

The Wiring Economy Principle: Connectivity Determines Anatomy in the Human Brain

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Overview

- Background
- Model
- Part-1 Minimising Wiring Cost
- Part-2 Connectivity Defines Anatomy
- Conclusion

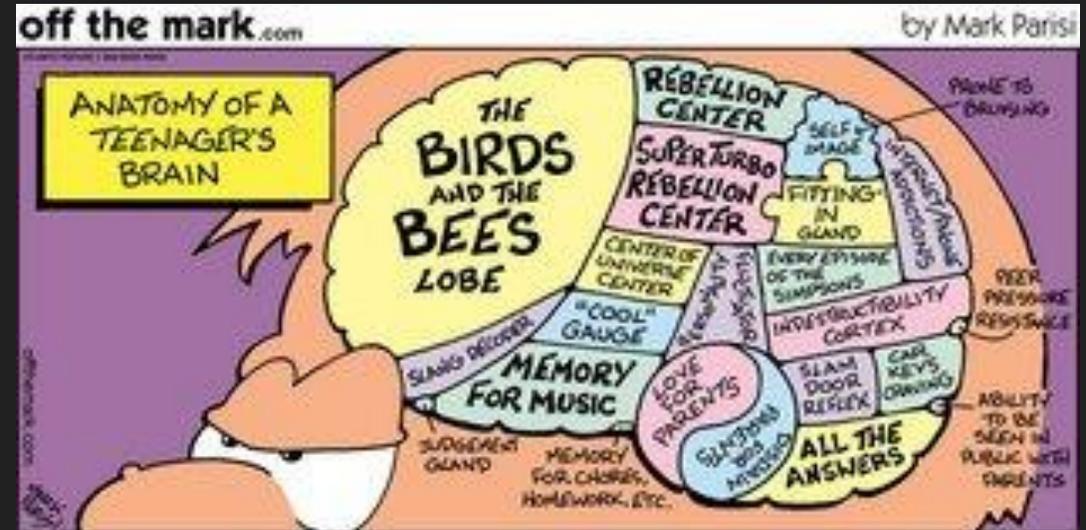


Image Source: 4.bp.blogspot.com

Background

- Brain network as a set of nodes and edges
- Complex enough to deliver high performance
- Simple enough to minimise the wiring function
- This paper looked at the relationship between brain anatomy and its connectivity



Does brain anatomy determines its connectivity or is it vice versa??

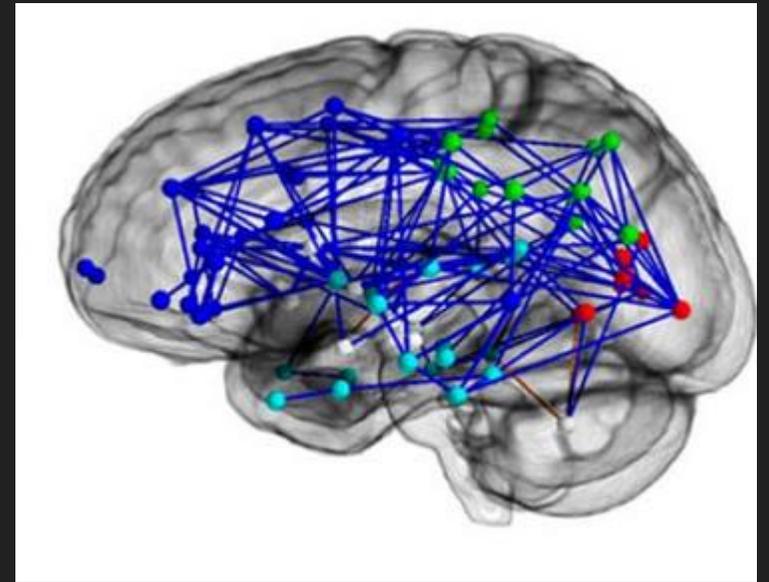


Image source : <http://thebrainbank.scienceblog.com/>

Model

- Brain is modelled as graph with nodes and edges
- Weights of edges is extracted using the dMRI technique on 14 subjects
- Extracted network contains
 - Nodes = 90
 - Edges = 233
- Nodes lie on the surface of two spheres –
 - $r=1$ (Cortical Nodes)
 - $r=0.5$ (Subcortical nodes)

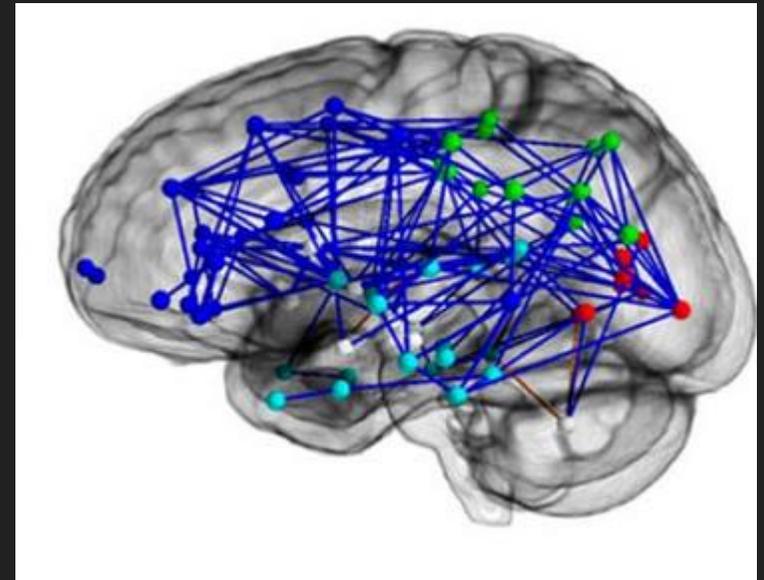
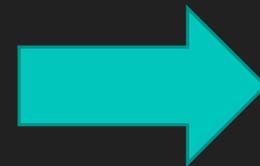
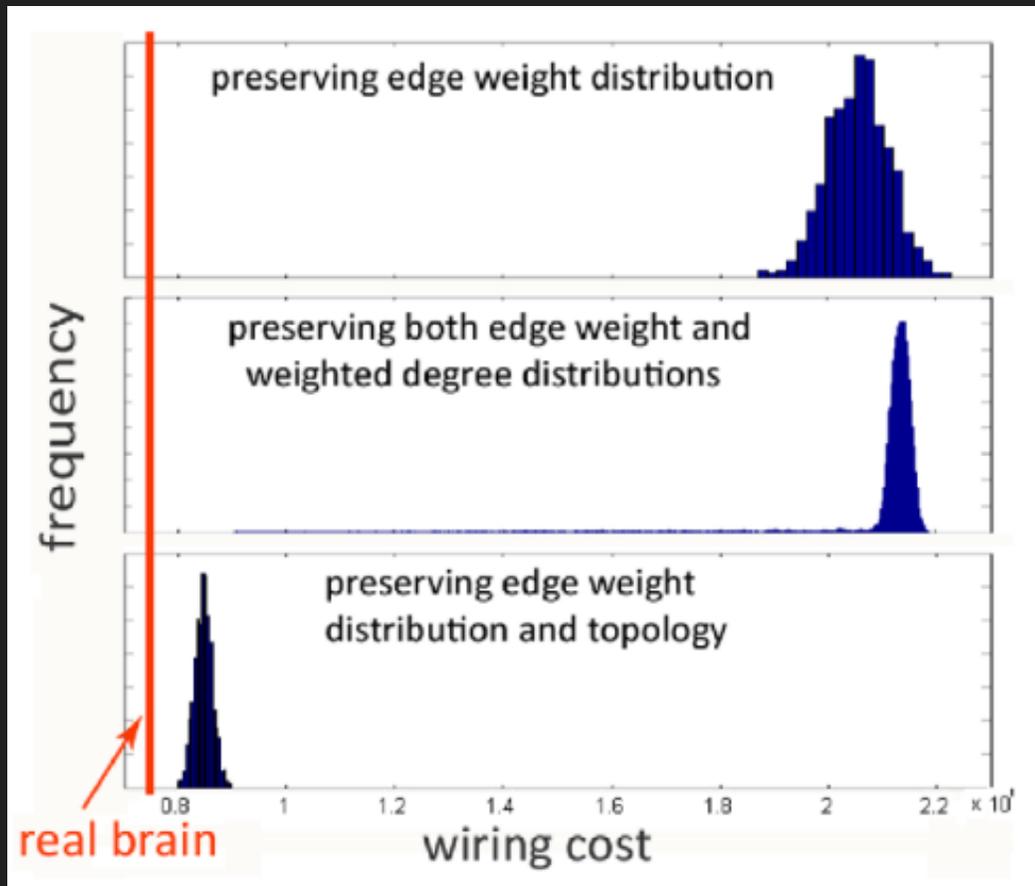


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I. Constant node placement; varying connectivity

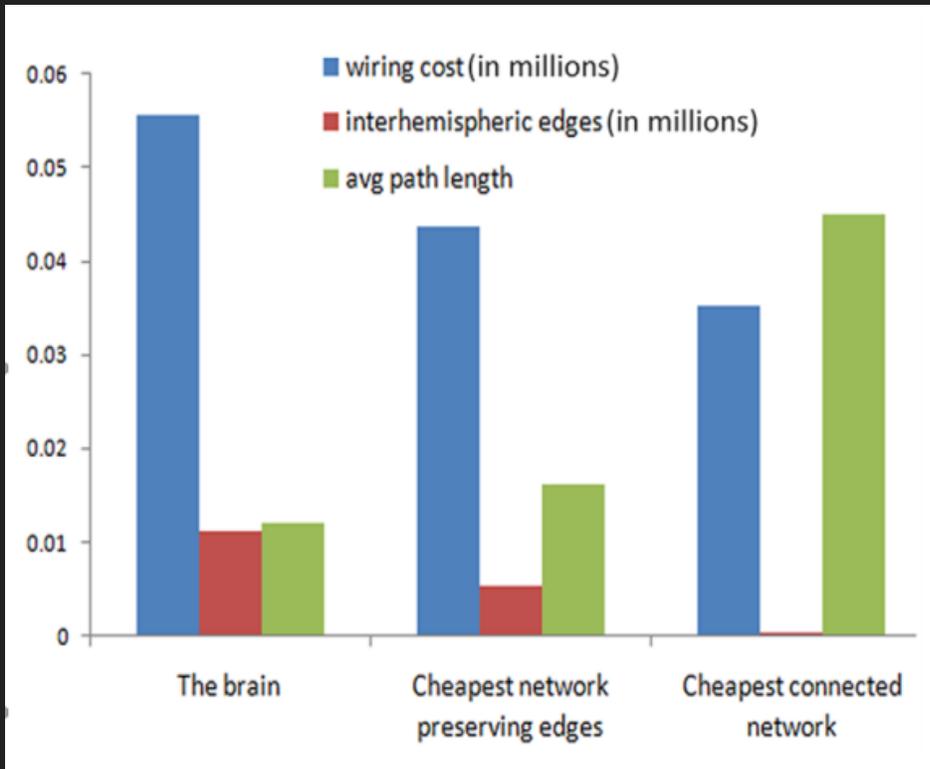
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The human brain network significantly minimizes it compared to any equivalent random network

I. Constant node placement; varying connectivity

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Wiring cost of some networks obtained from some algorithm can be lower than the brain. However it comes at the cost of highly reduced network performance.

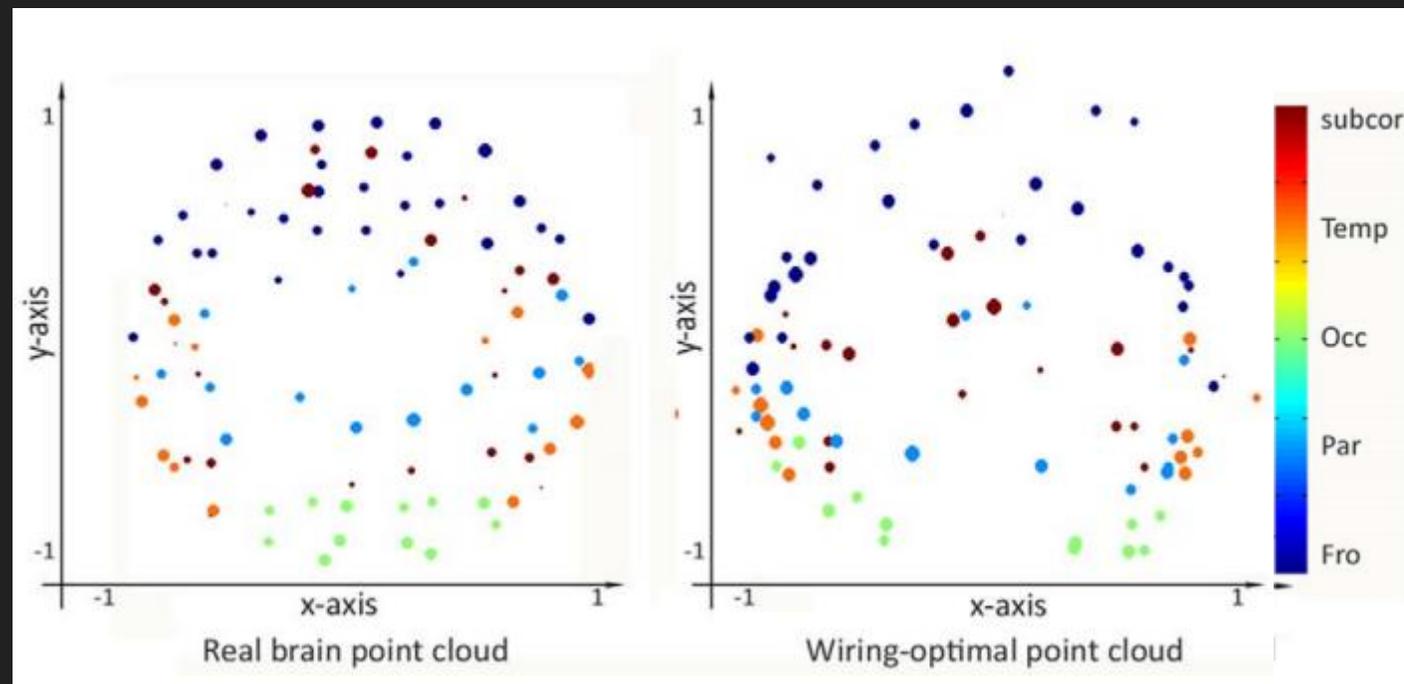


It is not possible to recover the connectivity keeping fixed the anatomy

II. Constant Connectivity, Varying Placement

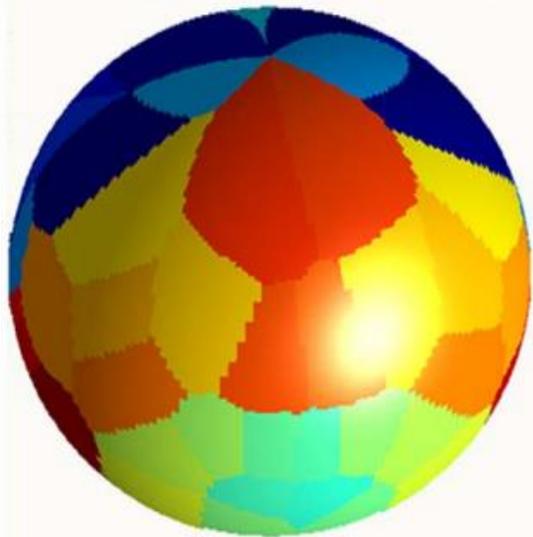
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Given the connectivity what configuration would the nodes take if they were free to roam the putative brain manifold?

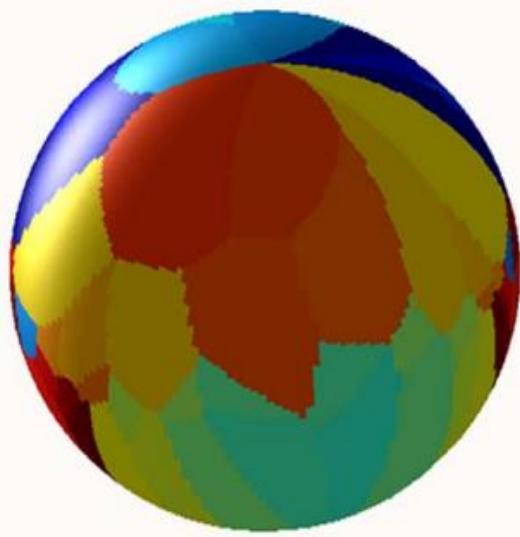


II. Constant Connectivity, Varying Placement

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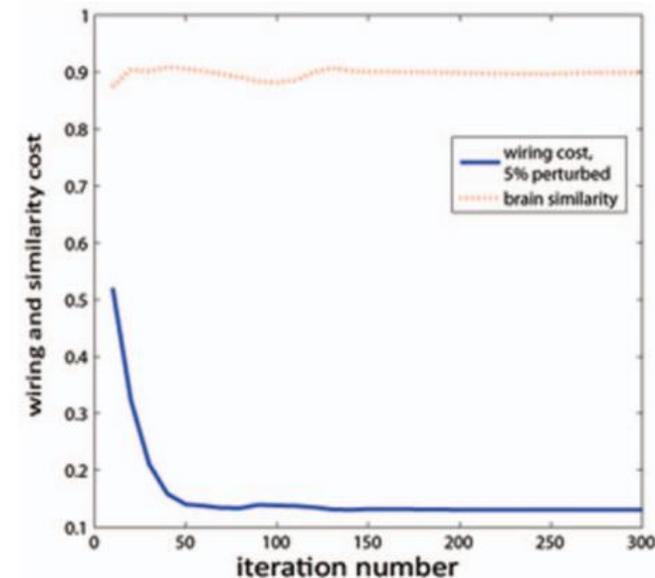
Real Brain Sphere Map



Wiring-optimal Sphere Map



Sphere Map - 5% perturbation



If the brain had a different topology/connectivity, its anatomy might have been quite different

Conclusion

Connectivity determines the anatomy of the brain

- In first set of analyses : **brain mainly optimizes for the most desirable network connectivity**
- In second set of analyses: we found that **beginning from any random configuration, the nodes invariably arrange themselves in a configuration with a striking resemblance to the brain. the observed brain anatomy is merely a result of this optimization**

References

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