Preliminary Evidence of Language Reorganization After Left Hemispheric Injury: A Whole Brain, Event-Related fMRI Study of Sentence Production

Richard W. Briggs, Jeffrey M. Anderson, Bruce Crosson, Lynn M. Maher, Heidi L. Roth, Kaundinya S. Gopinath, Didem Gokcay, Leslie J. Gonzalez Rothi, Edward J. Auerbach, & David A. Soltysik
University of Florida, Gainesville, FL 32610, U.S.A.

Purpose
The purpose of this study was to reveal the reorganization within the brain structures supporting covert production of sentences for an individual aphasic patient.

Introduction
PET studies of the mechanisms supporting the normative on-line construction of sentence-length language sequences have depicted prominent activation in left anterior cortices [1]. PET studies of aphasic patients who experienced left hemispheric injury have suggested that right hemisphere cortices may be recruited after this type of injury [2], but this finding is controversial.

Methods
Three normal control subjects and one 40 year-old male patient demonstrating a severe Broca aphasia (ten years post) performed a sentence production task. Clinically, the patient demonstrated limited, telegraphic speech consistent with the symptom of agrammatism. **Task:** During each 24s active task half-cycle subjects were presented with pictures of action scenes which had previously been demonstrated to reliably yield predictable agent-action-patient sentences. The subjects were instructed to silently produce a simple sentence based on the scene (e.g. "The man is pushing the woman"). If the subject had difficulty with this task they were instructed to simply think of the agent, the person or object that was performing the action in the scene. The pattern of activation associated with the picture naming task was compared to that which occurred during the control task, viewing of non-object pictures. Subjects were instructed to only passively view these non-object pictures. Subjects were instructed to only passively view these non-object pictures.

Image Acquisition: Whole brain images were obtained using a 1.5T GE Signa with a 2-spiral gradient echo scan with 22 contiguous sagittal 6 mm thick slices; 180 mm FOV; TR/TE/FA = 2200ms/40ms/65deg. Six images were acquired in each of the 24sec half-cycles, with a total of 7.5 cycles per functional run. A total of four functional runs were performed with the same stimuli set (42 action scenes/42 nonsense objects, presented 1 every 4s) randomly sorted.

Image Analysis: Each of the four 7-cycle data sets were collapsed into an averaged single-cycle data set. These four averaged datasets were summed across runs to form an average single-cycle response which was compared to a gamma variate function which has been reported to provide an approximate model of the hemodynamic response [3]. Averaging across cycles and runs was performed to boost statistical power for individual subjects and to increase the SNR. The significantly active voxels (r > + 0.5) were visualized using the AFNI package [4] and overlaid onto high-resolution anatomic images obtained with a 3D-SPGR sequence (TR/TE/FA = 27ms/7ms/45deg); FOV = 240 mm; 256 x 192 x 124 matrix; voxel size = 0.94 x 0.94 x 1.3 mm.

Results/Discussion
For this left-hemisphere-damaged patient, the sentence production task produced activation only in the right hemisphere cortices (Figure 1). However, the production of sentences by the three normal control subjects elicited only left lateral hemisphere activation. These data suggest that the right hemisphere may be recruited after a significant left hemisphere injury to support language functions. Figure 2 shows the increased signal-to-noise in the measured signal response gained from averaging across cycles and runs.

![Fig. 1. Aphasic subject’s activation during sentence production.](image1)

![Fig. 2. Temporal evolution of fMRI signal in standard multi-cycle block analysis (left), with averaging across cycles (middle), and with subsequent averaging across runs (right).](image2)

References

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