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SHORT COMMUNICATION

To speak, or not to speak? The feasibility of imaging overt speech in children with epilepsy

L.J. Croft[a,c,*], **P.M. Rankin**[a,c], **F. Liégeois**[a,c], **T. Banks**[c], **J.H. Cross**[b,c], **F. Vargha-Khadem**[a,c], **T. Baldeweg**[a,c]

[a] *Developmental Cognitive Neurosciences Unit, Institute of Child Health, University College London, 30 Guilford Street, London WC1 N 1EH, United Kingdom*
[b] *Neurosciences Unit, Institute of Child Health, University College London, 4/5 Long Yard, London WC1 N 3LU, United Kingdom*
[c] *Great Ormond Street Hospital for Children NHS Foundation Trust, Great Ormond Street, London WC1 N 3JH, United Kingdom*

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Summary We systematically compared fMRI results for covert (silent) and overt (spoken) versions of a language task in a representative sample of children with lesional focal epilepsy being considered for neurosurgical treatment ($N = 38$, aged 6—17 years). The overt task was advantageous for presurgical fMRI assessments of language; it produced higher quality scans, was more sensitive for identifying activation in core language regions on an individual basis, and provided an online measure of performance crucial for improving the yield of presurgical fMRI.

Introduction

Functional MRI (fMRI) is an important, non-invasive imaging tool to localise eloquent cortex in patients who are being considered for neurosurgical treatment (Liegeois et al., 2006; Swanson et al., 2007). Overt speech is commonly avoided during language fMRI due to the risk of head movement artefacts (Barch et al., 1999), despite successful mapping of motor cortex during limb movements (De Tiege et al., 2009). Functional MRI studies of expressive language therefore investigate covert (silent) speech or utilise button response paradigms. Imaging overt speech may be

* Corresponding author at: Developmental Cognitive Neurosciences Unit, Institute of Child Health, University College London, 30 Guilford Street, London WC1 N 1EH, United Kingdom.
Tel.: +44 207 905 2729.
E-mail addresses: louise.croft.09@ucl.ac.uk (L.J. Croft), p.rankin@ucl.ac.uk (P.M. Rankin), f.liegeois@ucl.ac.uk (F. Liégeois), Tina.Banks@gosh.nhs.uk (T. Banks), h.cross@ucl.ac.uk (J.H. Cross), f.vargha-khadem@ucl.ac.uk (F. Vargha-Khadem), t.baldeweg@ucl.ac.uk (T. Baldeweg).

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advantageous however. First, articulated speech engages more distributed regions of the brain (Shuster and Lemieux, 2005), providing a more valid model of the neural substrates supporting real-life expressive language. Second, overt responses provide an online measure of performance, essential for interpretation of findings. This is particularly important for children with cognitive impairment, who may struggle to perform the task inside the scanner. Third, overt speech may be more sensitive for identifying language cortex on an individual basis (Barch et al., 1999). Thus, overt speech tasks may be particularly appropriate for presurgical fMRI assessments, when accurate identification of language cortex is crucial on an individual basis, and when the margin for error is low. As movement-related artefacts can be minimised using image processing tools (Birn et al., 2004), we aimed to assess the feasibility and benefits of imaging overt speech in the presurgical setting, using continuous fMRI scanning. We hypothesised this would be both feasible and advantageous for children being considered for epilepsy surgery.

Methods

Participants

Data were collected from 38 children with medically resistant epilepsy (6—17 years, mean verbal IQ = 87 ± 15, mean age of onset 6 ± 4 years, mean duration of epilepsy = 7 ± 4 years, 63% female, 72% right handed). Structural lesions were identified in 34 patients, including; stroke/ischaemic injury ($N = 4$), medial temporal sclerosis ($N = 2$), focal lesions/tumours ($N = 20$) and other lesions ($N = 8$) including suspected Rasmussen's encephalitis. Approval for the use of human participants was given by the Institutional Research Ethics Committee; informed consent was obtained accordingly.

Functional MRI

A well-validated block-design verb generation (to noun) paradigm (VG) was used, as described previously (Liegeois et al., 2002). Children practiced the task prior to scanning. Three consecutive runs of VG were performed in a fixed order during fMRI; runs 1 and 2 were performed covertly (the routine clinical neuroimaging protocol), run 3 was performed overtly (the experimental protocol). Each run of VG used a different stimulus list, to minimise practice effects.

Outcome measures

Performance

Verb generation performance was measured (a) prior to scanning, and (b) inside the scanner using a sensitive head-mounted microphone.

Head movement

Measures of in-scanner movement per scan (mm/TR) were obtained using ArtRepair software (Mazaika et al., 2005).

Quality ratings

Subjective quality ratings were obtained for each individual t-map ($p < 0.001$, uncorrected) adhering to a 4-point scale based on extent of activation within language regions (Price, 2010) and levels of noise in the data (significant voxels outside these regions). Ratings were repeated by a blind expert reviewer for a third of the dataset and inter-rater reliability analyses were performed to ensure ratings were accurate and reliable.

Sensitivity to detect activation

We calculated the percentage of participants showing significant activation ($p < 0.001$ uncorrected, cluster size >20) in Broca's area (inferior frontal gyrus), Wernicke's area (posterior superior temporal lobe), and the superior parietal lobe (as a non-language control region). For patients with atypical language lateralisation, activation in right hemisphere homologues was credited for this analysis.

Laterality indices (LIs)

Threshold independent LIs (Wilke and Lidzba, 2007) were calculated in four language regions of interest (ROIs); 'Broca's area' (BA 44, 45, 47), 'extended Broca's area' (also including precentral and middle frontal gyri), the motor cortex (precentral gyrus) and the entire temporal lobe. Language dominance was determined according to LI values in extended Broca's area. The typical group (left language lateralisation) included 25 patients (66%); the atypical group (right or bilateral language lateralisation) included 13 patients (34%).

Statistical analysis

Parametric and nonparametric analyses were used as appropriate. All p-values were corrected for multiple comparisons using the Bonferroni procedure. When comparing quality ratings and LI values overt VG was compared to covert run 2, to reduce order effects.

Results

Effect of response mode on fMRI activation

Two patients were excluded due to poor scan quality. Covert and overt VG fMRI activations were largely overlapping in both groups (Fig. 1A). In the typical group both conditions produced activation in Broca's area, left precentral gyrus, basal ganglia and thalamus, bilateral posterior superior temporal lobe, insula, anterior cingulate cortex and supplementary motor area. In the atypical group both conditions produced activations in the right inferior frontal and superior temporal gyri. Condition specific activation loci are listed in Table 1.

Outcome measures

Performance

Patients performed the VG task more poorly during scanning (54% correct) than during practice (82% correct)