Structural and Functional Connectivity of the Human Cerebellum Using Anatomical Cerebellar Priors

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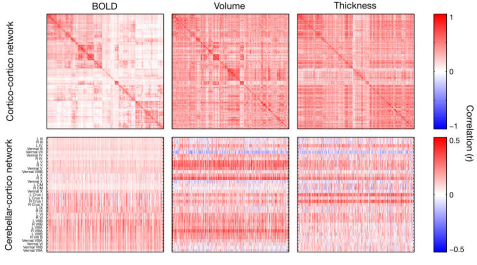
The cerebellum's role in the brain has been debated for over a century, and an accumulation of recent evidence suggests that the structure is involved a multitude of processes including motor movements, sensory perception, and high order cognitive processes[1]. One helpful, but internally inconsistent, line of research involved using resting-state fMRI to define the regions of the cerebellum that synchronize best with various regions of the cortex[2,3]. The results of these studies are varied, but consistently mapped individual cerebellar regions to a single cortical region or network.

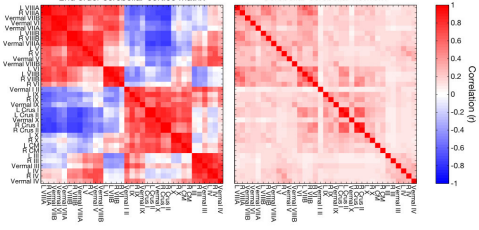
We sought to resolve some of the discrepencies in the literature by addressing the problem in reverse: using a novel segmentation algorithm and atlas[4], we were able to investigate cerebellar-cortico connectivity with high anatomical accuracy. The major advantage of this approach is that it does not constrain the connectivity of the cerebellum with a model of the cortex's structure. Furthermore, it allowed us to investigate structure-function relationships in the cerebellar-cortico network.

We found significant structure-function homology throughout the cerebellar-cortical network. These relationships were strongest in the recently-evolved cerebellar structures. These regions of interest clustered nicely into a set of cerebellar resting-state networks that show good structure-function homology and are positioned to integrate signals arising from multiple cortical resting-state networks.

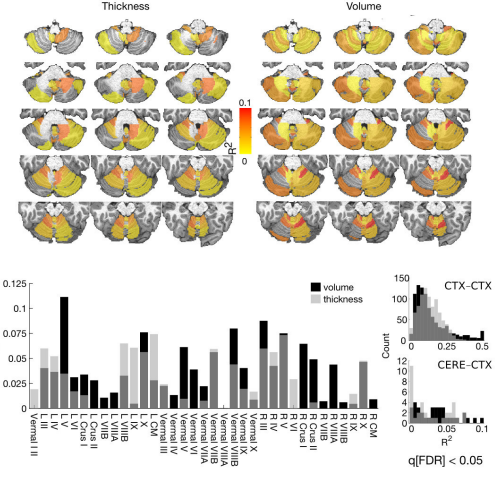
Networks derived from BOLD correlations, volume-volume correlations, thickness-thickness correlations (cortico-cortico only), and volume-thickness correlations (cerebellar-cortico only)



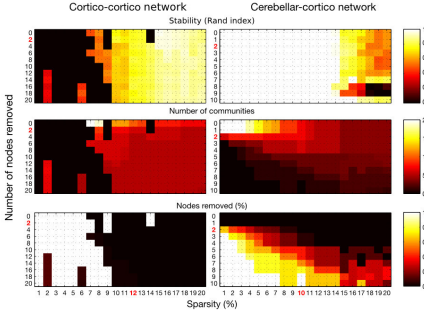
2nd order cerebellar-cortico BOLD network resembles the functional connectivity of the cerebellar-cerebellar network



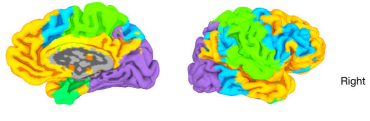
Cerebellar-cortico structure-function relatonship in each cerebellar ROI



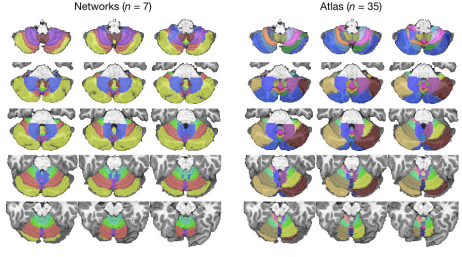
To define cerebellar-cortico networks, we applied the louvain algorithm to a 2nd order correlation matrix at various levels of sparsity and while enforcing minimum-community sizes. We preformed a grid search to find a stable and broadly consistent network sparsity / minimum community size.



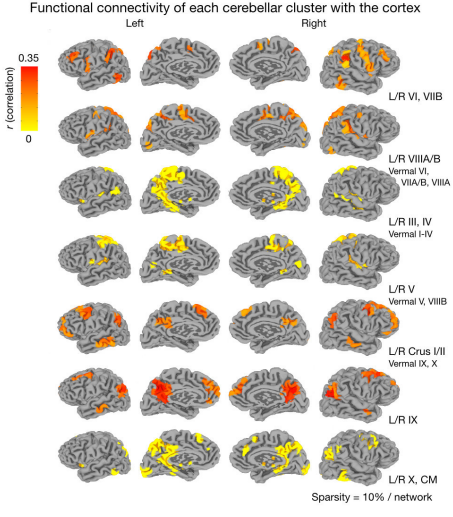
Cortico-cortico communities reveal known resting-state networks



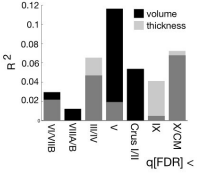
Functional clusters derived from cerebellar-cortico connectivity



Functional connectivity of each cerebellar cluster with the cortex



Cerebellar-cortico network-level structure-function relationship



References

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