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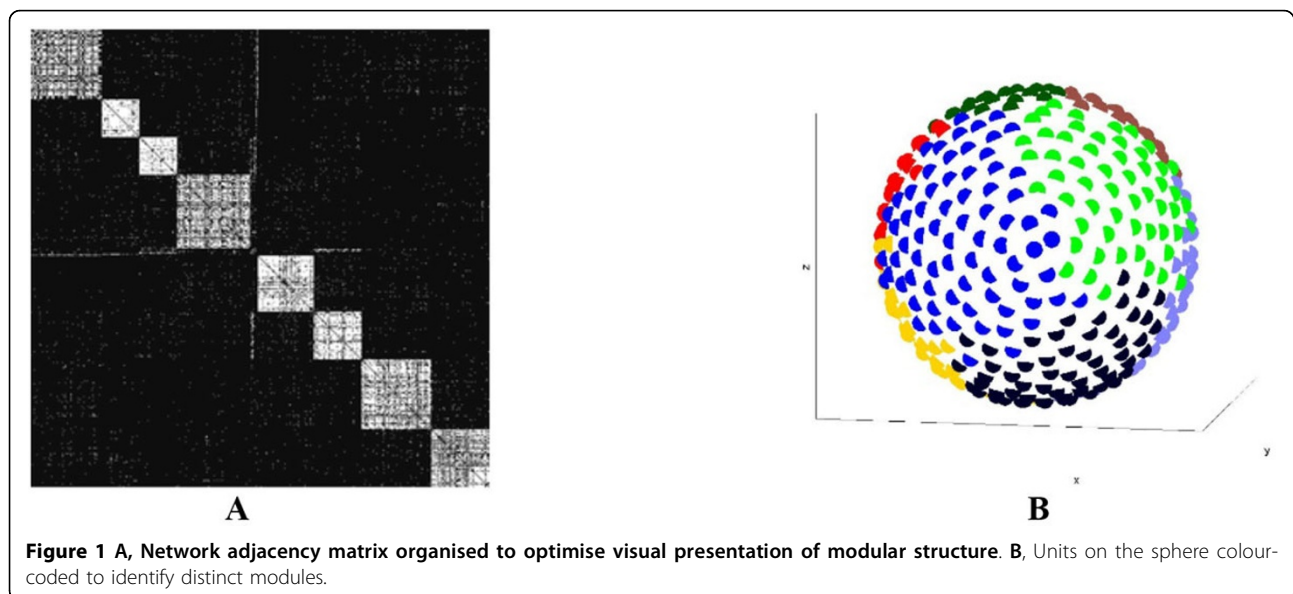
Proof of concept: a spatial modular small-world self-organises by adaptive rewiring

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A small-world network is a network that reconciles two opposing properties, segregation and integration. It is this reconciliation that gives rise to the impressive information processing capacity of the human brain; segregation provides a platform for information processing, whilst integration provides for the fast transmission of information. However, the connectivity structure of the brain is not static [1]; it changes on multiple time-scales; on a relatively fast time-scale, synaptic plasticity takes place, whilst on a slower time-scale there is rewiring of brain connectivity through growth of axons and dendrites. This structural plasticity depends on the even faster time-scale of neural activity. But the relationship is

symbiotic: patterns of synchronous activity are, of necessity, mediated by the brain connectivity structure. Gong & van Leeuwen [2] showed that rewiring of an initially random network - adaptive rewiring - in a model of spontaneous cortical activity gives rise to a particular type of network connectivity structure: a modular small-world. In order to improve the applicability of such a model to the cortex, spatial characteristics of cortical connectivity need to be respected. For this purpose we consider networks endowed with a metric by embedding them into a physical space. Such spatial constraints may represent wiring and metabolic costs in the brain. We provide an adaptive rewiring model with a spatial



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distance function and a corresponding spatially local rewiring bias [3].

Conclusion

The resulting rewiring scenarios showed a spatial layout of the connectivity structure, in which topologically segregated modules correspond to spatially segregated regions, and these regions are linked by long-range connections (see Figure 1, A and B). Greater realism and increased efficiency and robustness of the symbiosis of activity and structure is achieved compared to non-spatial adaptive rewiring. Thus, the principle of locally biased adaptive rewiring may explain both the topological connectivity structure and spatial distribution of connections between neuronal units in a large-scale cortical architecture.

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