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The hidden geometry of the brain

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The human brain connectome is a topologically complex, spatially embedded network. One of the characteristic, basic, nonrandom rules on which brain topology relies on is the tendency of brain networks nodes to cluster into modules with high efficiency and short path length, thus reflecting an intrinsic small-world behavior, functionally segregated (local clustering) and integrated (global efficiency) [1]. Although network topology seems to be somehow connected to network geometry, one of the most challenging issues of the current network science is to infer the hidden geometry from the mere topology of a complex network. Here in, aiming at disclosing the latent geometry of the brain, we apply coalescent embedding – a novel advanced technique able to map a given network in the hyperbolic space inferring the node angular coordinates - on different structural brain networks [2]. Interestingly, we show that we can unsupervisedly reconstruct the intrinsic brain geometry with an incredible level of accuracy and that it strongly resembles the known brain anatomy. As a matter of fact, the first rule of organization of brain networks emerging in the hyperbolic space is their structural segregation into two distinct sections corresponding to the left and right hemispheres, which is a simple concept yet quite neglected in previous studies on brain connectomics. In addition, we demonstrate that the human structural brain networks exhibited a significant different geometry in two age range-specific groups. Finally, we show that the intrinsic geometry of Parkinson's Disease patients is significantly altered compared to the healthy subjects as revealed by two novel latent geometry markers. The present study may bridge the gap between brain networks topology and geometry and may open a completely new scenario towards the realization of latent geometry network markers for the evaluation of brain disorders.

References

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Keywords

Brain networks, connectome, latent geometry, topology, network neuroscience