NEUROINFORMATICS TOOLS FOR LANGUAGE MAPPING

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The availability of functional mapping modalities such as fMRI, PET, and EEG, as well as intraoperative modalities such as cortical stimulation mapping (CSM) and single-cell recording, has provided unprecedented opportunities to understand language organization in the human brain. The goal of the University of Washington Human Brain Project is to develop methods for mapping, integrating, organizing, accessing, sharing, and visualizing multiple sources of language mapping data in order to gain an understanding of language organization that would not be possible using a single modality alone. To that end we are developing a distributed structural (neuroanatomical) information framework for organizing and integrating multimodality brain-mapping data.

Over the years of our Human Brain Project funding we have developed methods for 1) extracting the cortical surface, veins, and arteries from MR images; 2) mapping CSM sites and fMRI activation to the reconstructed anatomical model; 3) linking the mapped sites to a neuroanatomical ontology, based on Neuronames, that is part of a larger ontology of all anatomy developed by our group; 4) organizing and managing the mapped data in a Web-based Experiment Management System (EMS) based on an EMS-building toolkit developed for this project; 5) querying the EMS via a filter that dynamically presents the relational data as a virtual XML document suitable for data exchange; 6) displaying the returned results on a parcellated image of the brain that is labeled with terms from the neuroanatomy ontology; and 7) displaying the results on a Web-based 3-D visualization server that can be accessed from any Web browser.

These tools have been used to show that 1) there is a difference in distribution of CSM language sites for high verbal IQ versus low verbal IQ patients; 2) CSM semantic paraphasias are elicited in widespread perisylvian areas whereas phonological paraphasias are largely confined to posterior parietal and temporal sites; 3) there is no clear correlation between CSM and fMRI measures of language; 4) CSM can result in disruption of noun and verb identification in different cortical areas for the same patient; and 5) the distribution of CSM language sites for a deaf patient was not significantly different than that for hearing patients. These studies support the hypothesis that, although there is significant variation in the cortical representation of language among patients, there exists some underlying regularity that can be further revealed through the analysis of multiple functional mapping methods integrated in a common structural framework.

Current and future work will increase our ability to test this hypothesis. Current informatics work in support of this neuroscience goal includes the development of methods for 1) semiautomatically generating and evolving a Web-based EMS for an individual laboratory; 2) transparently embedding database management within a common fMRI analysis tool (SPM); 3) processing distributed queries over several independent EMS's and databases, on the assumption that no single lab can collect all the data required; 4) (with David Van Essen) warping the functional language data to a common template atlas; 5) visualizing the retrieved data via a next-generation Java3D toolkit that can run in local or client-server mode; and 6) providing content-based retrieval and integration of functional data from various sources. The continued development of these methods should lead to tools of use, not only for language mapping, but also for analysis of other forms of brain map data as well.

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