

Isolating the Pathways Critical for Speech Repetition with Connectome-based Lesion-Symptom Mapping in Stroke Induced Aphasia

Vatché Baboyan¹, Alexandra Basilakos², Brielle Stark⁵, Grigori Yourganov³, Roger Newman-Norlund³, Chris Rorden³, Leonardo Bonilha⁴, Julius Fridriksson², Gregory Hickok¹

¹Department of Cognitive Sciences, Department of Language Science, University of California, Irvine

²Department of Communication Sciences and Disorders, University of South Carolina

³Department of Psychology, University of South Carolina

⁴Department of Neurology, Medical University of South Carolina

⁵Department of Speech, Language and Hearing Sciences, Indiana University



Introduction

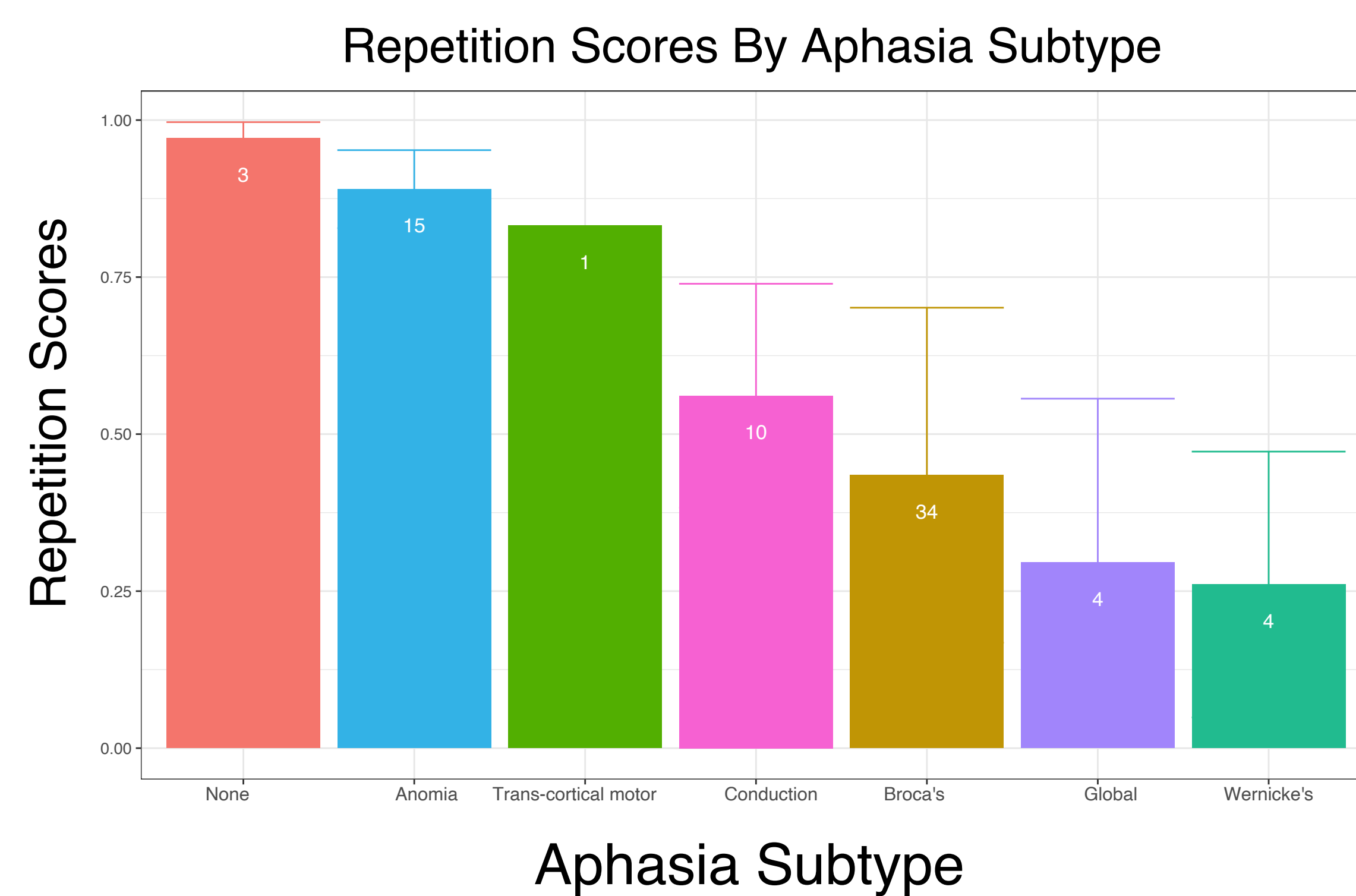
The neuroanatomical basis for speech repetition has long been a point of contention ever since classical neurobiological models of language were proposed in the late 19th century [1]. So-called “disconnection” accounts, whereby disruptions to the arcuate fasciculus prevents communication between anterior and posterior language sites [2], are still widely taught in textbooks today yet modern evidence in support of this claim is surprisingly lacking. There is increasing evidence that repetition is subserved by cortical substrates in perisylvian parieto-temporal areas [2].

Here, we mapped the structural connectome consisting of over 2000 unique connections in stroke-induced aphasic individuals and used algorithmic feature selection to isolate the connections predictive of repetition in a data-driven manner [3].

Methods: Behavioral

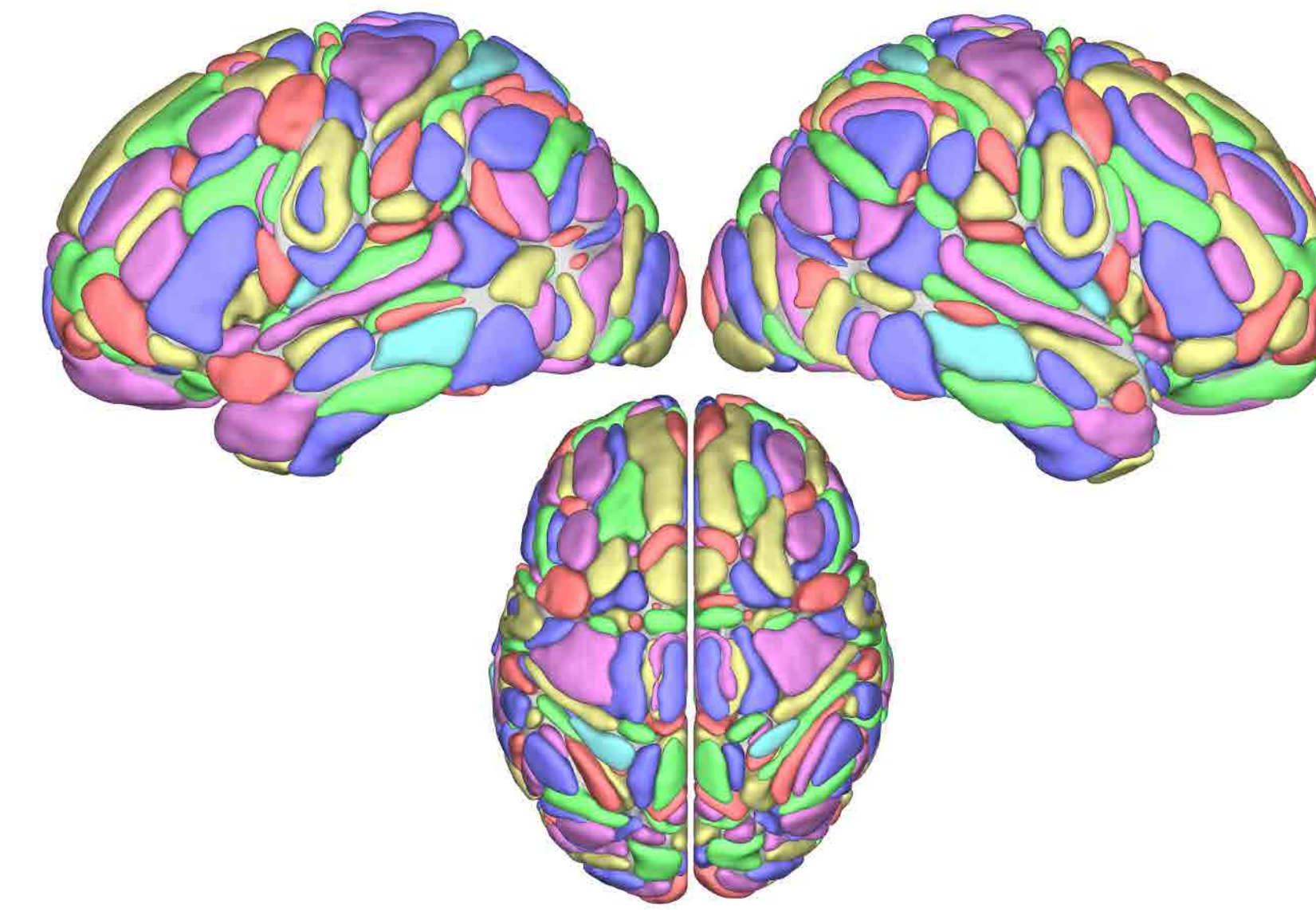
72 participants with stroke induced aphasia resulting from a single ischemic or hemorrhagic stroke to the left hemisphere were recruited.

Repetition ability was tested using the Philadelphia Repetition Test (PRT) and the repetition subtest of the revised Western Aphasia Battery (WAB-R). Features were visualized and then used to generate out of sample predictions.

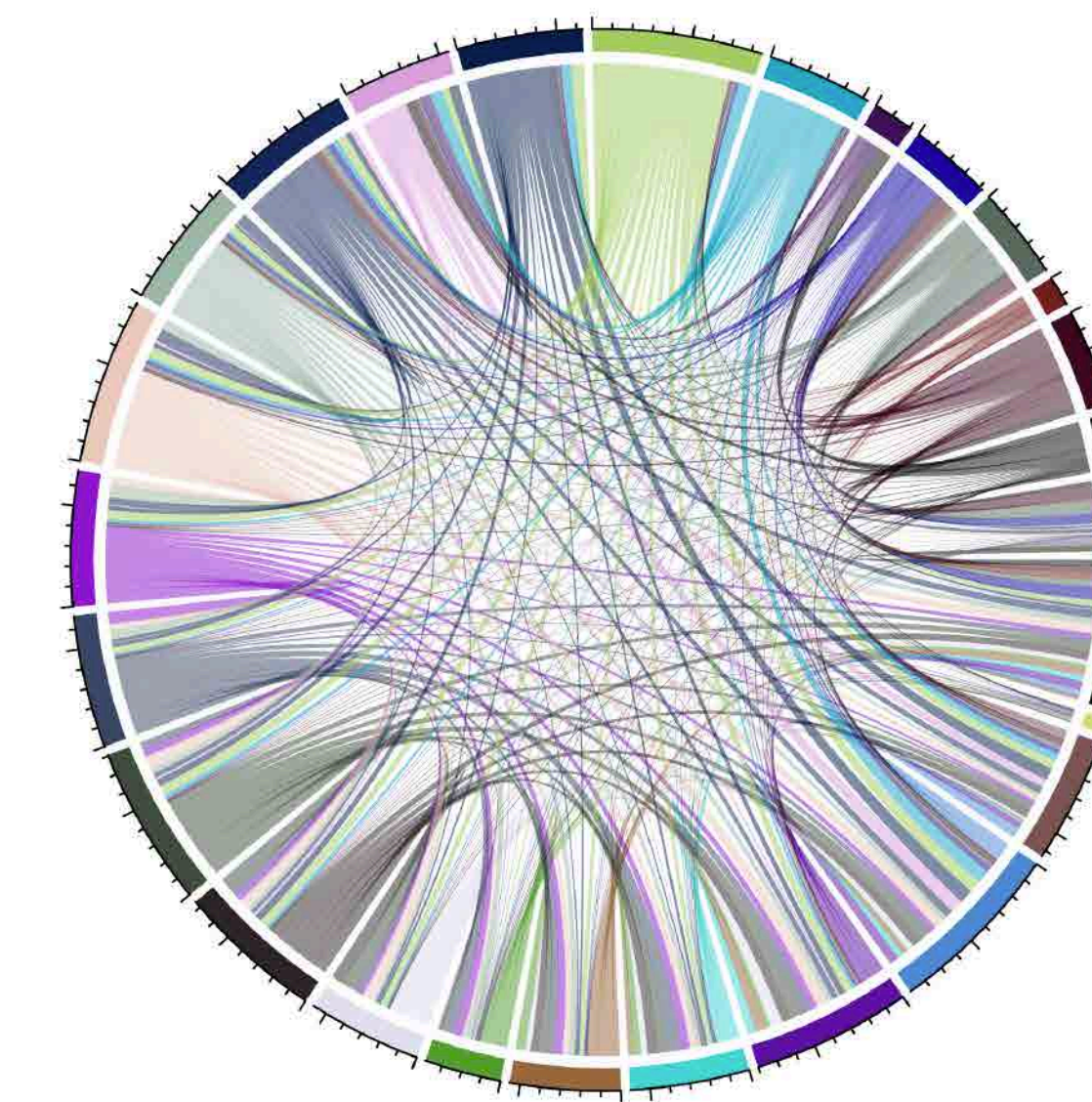


Methods: Connectome Mapping

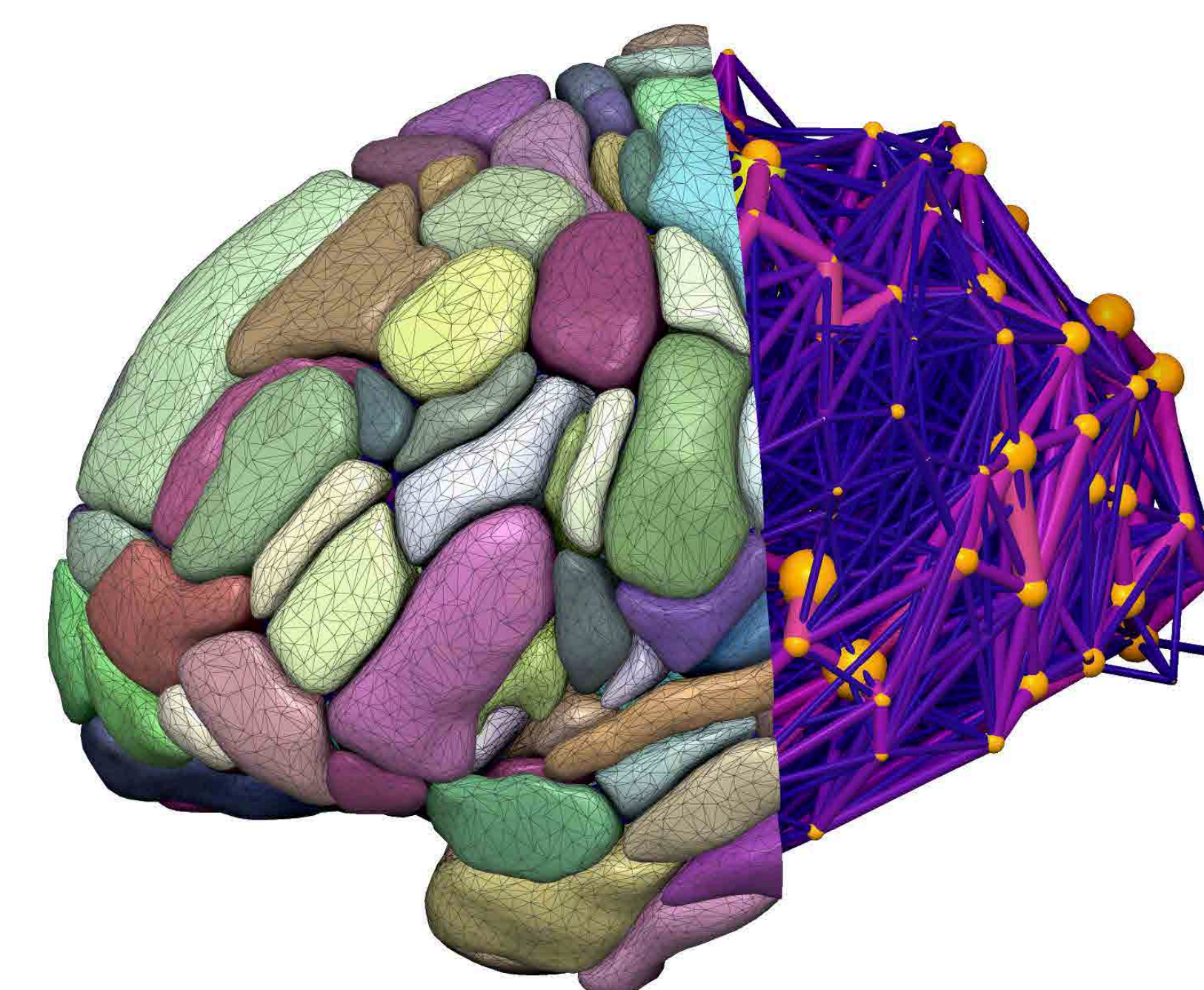
AICHA Atlas [5]



Pairwise Connections mapped using probabilistic tractography



Chord Diagram (Single Subject)

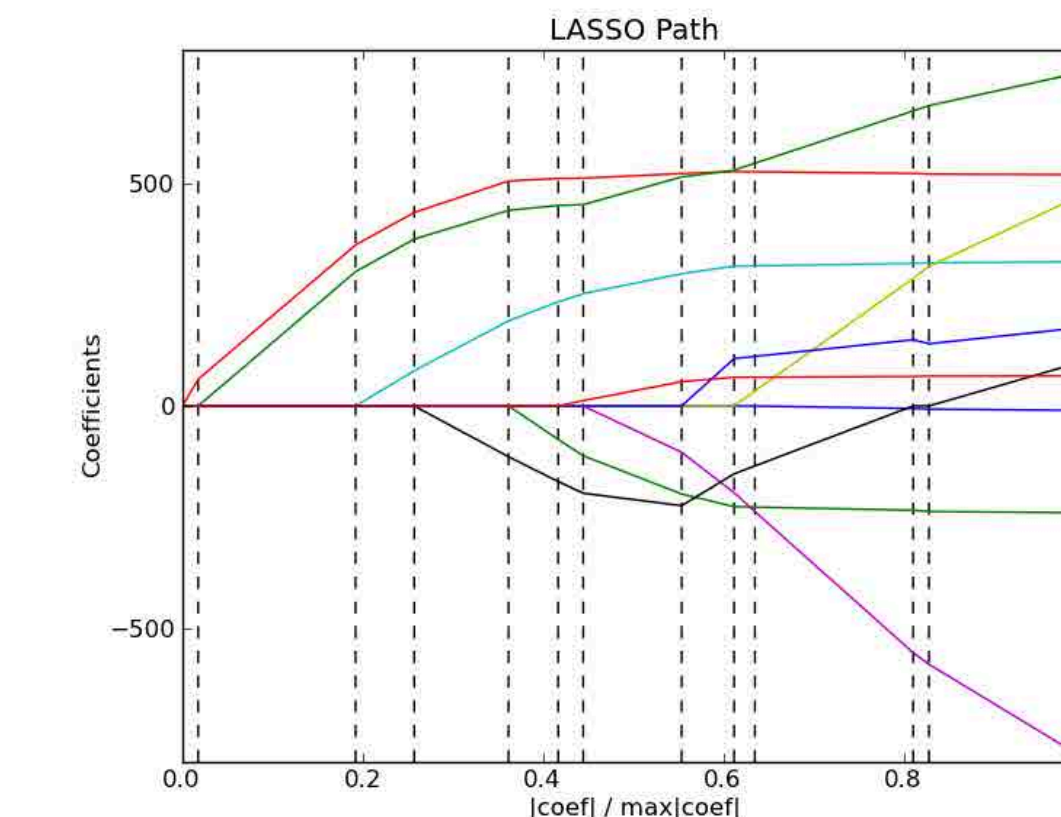
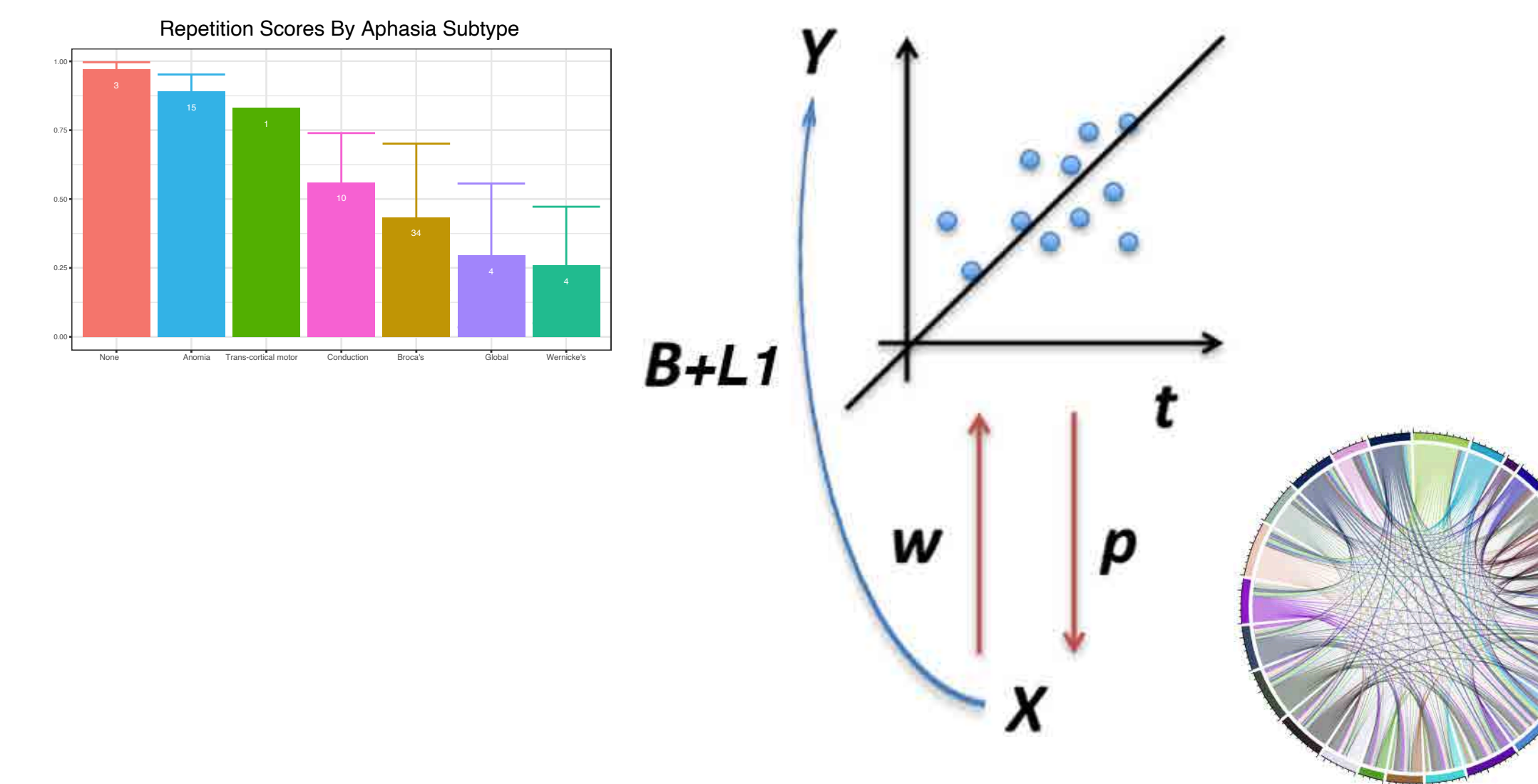


Group Averaged Connectome (2300+ connections)

Methods: Brain-Behavior Relationship

sparse Partial Least Squares (PLS) Regression

PLS accommodates highly dimensional and highly collinear datasets via supervised latent projections, while performing feature selection using the LASSO [6]

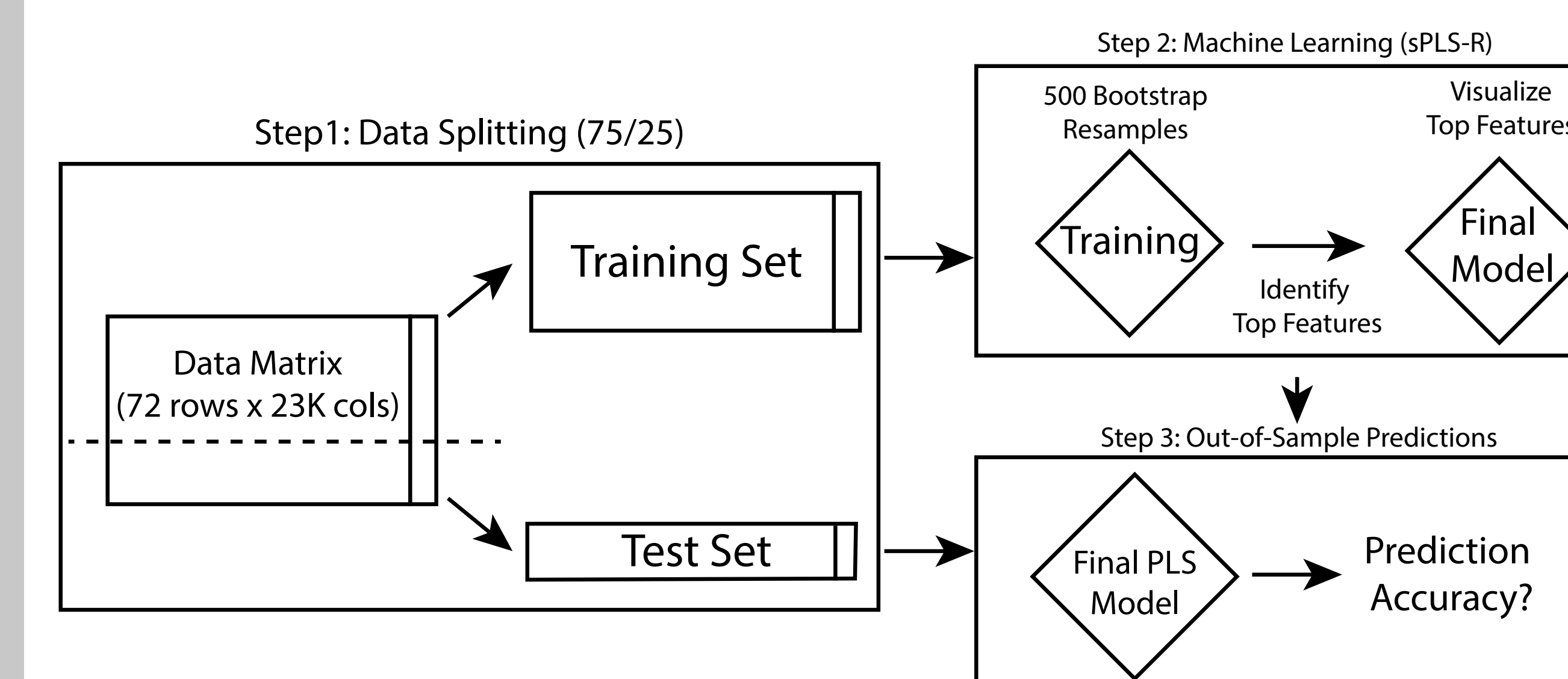


Sparse PLS with LASSO penalty: Algorithmic feature selection

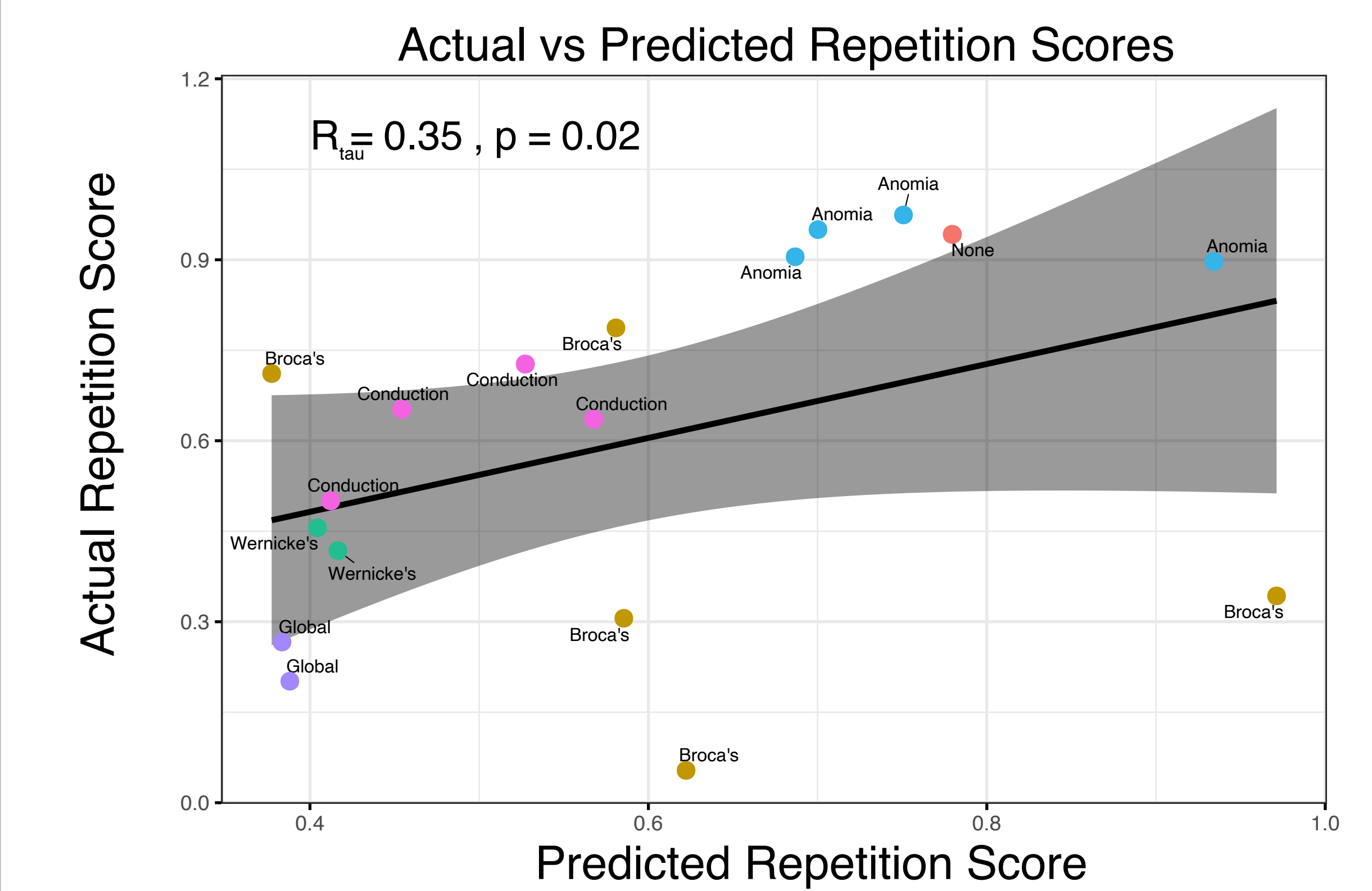
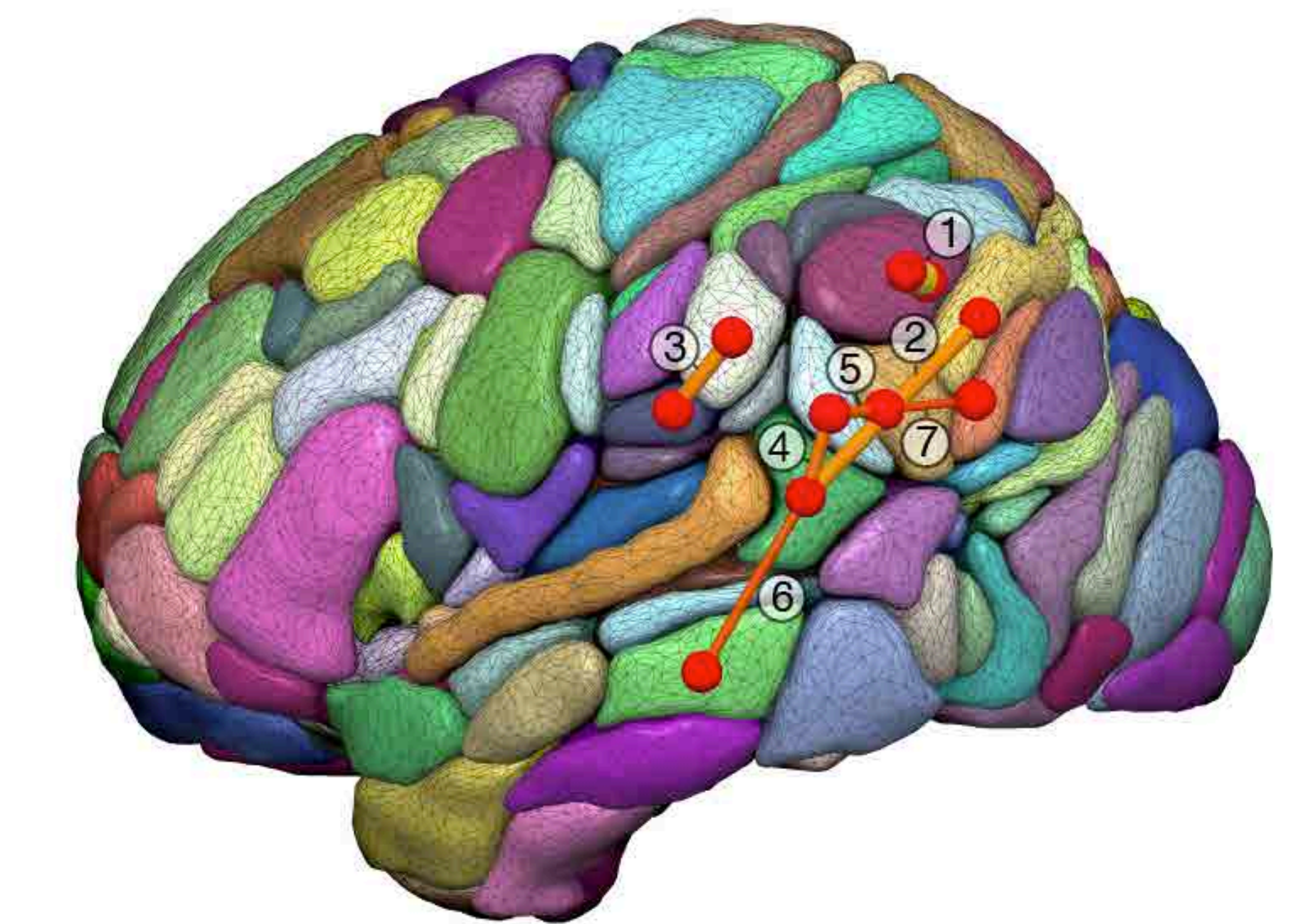
Feature Importance Metric: VIP Score [7]

$$VIP_j = \sqrt{\frac{\sum_{f=1}^F w_{jf}^2 \cdot SSY_f \cdot J}{SSY_{total} \cdot F}}$$

Methods: Machine Learning



Results: Top Features & Predictions



Conclusions

These data indicate that speech repetition may better be explained by a disruption to an essential set of short-range pathways interconnecting posterior language areas known to possess auditory-motor properties rather than a long-range disruption to the arcuate fasciculus.

References

- Binder, J. R. (2017). Current controversies on Wernicke's area and its role in language. *Current neurology and neuroscience reports*, 17(8), 58.
- Buchsbaum, B. R., & D'Esposito, M. (2019). A sensorimotor view of verbal working memory. *Cortex*, 112, 134-148.
- Geschwind, N. (1965). Disconnection syndromes in animals and man. *Brain*, 88(3), 585-585.
- Gleichgerrcht, E., Fridriksson, J., Rorden, C., & Bonilha, L. (2017). Connectome-based lesion-symptom mapping (CLSM): A novel approach to map neurological function. *NeuroImage: Clinical*, 16, 461-467.
- Joliot, M., Jobard, G., Naveau, M., Delcroix, N., Petit, L., Zago, L., ... & Tzourio-Mazoyer, N. (2015). AICHA: An atlas of intrinsic connectivity of homotopic areas. *Journal of neuroscience methods*, 254, 46-59.
- Rohart, F., Gautier, B., Singh, A., & Lê Cao, K. A. (2017). mixOmics: An R package for 'omics feature selection and multiple data integration. *PLoS computational biology*, 13(11), e1005752.
- Farrés, M., Platikanov, S., Tsakovski, S., & Tauler, R. (2015). Comparison of the variable importance in projection (VIP) and of the selectivity ratio (SR) methods for variable selection and interpretation. *Journal of Chemometrics*, 29(10), 528-536.