Reorganization of functional connectivity does not obviously explain outcome post-lobectomy

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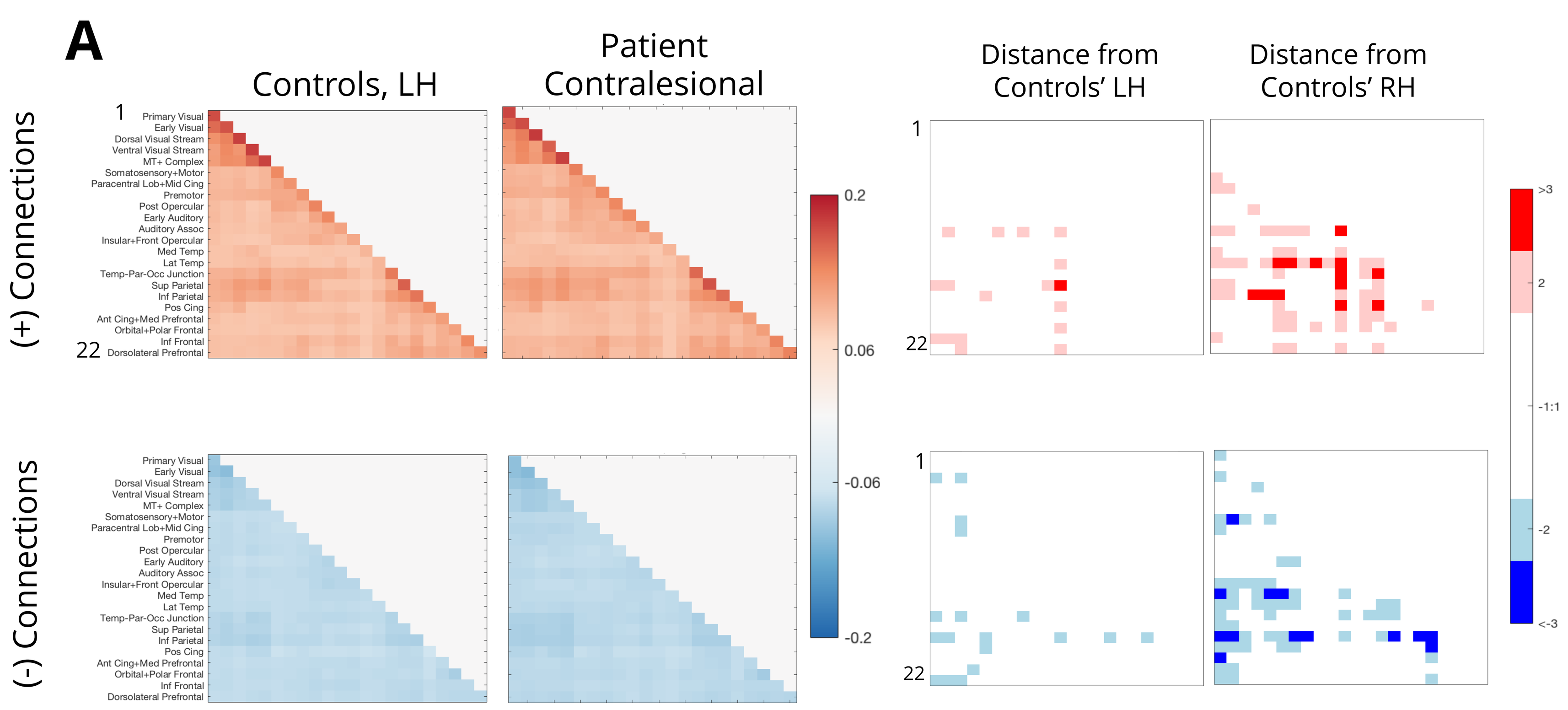
Background

- Children who undergo unilateral visual cortical resection for the management of epilepsy evince normal intermediate and higher-order visual perception
- Previously, we have shown that category selectivity[1,2] and structural connectivity[3] in these children were comparable to age-matched controls
- Now, the question remains: *what processes enable the maintenance of a normal neural and behavioral profile in these morphologically altered brains?*

1 How does the functional connectivity in children who had unilateral resection compare with those of age-matched controls?



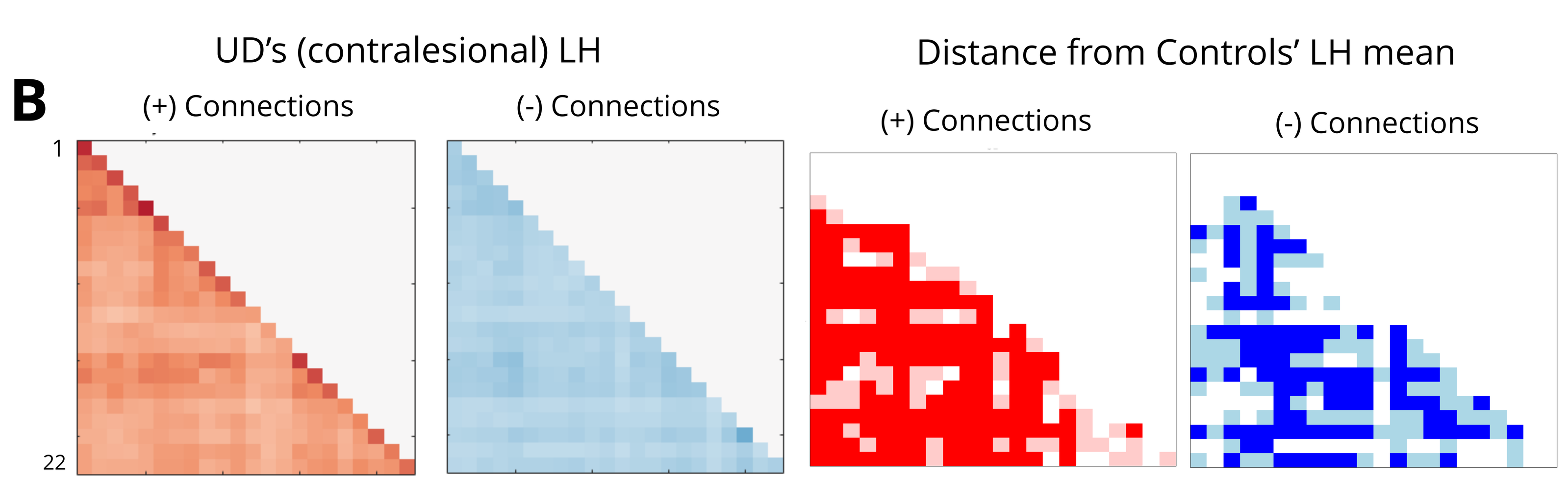


Figure 1A. Mean pattern of positive and negative functional connectivity in controls' left hemisphere (LH) and in patients' contralesional hemisphere. Compared to controls, on average, patients *exhibit diffuse differences in both positive and negative directions indicating enhanced connectivity between networks*. Distance from mean is defined here as the difference between control and patient mean divided by standard deviation in controls. Controls' left and right hemispheres (RH, not shown) are similar.

Figure 1B. Exemplar subject comparison to control mean. As there is heterogeneity in the site of resection in the patient cohort, we also present here a single-subject comparison between a patient with right occipitotemporal resection (shown in Fig. 2) and controls. UD's contralesional networks are more strongly (both in positive and negative directions) connected and the differences are spread out over almost the entire hemisphere. Color scale same in (A).

Methods

- N=9 controls (mean age: 14±2 years) and N=7 children with visual cortical resection (mean age: 15±2 years) participated in the study
- Evoked BOLD signals were acquired as participants viewed stimuli from different visual categories (e.g., faces, houses, words).
- We defined 22 networks (total 180 regions of interest) based on the HCP multi-modal cortical parecellation[4], separately in each hemisphere, and examined their within- and between-network connectivity.
- We split the connectivity matrices into positive (+) correlations and negative (-) correlations (Section 1)
- We also investigated whether any changes to the functional connectivity arises from short or long-range reorganization (Section 2)
- Last, we investigated effects of regressing out different nuisance signals on connectivity profiles (Section 3)

2 What mediates these changes in functional connectivity between networks?

We used an assumption-free, distance-scaled approach by defining communities, and computed effective connectivity as the ratio of significant connections of a voxel to the number of its connections inside the community.

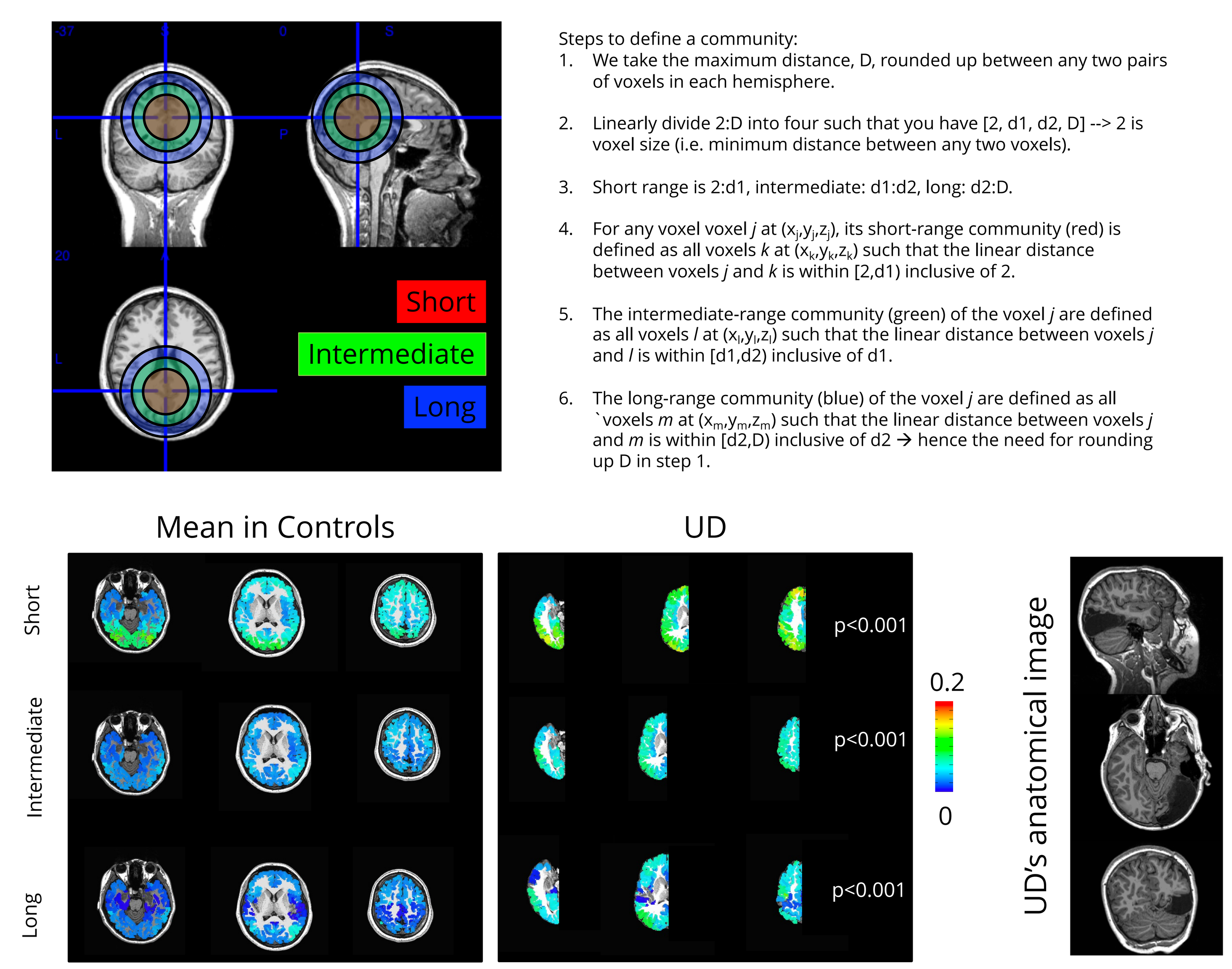


Figure 2. Comparison of effective community (EC) in the contralesional hemisphere of a single subject. Top panel (not drawn to scale) illustrates how a voxel's community is defined. Bottom panel: EC — the ratio of significant ($p<0.001$) connections between any one voxel to the ratio of connections of that voxel in each community — of controls and UD visualized at different axial slices. UD exhibits statistically higher EC in his contralesional LH compared to the LH of controls across all communities (short, intermediate, long). p-values, Wilcoxon rank-sum test.

Conclusions

- In (1), we showed that there are network pairs in the contralesional hemisphere with increased connectivity in children who had unilateral resection compared to age-matched controls. These changes, even on an individual level, are widespread throughout the brain.
- In (2), we showed that the changes in functional connectivity are a result of short, mid- and long-range reorganizations.
- In (3), we showed that these results hold irrespective of data pre-processing (e.g. regressing only the mean white matter, CSF signal, or a combination of both, and/or regressing out the global signal).
- In this work-in-progress, we will further investigate cortico-subcortical connections that might possibly mediate these changes.

3 How robust are these results to differences in pre-processing?

We regressed out nuisance variables including signal from the cerebrospinal fluid, white matter, and global signal.

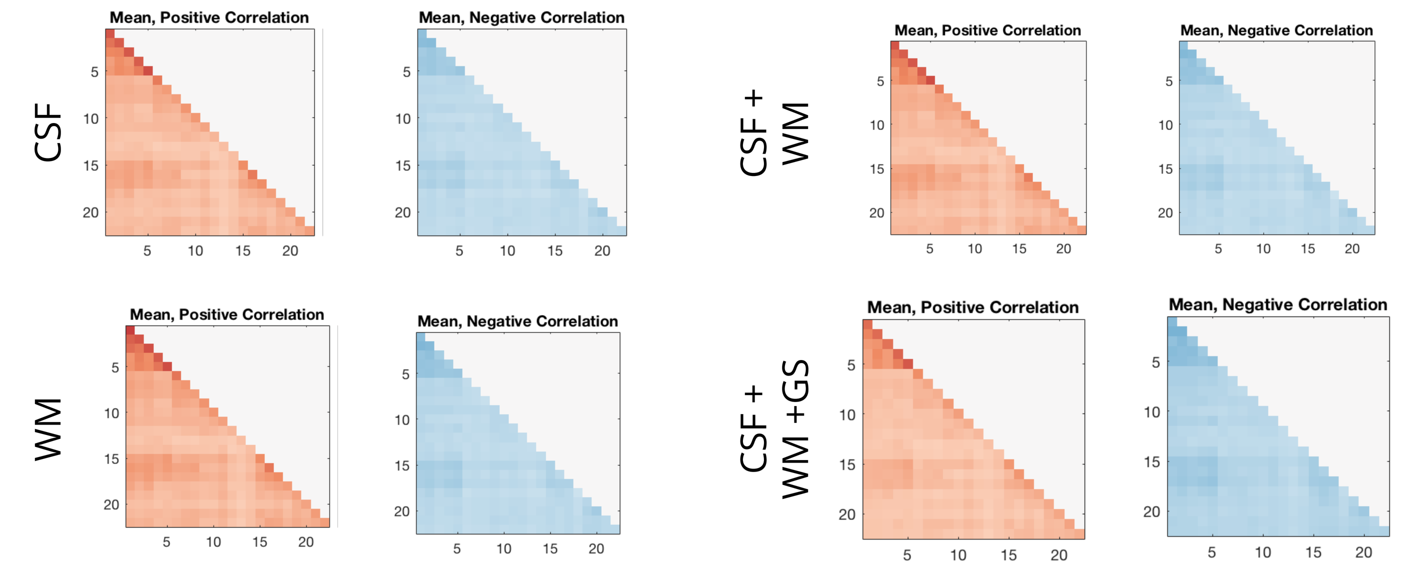


Figure 3. Effects of regressing out nuisance signal on correlation strength. Overall, the connectivity profiles appear qualitatively similar whether we regress out signal from only white matter (WM), cerebrospinal fluid (CSF), or even a combination of both. Even the regression of global signal (GS) in addition to WM+CSF results in a similar profile. These results are from the LH of a single control subject and will need to be investigated in all the participants. Color scale same in Figure 1.

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