Functional organisation for verb generation in children with developmental language disorder

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Abstract

Developmental language disorder (DLD) is characterised by difficulties in learning one’s native language for no apparent reason and occurs in 7% of children. DLD increases the risk of academic underachievement, unemployment, and social and emotional problems. Our understanding of the brain basis of DLD is limited. Previous fMRI studies have yielded inconsistent results, perhaps as a consequence of small sample sizes, heterogeneity in the populations studied, and the tasks used to study neural activity. An important step for the field is to develop a basic understanding of how variation in language ability patterns with functional organisation. As part of the Oxford BOLD study (boldstudy.wordpress.com), we assessed brain activity in 10- to 15-year-olds for a simple language task, overt verb generation (e.g., saying “fly” in response to an image of a kite). We monitored in-scanner performance, and only included those participants with >75% accuracy. Our final sample included 67 typically-developing (TD) children, 50 with DLD, and 26 with a history of speech-language problems (who do not fully meet our criteria for DLD). This is the largest investigation of the functional neural basis of DLD to date. Our pre-registered hypotheses (osf.io/r2fc5/) were that those with DLD would have: (i) reduced activity in the left inferior frontal gyrus (LIFG); (ii) abnormal striatal activity, and (iii) reduced task-related laterality in frontal cortex.

First, performance of this simple language task evoked activity in children with DLD in the same regions and to a similar level as in TD children. We found no evidence for group-level differences in activity in LIFG (pars triangularis) and striatal brain regions in DLD and TD children. Second, our results revealed that atypical laterality was not associated with language proficiency or a diagnosis of DLD. Given the large size of our sample, this suggests that previously reported differences were false positives. In a follow-up analysis, we contrasted a subset of the DLD group with the lowest verb generation accuracy (50-83.3%, N=14) with a subset of TD children who performed the task with high accuracy (100%, N=14). This revealed sub-threshold differences in the LIFG and caudate nuclei bilaterally; these areas had reduced activity in the low-performing DLD group consistent with previous studies. These findings confirm the importance of monitoring and controlling for task performance in studies of DLD.
We also conducted a planned whole-brain analysis including all our participants (N=143), using language and verbal memory factors as continuous variables. These factors were computed from a range of standardised tests assessing participants' grammatical, vocabulary, narrative, list learning and working memory abilities. This analysis revealed that 1) higher language proficiency was associated with greater task-related activity in the LIFG (pars orbitalis) and the supramarginal gyrus, and 2) better verbal memory ability was associated with greater task-related activity in the left hippocampus, left cerebellum, and ventral sensorimotor cortex bilaterally. This work suggests a lack of sharp dividing lines between TD and DLD brains. Modelling continuous language variation in large samples might yield greater insight into the brain basis of DLD than using dichotomous categories.