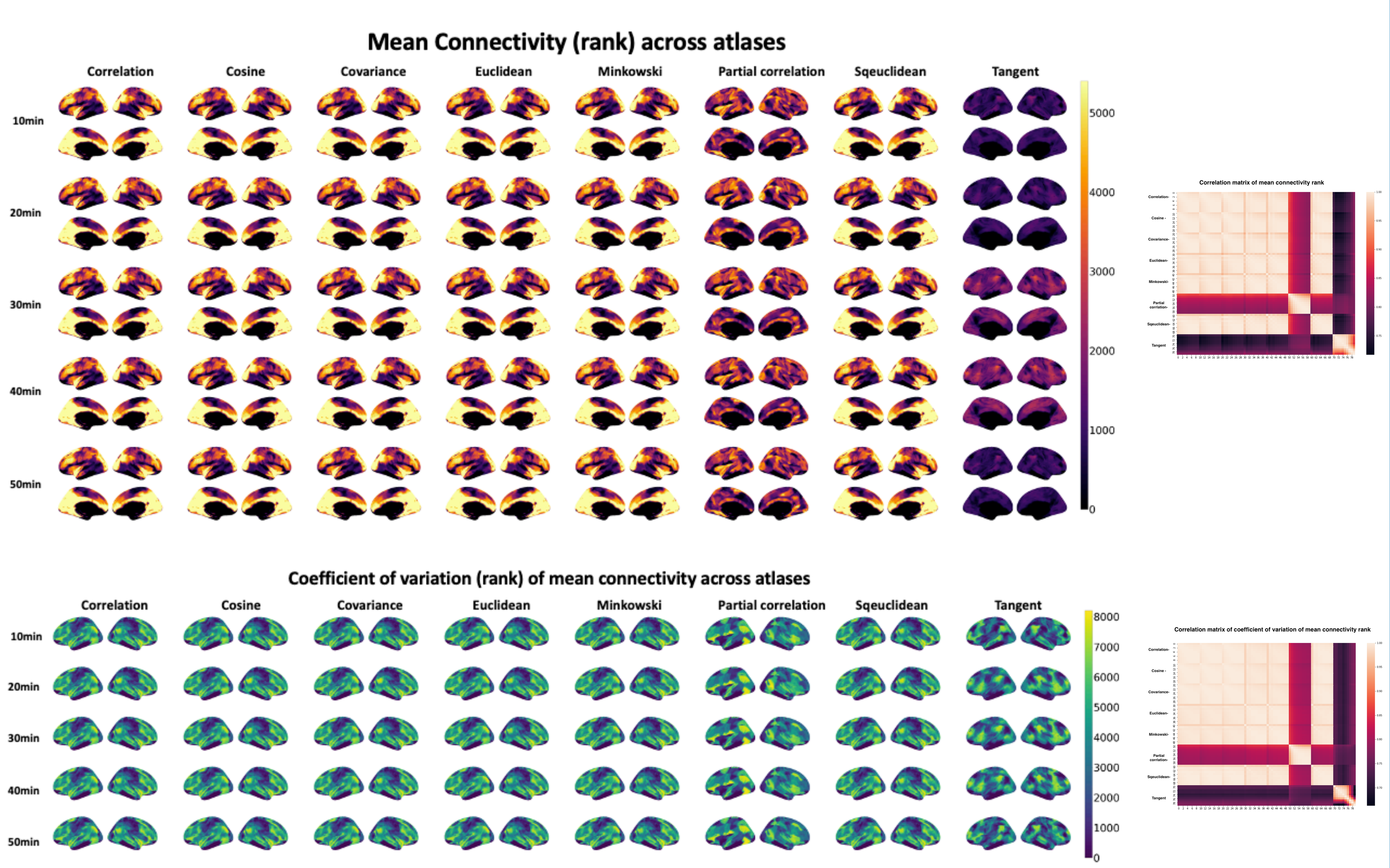
Data Extraction: 10 sessions were concatenated into test and retest datasets with 5-50 minutes of scan time in 5-minute increments. Timeseries were extracted for the ten 100-1000 region Schaefer atlases[4] in volume space in increments of 100 regions.

Distance Metrics: Scipy was used to derive our library of distances, including: Pearson's correlation, cosine, covariance, Euclidean, Minkowski, partial correlation, squared Euclidean, tangent correlation. All distances were standardized and subtracted from 1 to create a corresponding similarity metric.

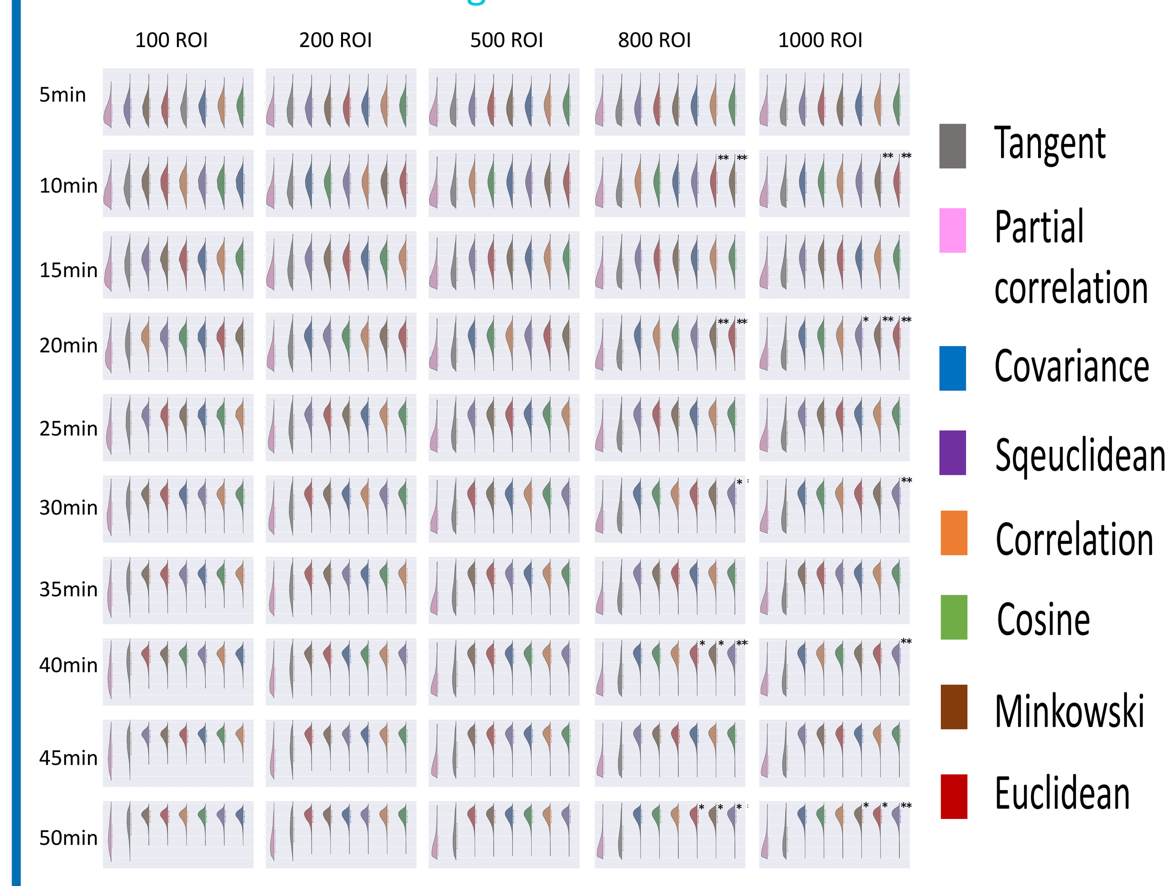
Reliability: We assessed univariate reliability of the individual edges through intraclass correlation coefficient (ICC)[5]



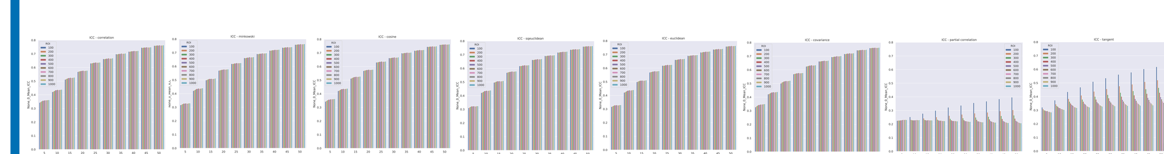
Mean Connectivity and Coefficient of Variability Across Atlases



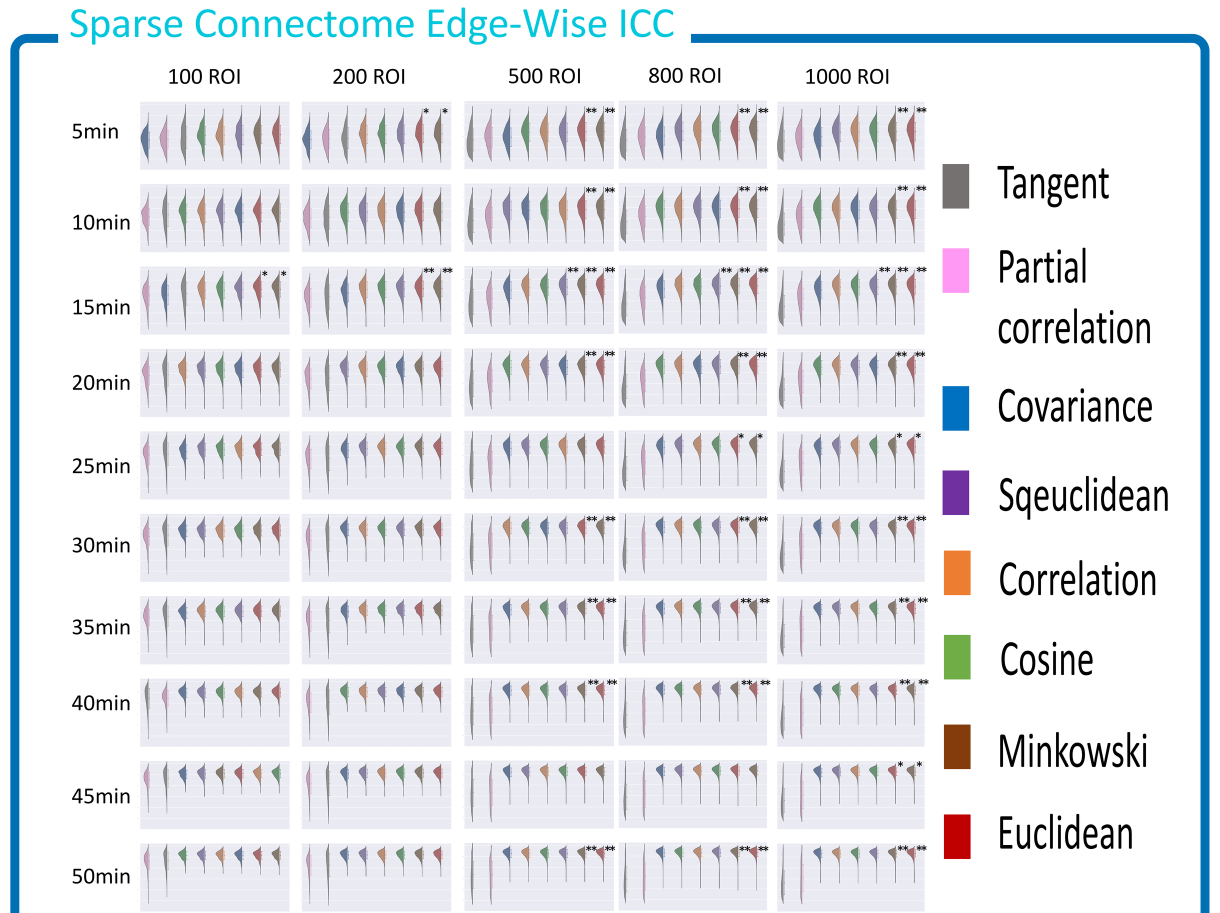
Dense Connectome Edge-Wise ICC



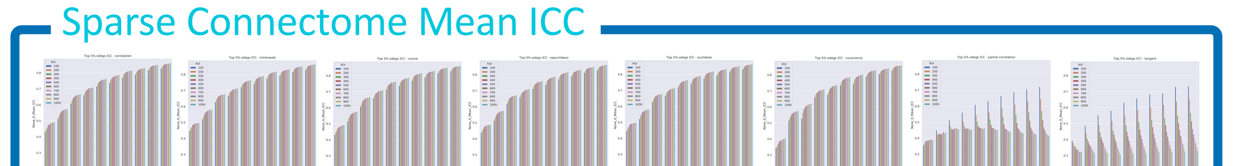
Dense Connectome Mean ICC



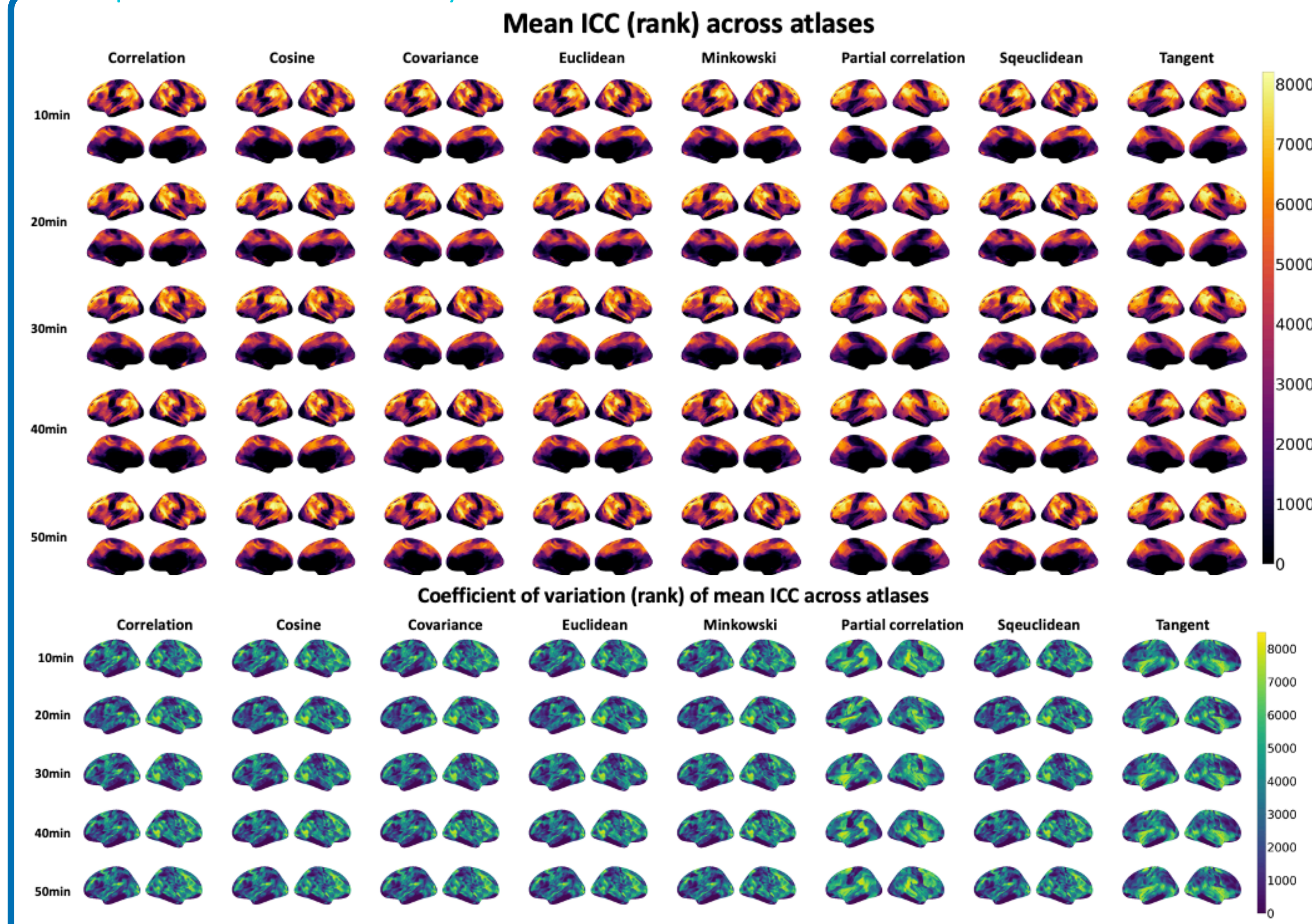
Sparse Connectome Edge-Wise ICC

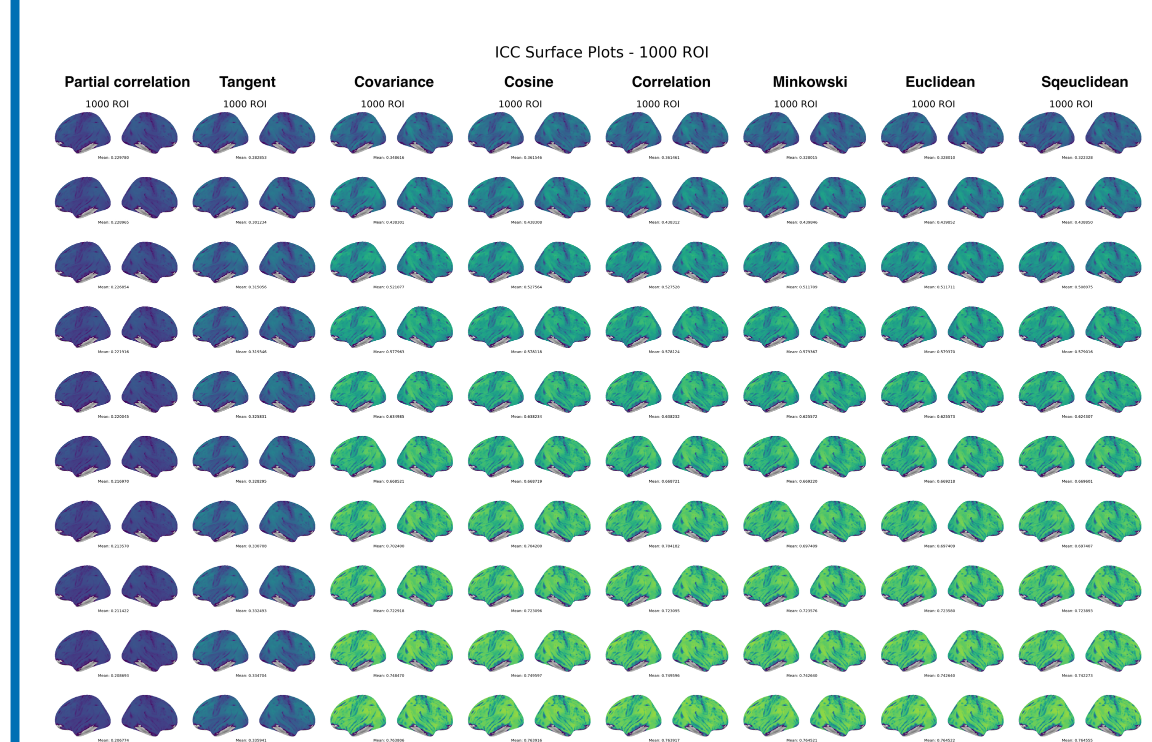


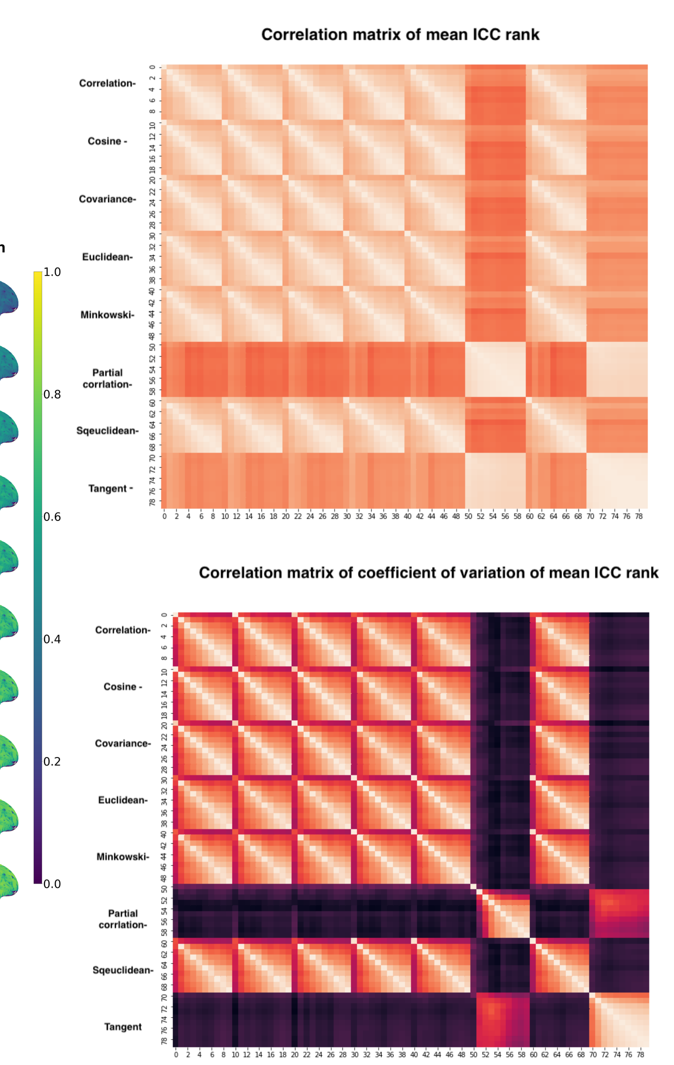
Sparse Connectome Mean ICC



Spatial Distribution of ICC by Time and Distance







References

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Conclusions

- Euclidean, Minkowski, Squared Euclidean, and Cosine distances tend to outperform Pearson's correlation with respect to univariate edge-wise ICC
- Univariate methods perform quite differently compared to univariate approaches (Partial & Tangent Correlation
- Spatial distribution of mean connectivity and ICC highly conserved
- Node-wise heterogeneity in connectivity and ICC highly conserved
- Longer scans and greater numbers of ROIs associated with higher ICC
- Highest node-wise ICC heterogeneity: Lingual Gyrus, Temporal Fusiform Cortex, Occipital Pole, Cingulate Gyrus, Middle frontal gyrus, Frontal Pole