Handedness and interhemispheric differences in the anatomical connectivity of perisylvian language areas: a network-based approach

A. Jakab 1,2, M. Beres 2, T. Spisak 3, S. A. Kis 3, M. Emri 3, E. L. Berenyi 2;

1 Computer Vision Laboratory, ETHZ, Zürich, Switzerland,
2 Department of Biomedical Laboratory and Imaging Science, University of Debrecen, Debrecen, Hungary,
3 Nuclear Medicine Institute, University of Debrecen, Debrecen, Hungary.

Introduction: Language - the highly specialized mental faculty that enables humans to acquire and use complex systems of communication – is described as collaborative network of specific neocortical loci in the frontal and temporal lobe, mainly interconnected by the arcuate fasciculus. Recent advances in neuroimaging stratified the importance of additional structures and that morphology and fiber-architecture is highly lateralized in the perisylvian network. Our aim was to investigate the hemispheric asymmetry of this extended network by elucidating the structural connectivities between perisylvian areas, and to apply graph theoretical analysis to provide global descriptors of network organization.
Subjects and Methods: For normative measurements of the right-handed population, 40 young adults were scanned using diffusion tensor imaging (DTI). Additionally, age-matched cohorts of 14-14 left- and right-handed subjects were accessed from a community-shared sample [1]. Standardization of individual DTI images to a template was performed and 12 perisylvian cortical regions were delineated using the Harvard-Oxford Atlas. Connection strengths between each element of the 12*12 matrix were given as estimates of confidence that tracts reach their target through a tra- jectory guided by diffusion characteristics [2]. For each interconnection, the lateralization index (LI) was calculated. The cortical regions were defined as nodes for graph analysis while connection strengths were used as edges in a weighted, directed graph.
Results: An overall leftward lateralization of the fronto-temporal connec- tions was observed for both cohort (LH:-0.508, RH:-0.388) similarly to the parieto-temporal connections (-0.134, -0.242). Fronto-parietal paths were right dominant (0.025, 0.125). Left-handed subjects had more bilateral fron- to-parietal and parieto-temporal connections while in some regions (posterior part of superior temporal gyrus, superior parietal lobule) the lateralization was rightward. Graph analysis revealed asymmetry in the clustering coefficient and the characteristic pathlength of the network; no difference was found in the network properties of left- and right-handed people.
Discussion/Conclusion: Our findings are in accordance with the functional and structural descriptions that report a predominantly leftward lateralization of white-matter structures included in language processing, while posteriorly located connectivities show bilateral or rightward lateralization. The left-handedness did not affect the overall organization the network, while the right perisylvian network showed increased efficiency of interconnections indicated by the higher clustering coefficient.