Cortical geometry as the determinant of the structure of dominant brain eigenmodes and resting state networks: neural field analysis.

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**Background:** Natural modes (eigenmodes) of brain activity have recently been identified with resting state networks. These eigenmodes are akin to the natural modes of a drum and form the basic building blocks of large-scale brain activity. The modes seen in a given brain hemisphere have been shown to have structures that are very similar to those of natural modes of a sphere. Neural field theory (NFT), which averages over brain microstructure, is ideally suited to deriving brain eigenmodes and interpreting them in terms of underlying physiology. The present objective is to use NFT to relate eigenmodes on the folded cortex to simpler ones on a sphere in order to obtain new and deeper insights into their properties.

**Methods:** Motivated by the similarity between brain eigenmodes and modes of a sphere, cortical folding is treated as a perturbation from an initially spherical geometry in order to calculate eigenmodes of large-scale brain activity using NFT. Perturbation analysis on a widely-verified corticothalamic neural field model is used to obtain estimates of eigenmode structure and frequency and to relate them back to eigenmodes of a spherical cortex.

**Results:** Eigenmodes and frequencies obtained by perturbation analysis are found to agree well with full numerical solutions of the neural field equations. These eigenmodes can thus immediately be related back to eigenmodes of a spherical cortex, thereby enabling new insights based on this simpler case. It is shown that the gross shape of the cortex, rather than the finer-scale gyri and sulci, is what determines the overall orientation of the dominant eigenmodes. This means that brain geometry can explain why dominant patterns of brain activity are similar in different individuals.

**Conclusions:** Brain geometry can determine the structure of cortical eigenmodes via NFT, with gross geometry explaining the main departures from the purely spherical case. Because eigenmodes have recently been identified with resting state networks using this model, these results imply that the orientations of resting state networks are fixed by the overall shape of the cortical surface and are not strongly dependent on fine-scale cortical folding or its variation between subjects. Furthermore, these results support the interpretation that resting state networks are not a separate phenomenon, supported by discrete network structures. Rather, they primarily reflect the natural modes of brain activity that are consistent with the geometry of the cortical surface and, indeed, approximately with the geometry of a sphere. Thus resting state networks are linked back to the same spherical eigenmodes that have long been used to analyze brain activity and EEGs.