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Connectivity-based parcellation using volume-based and surface-based diffusion tractography

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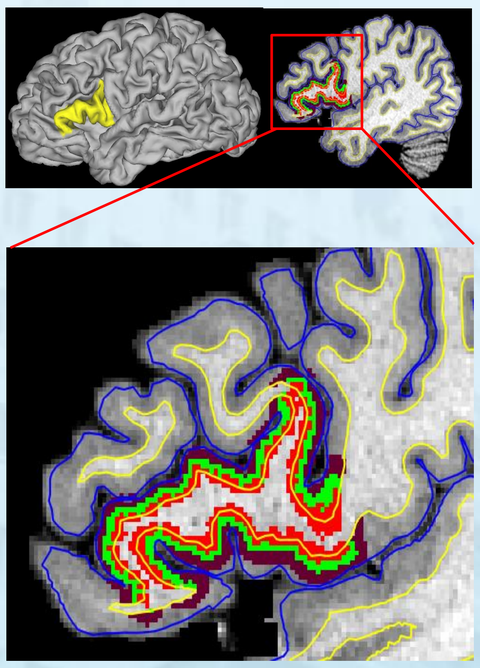
Introduction

The parcellation of the cortex via diffusion tractography have been widely used to parcellate the cortex into individual areas based on the presence of distinct connectivity profiles. Diffusion tractography depends on the diffusion model and tracking method. As the low anisotropy in the grey matter, the estimated orientation in grey matter is uncertainty so that the tractography is problematic. Whether different thickness ROI within grey matter influence the parcellation is still unknown. Here, in order to investigate this question, we choose region of interest (ROI) of the inferior frontal gyrus(IFG), which is known as Broca' area, to construct the diffusion tractography using volume-based and a novel surface-based probabilistic tracking and perform the parcellation.

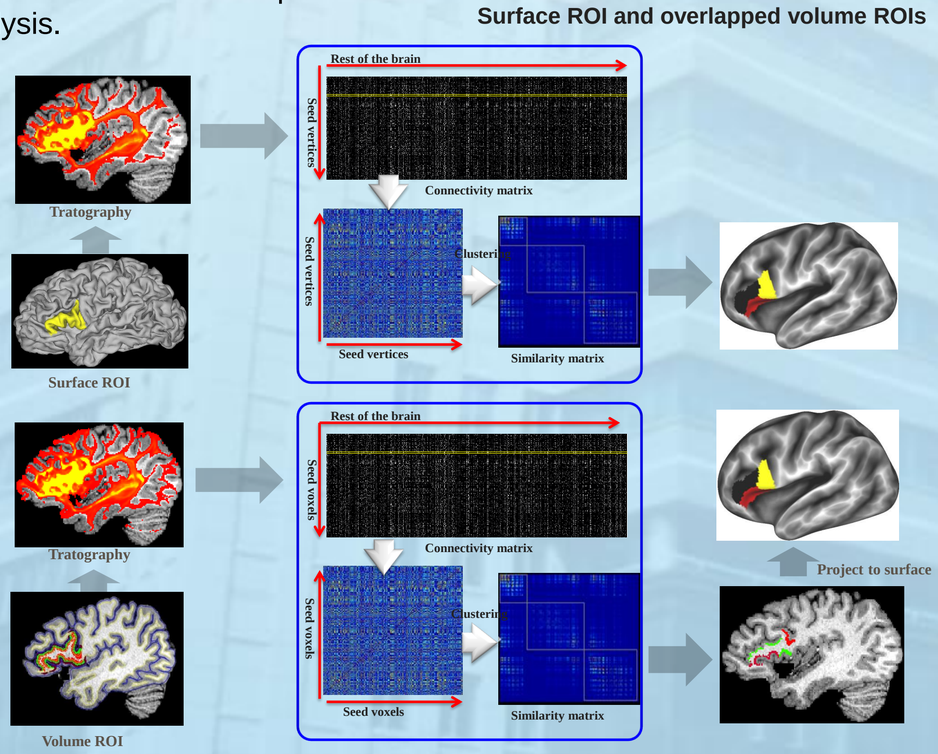
Material and Methods

In the current study, we parcellate the IFG into 2 to 6 clusters using volume-based and surface-based probabilistic tracking via a well established parcellation scheme [3]. One healthy, male adults is randomly obtained from the Human Connectome Project (HCP) database. The structural and diffusion data have been preprocessed following the HCP's minimal preprocessing pipelines [4].

- Firstly, the surface ROI is derived from the 32k mesh Desikan–Killiany (DK) atlas [2]. Three volume ROIs are based on the thickness of the cortical ribbon. One is the grey/white interface, one is between the white and midthickness surface and one is between the white and pial surface.
- Probabilistic tracking is performed using FSL [1,5] and the parcellation is using the spectral clustering [3].
- Results of the volume are projected to the 32k mesh surface and then the labels are reassigned via the Munkres algorithm [6].
- A probability map (PM) is created across all ROIs. The probability of the most overlapped vertices within the PM is calculated for the quantitative analysis.



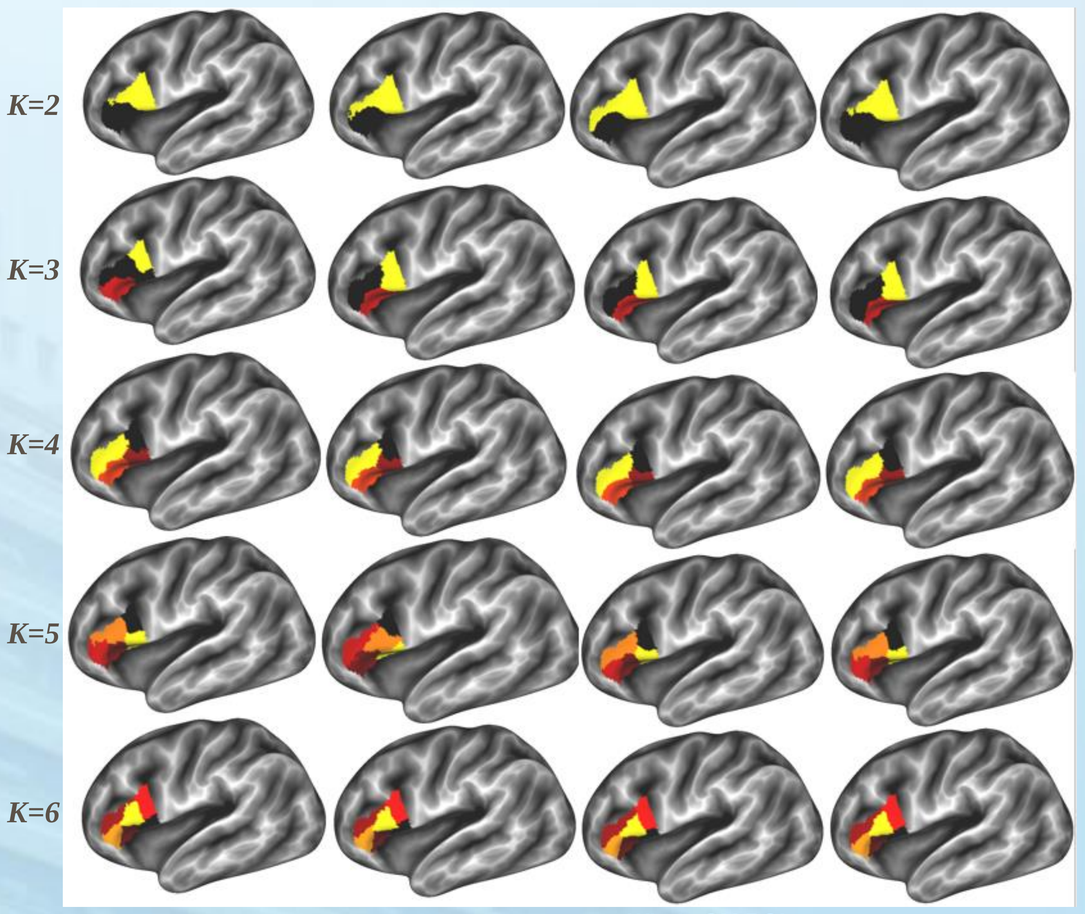
Surface ROI and overlapped volume ROIs



Surface-based and volume-based parcellation pipelines

Results

The IFG was clustered range from 2 to 6. The subdivisions were not always consistent and were variable. The cluster solutions of 2, 4, 6 have more consistent than 3, 5. One subregion of the cluster solution 5 is lowest, 0.095. However, 6 cluster shows a high consistency, whose spatial pattern is consistent with the Human Brainnetome Atlas [3]. When surface-based results are taken into account, the change of the probability is very small.



Parcellation results of different ROIs

	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5	Cluster 6
K=2	0.834	0.803	-	-	-	-
K=3	0.374	0.527	0.574	-	-	-
K=4	0.897	0.885	0.871	0.849	-	-
K=5	0.731	0.410	0.096	0.158	0.544	-
K=6	0.877	0.818	0.747	0.901	0.767	0.723

Table 1. the probability of the most overlaped vertices of each clusters(without surface-based result). The row is the cluster solution and the column is correspond subregions

	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5	Cluster 6
K=2	0.826	0.790	-	-	-	-
K=3	0.360	0.468	0.572	-	-	-
K=4	0.872	0.860	0.836	0.849	-	-
K=5	0.713	0.401	0.095	0.158	0.536	-
K=6	0.860	0.804	0.747	0.887	0.767	0.721

Table 2. the probability of the most overlaped vertices of each clusters(with surface-based result). The row is the cluster solution and the column is correspond subregions

Overlap probability of all subdivisions

Conclusion

The most limitation of this result is just one subject selected. Restricting all conditions except the cortical area, the different thickness ROIs within grey matter lead to different parcellation results. The thickness of the ROIs have more influence than the cluster solution we choose. When parcellating the cortex, we should need more caution to place the ROIs. Parcellation using surface-based diffusion tractography is more stable.

References

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