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# Hyperbolic Model Captures Temporal Small Worldness of Brain Dynamics

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Brain activity can be represented as a complex network

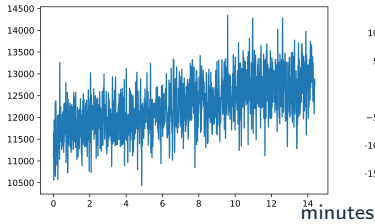
- **Small Worldness:** combination of high clustering coefficient (*local property*) and short temporal path length (*global reachability property*)
- **Scale Freeness:** small number of nodes have a degree that exceeds the average one

What is the best model that simulates the functional connectivity of the brain and can be used as a null model?

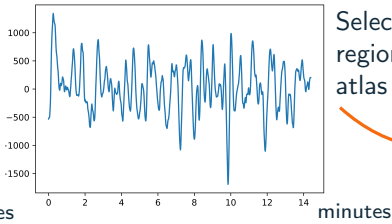
## Pipeline

Linear Regression and Bandpass Filtering to remove patient, respiratory and cardiac movements

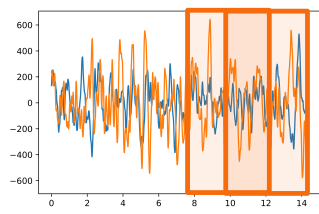
BOLD signal of a voxel



Clean BOLD signal of a voxel



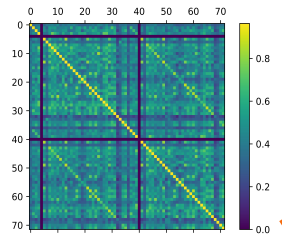
BOLD signal of two regions



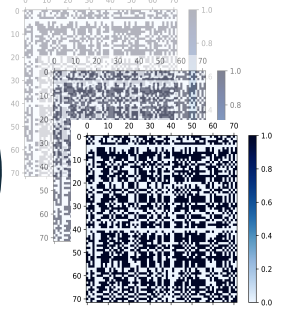
Sliding windows method

Computing correlation coefficient within each window

Adjacency matrix

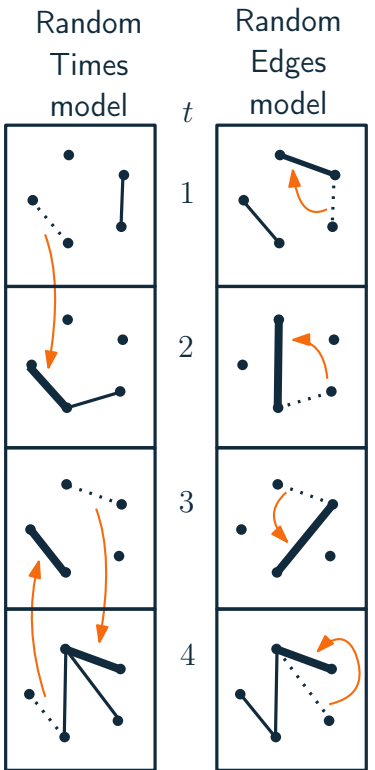


Thresholding



Temporal Brain Network

## Popular models

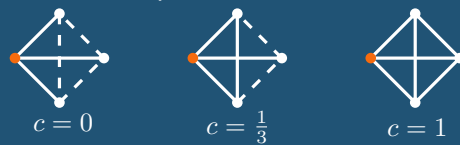


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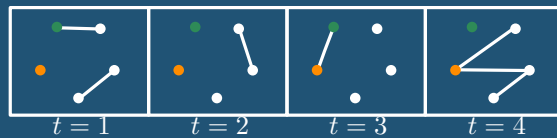
1. Tang, J., Scellato, S., Musolesi, M., Mascolo, C. & Latora, V. Small-world behavior in time-varying graphs. *Phys. Rev. E* 81, 055101 (2010).
2. Humphries, M. D. & Gurney, K. Network 'Small-World-Ness': A Quantitative Method for Determining Canonical Network Equivalence. *PLoS ONE* 3, 11 (2008).
3. Sizemore, A. E. & Bassett, D. S. Dynamic graph metrics: Tutorial, toolbox, and tale. *NeuroImage* 180, 417–427 (2018).
4. Watts, D. & Strogatz, S. Collective dynamics of 'small-world' networks. *Nature* 393, 440–442 (1998).

## Measures

- **clustering coefficient:** average over all the nodes of the local clustering coefficient, measures the tendency of the neighbors of a node to form a clique

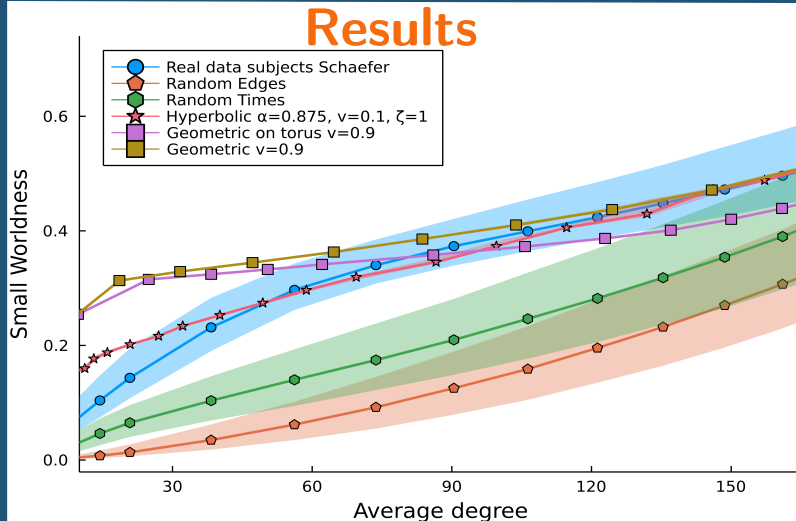


- **temporal path length:** average of the fastest paths between all pairs of nodes

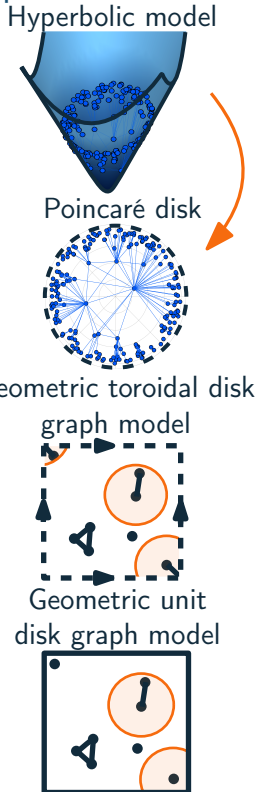


fastest path length from the green to the orange nodes = 3

## Results



## Proposed models



The Hyperbolic model not only is close to real data but it has the same behaviour