Examining brain dynamics associated with trait rumination using video self-reflection

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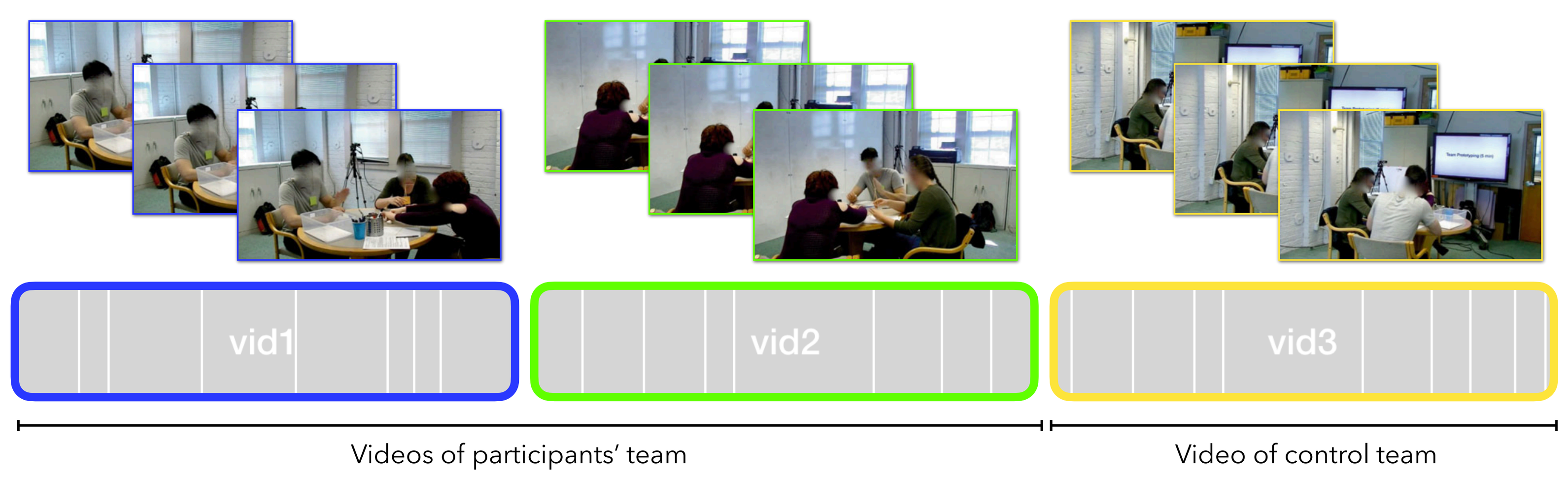
Motivation

The tendency towards repetitive negative thought about one's own affective state (rumination) has adverse effects on well-being and cognition.[1] To study the neural bases associated with trait rumination, we characterized whole-brain fMRI dynamics while individuals watched and reflected on recordings of their own previous social interactions.

Data

Naturalistic video self-reflection fMRI paradigm

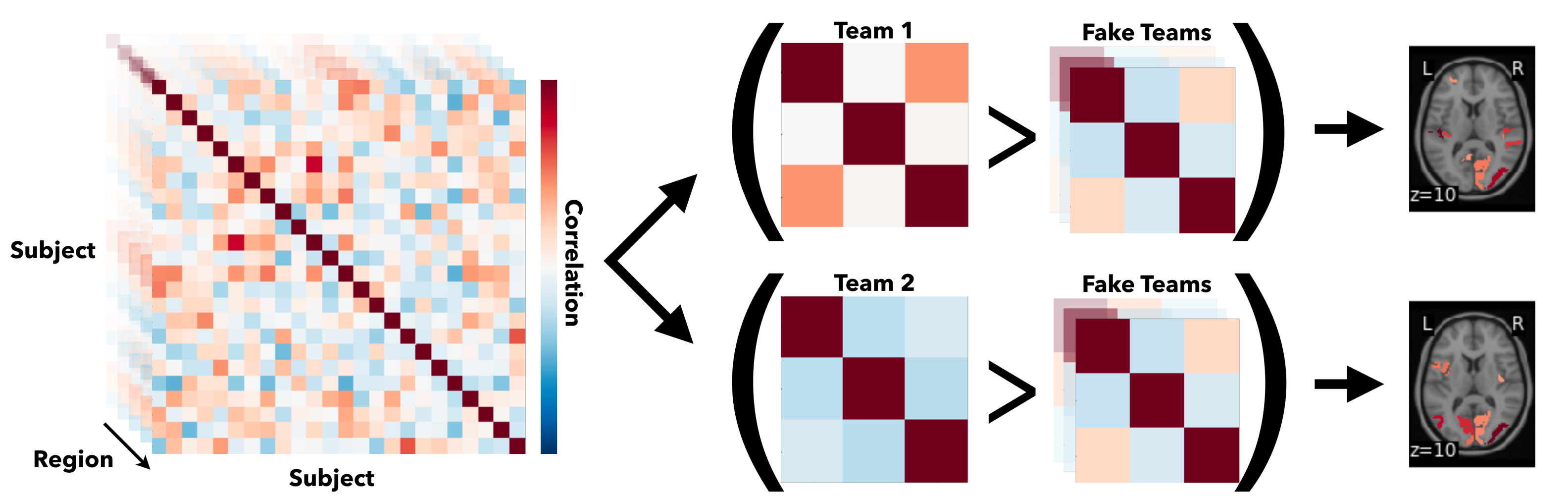
Freely watching videos from a prior team creativity session (brainstorming only)
Total Duration: 300s x 3 + 12s x 2 = 924 s = 15.4 min

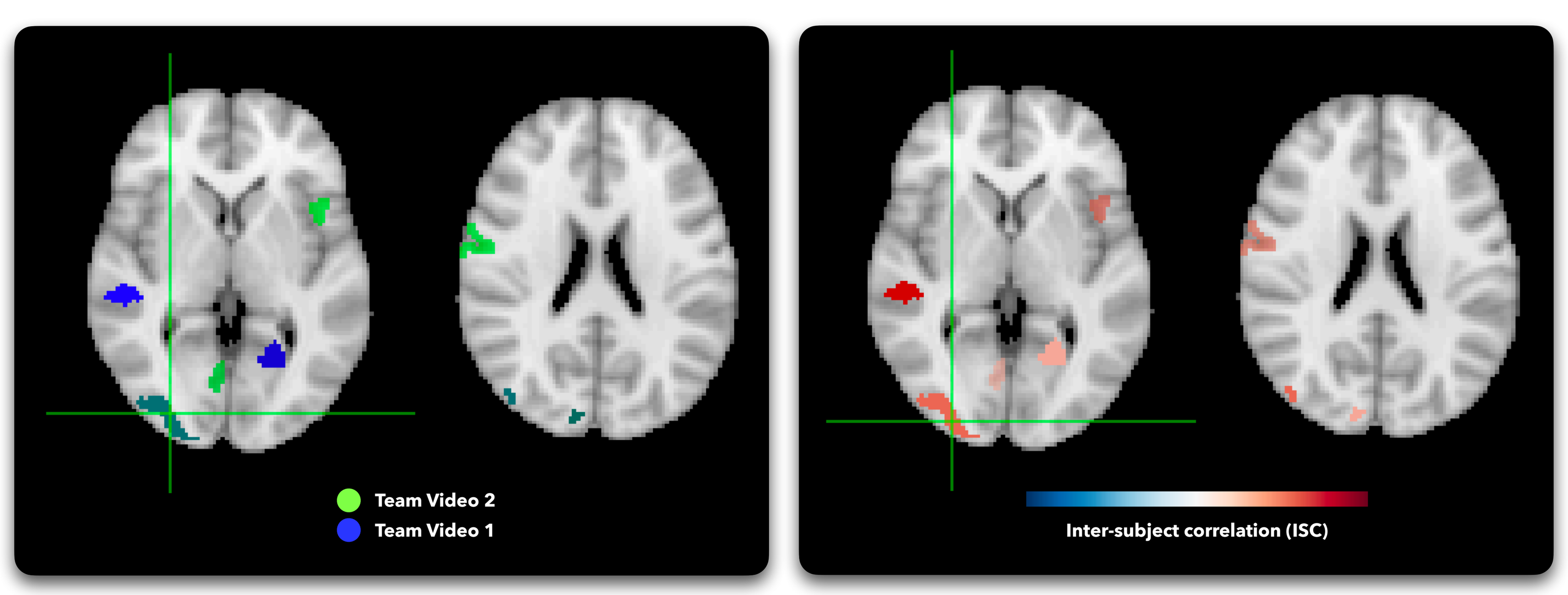


- Functional data from 32 participants acquired on a 3 Tesla MRI scanner (TR = 0.71 s).
- Average time-series were extracted from 375 ROIs after standard fMRI data processing.
- Behavioral data includes scores from the Rumination Reflection Questionnaire.

Results

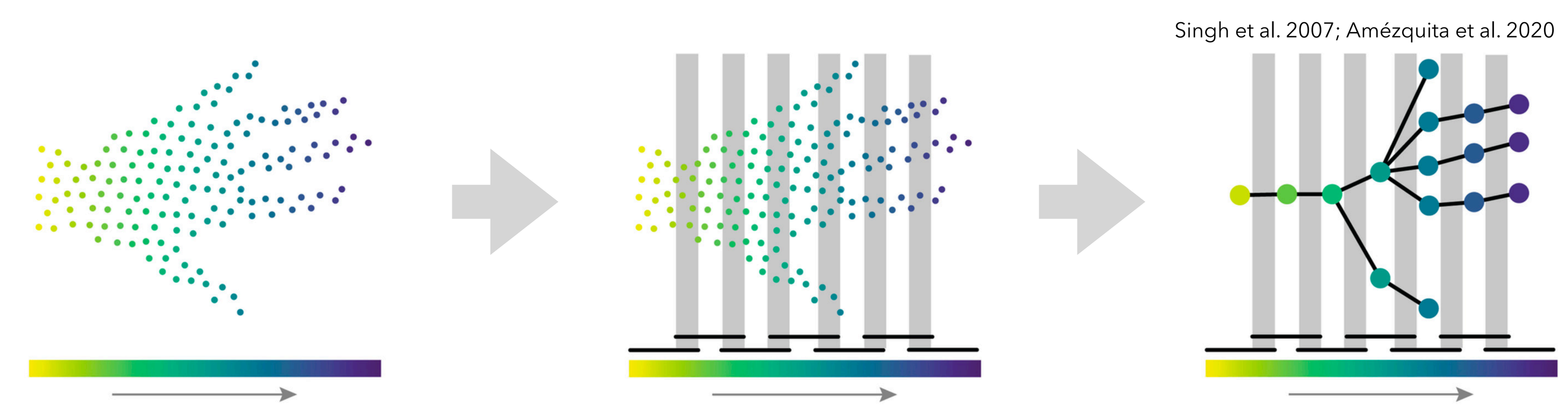
Inter-subject correlation within teams during self-viewing





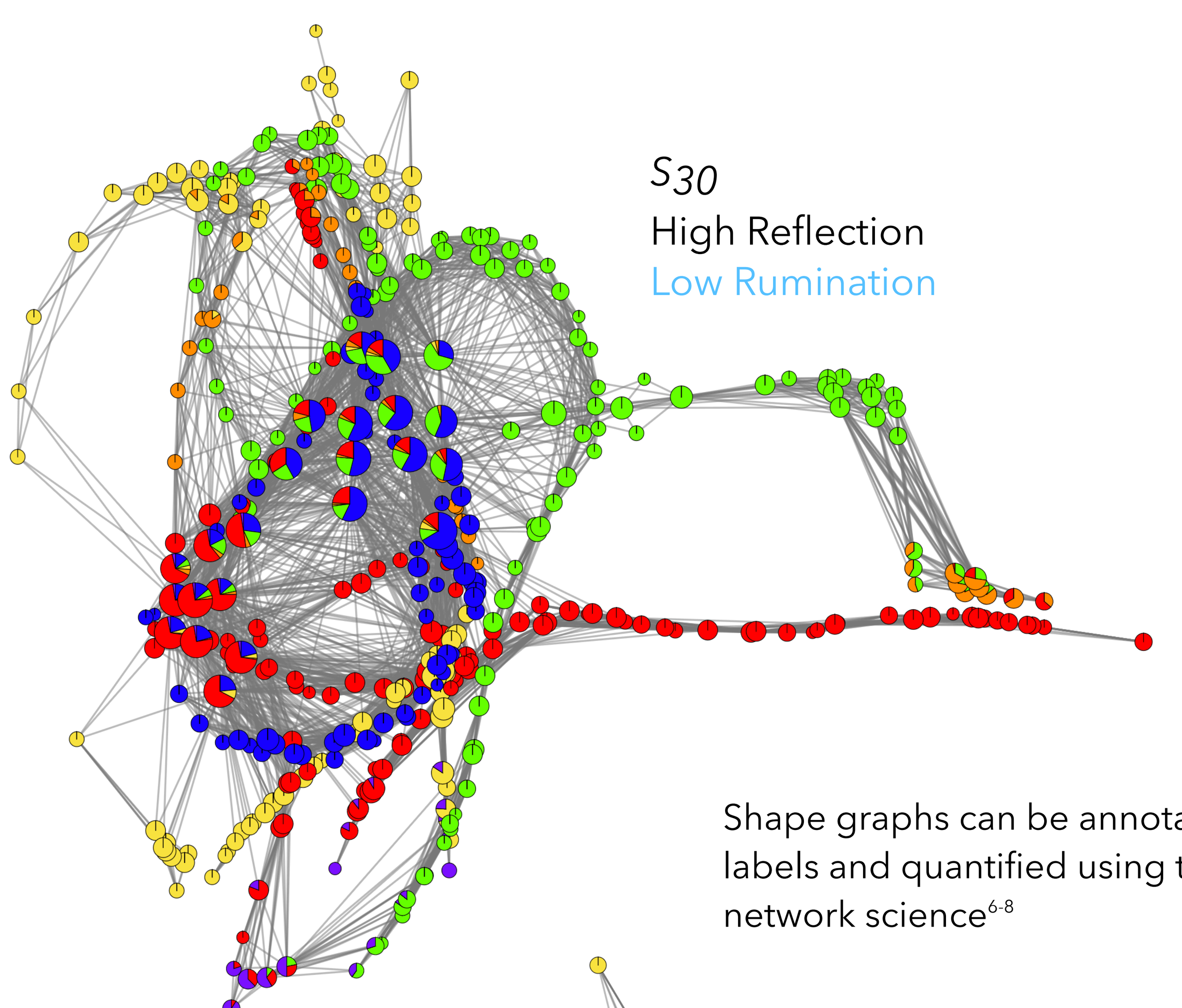
Triadic ISC revealed several regions (e.g., Insular Cortex, Occipital Pole) that were consistently synchronized across individuals from the same team—while viewing clips of their own team's previous brainstorming session.

Topological data analysis using Mapper

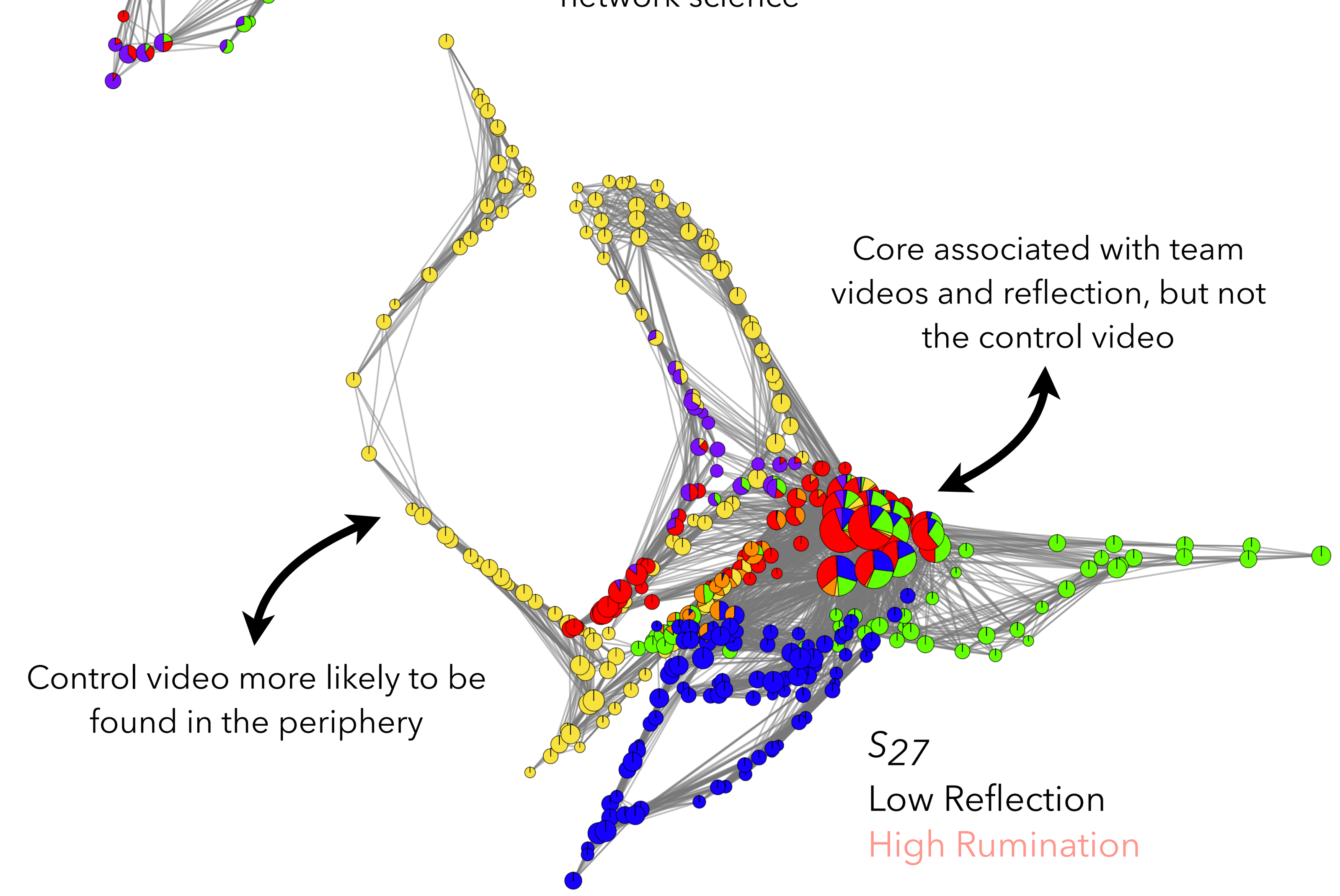


- Project data into lower-dimensional "lens"
- Bin points in low-dimensional space into overlapping sets
- Cluster points from each bin, in high-dimensional space
- Connect clusters by an edge if they have points in common

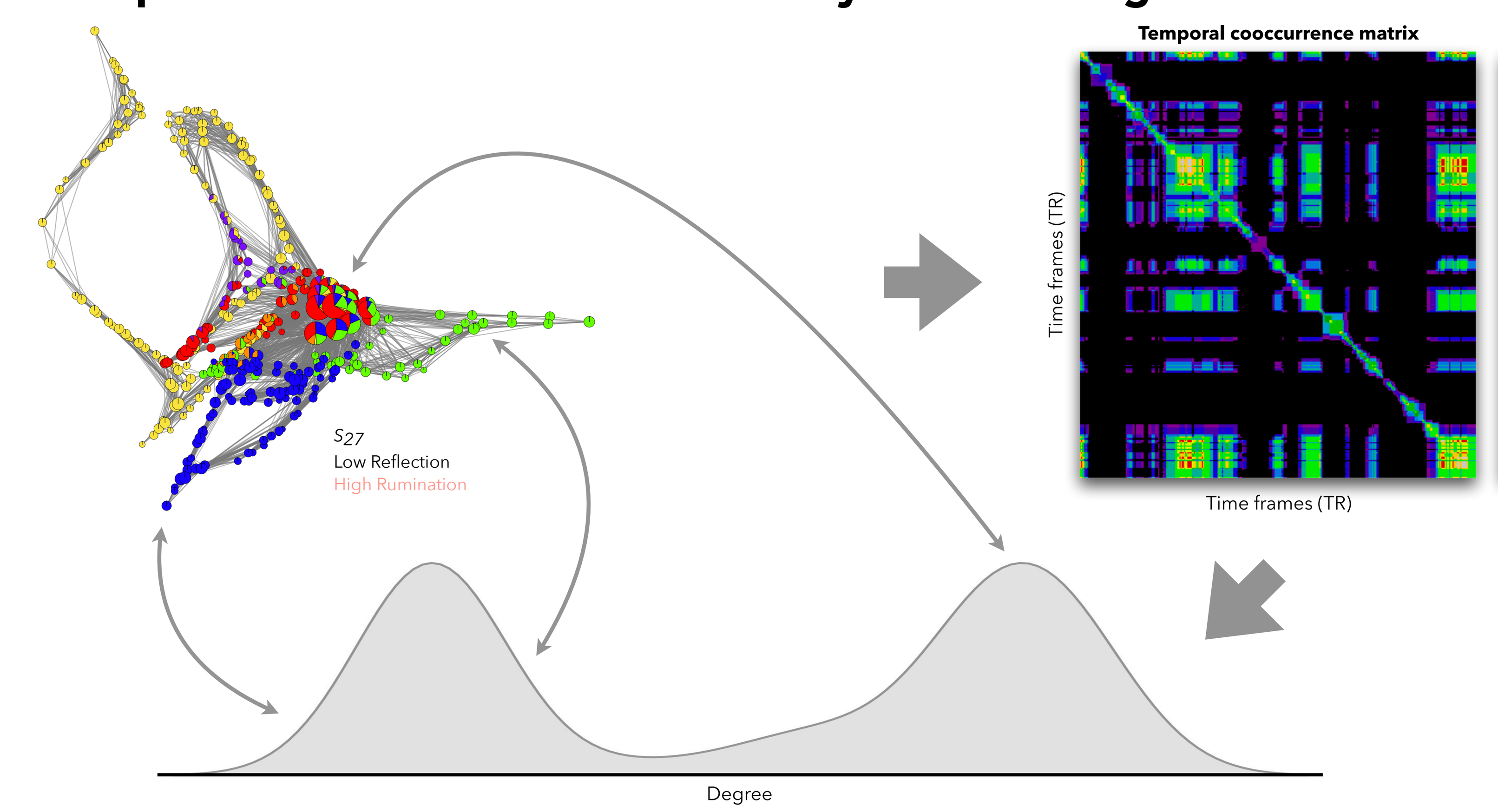
Mapper captures individual differences in whole-brain dynamics



Shape graphs can be annotated with labels and quantified using tools from network science[6-8]

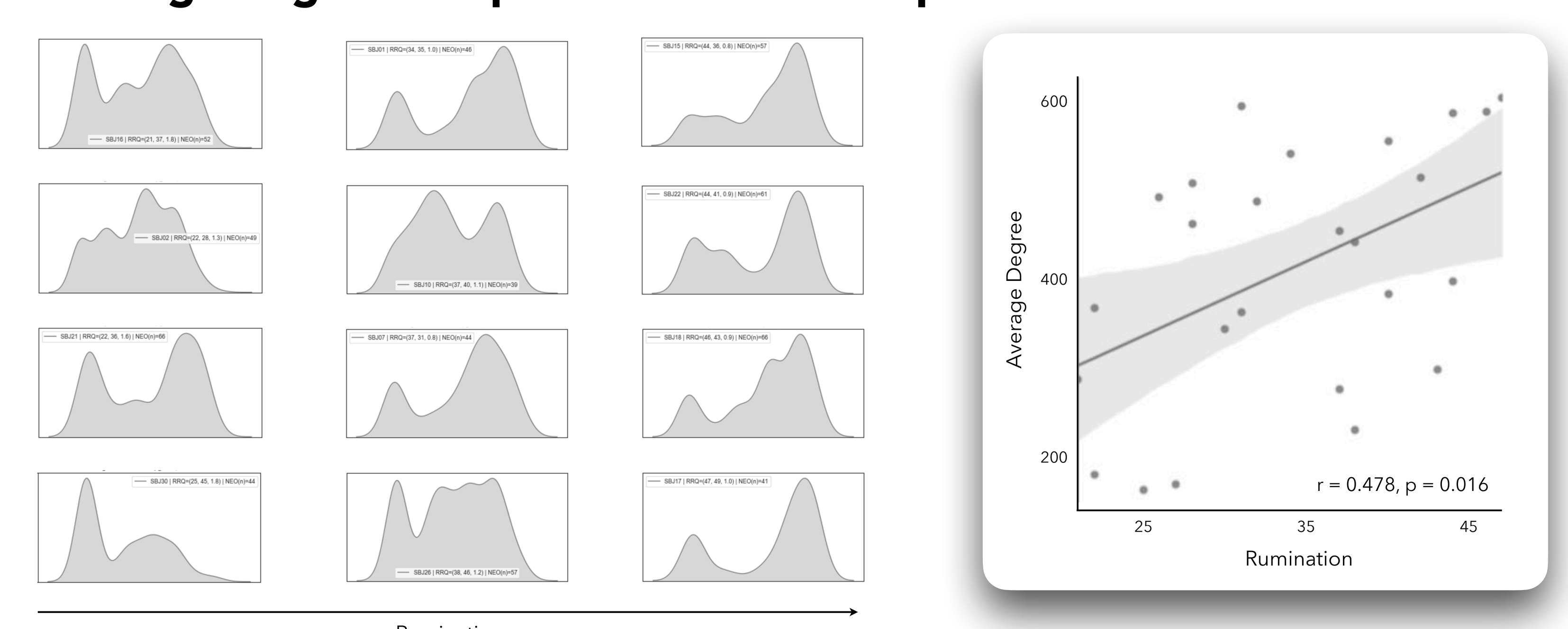


Temporal cooccurrence reveals "sticky" hubs during self-reflection



The temporal cooccurrence matrix quantifies the co-localization of similar time frames into one or more of the same nodes in the shape graph. The distribution of degree cooccurrence reveals the overall temporal similarity of an individual's data.

Average degree temporal cooccurrence predicts trait rumination



We hypothesized that more ruminative individuals may display lower variation in brain dynamics during recurrent thought, quantified here as having a higher number of higher degree time frames. Indeed, we found a significant positive correlation between average degree temporal cooccurrence in the shape graph and trait rumination.

Conclusion

We present a novel naturalistic fMRI paradigm for studying self-reflection where participants view and reflect on videos of their own previous social interactions. As initial validation, we report preliminary results from triadic ISC analysis which reaffirm and strengthen previous findings that the Insular Cortex is involved in self-reflection.[8] At the individual level, we extract novel insights using Mapper, namely that increased temporal similarity increases with trait rumination, suggesting that lower variability in brain dynamics could perhaps underlie ruminative processes more generally.

Going forward, we aim to more rigorously validate these preliminary results. To link the results from the team-level ISC and individual-level Mapper, we are exploring ways to run Mapper on concatenated data (i.e., across participants within the same team). Further down the line, we hope to extend our triadic ISC and Mapper-based analyses to other naturalistic datasets (e.g., three person fMRI hyper-scanning, Sherlock movie watching).

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