The contribution of the inferior parietal cortex to spoken language production

Fatemeh Geranmayeh[1], Sonia Brownsett[1], Robert Leech[1], Christian F Beckmann[1], and Richard J.S. Wise[1]
[1]*The Computational, Cognitive and Clinical Neuroimaging Laboratory, Imperial College London, London, United Kingdom*

Introduction. The role of the left inferior parietal cortex (IPC) in aspects of language processing has been apparent in some studies[1,2] but not others,[3] and is not convincingly supported by clinical studies as they rarely include cases with lesions confined to the parietal lobe.[4]

Aim. The objective of this functional MRI (fMRI) study was to investigate the participation of the IPC in spoken language production.

Methods. The experimental paradigm consisted of three conditions: spoken language production when subjects were required to define nouns over 7 seconds (Speech), repetitive tongue movements (Tongue), and a silent rest condition (Rest). A "sparse" fMRI design was used to minimize movement- and respiratory-related artifact associated with speech.[5] fMRI images were obtained using a T2*-weighted, gradient-echo, echoplanar imaging sequence (repetition time, 10s; acquisition time, 2s; echo time, 30ms). Data from nineteen, healthy, right handed, native English speakers were analyzed with both univariate contrasts between conditions and group temporal concatenation independent component analysis (ICA)[6]. To determine the activation of brain regions within one of the ICA components, region of interest (ROI) analysis were carried out.

Results. The univriate subtractive contrast of Speech against Tongue showed no Speech related activity in the left IPC (Figure 1). The ICA revealed two components (C_1 shown in blue, and C_{24} shown in red/yellow, see Figure 2) in which coherent activity during Speech was significantly greater than during Tongue ($P = 0.05$ and 0.025 respectively). In contrast to the univariate analysis that showed no Speech related activity in the left IPC, C_{24} from the ICA showed correlated activity between left IPC, and the frontal and temporal cortices known to be involved in language. Interestingly, ROI analysis (Figure 3) confirmed decreased activity of left IPC during Speech relative to Tongue ($P = 0.03$).

Conclusion. Combining a univariate subtraction analysis with a multivariate analysis has enhanced the interpretation of this study. Therefore, although net synaptic activity throughout the left IPC may not increase above baseline conditions during Speech, one or more local systems within this region are involved, evidenced by the correlated activity with other language regions.

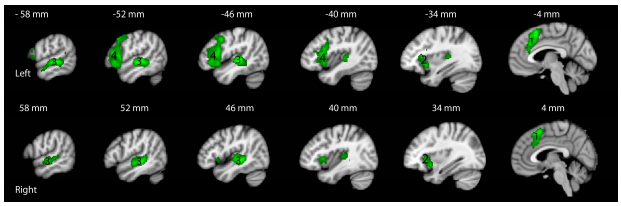

Figure 1. T1-weighted anatomical slices overlaid with activity from the contrast of spoken language production (Speech) with non-communicative repetitive tongue movements (Tongue). The statistical threshold was set at Z >2.3, cluster-corrected. The MNI co-ordinates are along the x-axis. Regions of activity were located in: 1. pre-SMA and anterior cingulate cortex; 2. bilateral anterior insula; 3. bilateral superior temporal cortex including left and right medial planum temporale; 4. left posterior inferior gyrus (incorporating Broca's area) and extending dorsally into posterior middle frontal gyrus.

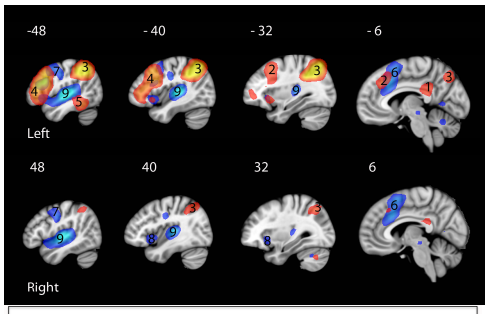

Figure 2. T1-weighted sagittal slices showing regions where correlated activity for Speech was significantly greater than for non-speech repetitive tongue movements. Components 1 and 24 from the ICA analysis are shown in blue and red/yellow, respectively. The statistical threshold was set at Z >4. The MNI co-ordinates are along the x-axis. The results from the ICA analysis demonstrated a much wider distributed network than the univariate subtraction analysis, including activity in left IPC (region number 3). The numbered regions are: 1. posterior cingulate cortex; 2. dorsal anterior cingulate cortex; 3. left and right IPC; 4. left dorsolateral prefrontal cortex; 5. left inferolateral temporal cortex; 6. pre-supplementary area and dorsal anterior cingulate cortex; 7. lateral premotor cortex; 8. anterior insula 9. left and right superior temporal gyri.

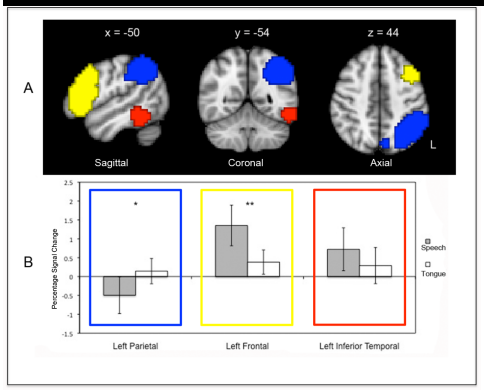

Figure 3. A illustrates the left IPC (blue), dorsal frontal (yellow), and inferolateral temporal ROIs, as determined from the ICA (regions 3, 4 and 5 in Figure 2). B. The bars, with 95% confidence intervals, show mean percentage signal change averaged across the ROIs during Speech and Tongue, relative to Rest. There was a significant deactivation in the left IPC during Speech compared to Tongue (*P = 0.03). The frontal region had significantly more activity during Speech compared to Tongue (**P = 0.005), evident from the univariate analysis (Figure 1). There was no significant difference between conditions in the inferolateral temporal region (P = 0.2).

References.

1. Binder et al., 2009. Cerebral Cortex, 19, 2767-2796.
2. Vigneau et al., 2006. Neuroimage, 30, 1414-1432.
3. Indefrey & Levelt 2004. Cognition, 92, 101–144.
4. Borovsky et al., 2007. Neuropsychologia, 45, 2525-2533.
5. Hall et al., 1999. Human Brain Mapping, 7, 213–223.
6. Beckmann & Smith, 2004. IEEE Transactions on Medical Imaging, 23,137-152.