Investigating the Microstructure of Language-Related White Matter Tracts in Developmental Language Disorder

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Introduction:
DLD (previously known as specific language impairment) is characterised by unexplained difficulties in learning one’s native language and affects at least 7% of children. White-matter differences related to DLD remain relatively under-specified, but abnormal connectivity has been identified in several tracts associated with language processing in children with DLD (Vydrova et al., 2015).

We used diffusion tensor imaging (DTI) and probabilistic tractography to examine the microstructure of four language tracts: arcuate fasciculus (AF), frontal aslant tract (FAT), extreme capsule fasciculus (ECF) and uncinate fasciculus (UF) in children with DLD. We hypothesised that children with DLD would show reduced fractional anisotropy (FA) in these tracts.

Methods:
16 children with DLD (14 male, 2 female; age range: 10-15 years; mean age: 11.6 years) and 44 typically-developing controls (13 male, 31 female; age range: 10-15 years; mean age 12.2 years) were scanned at 3T to acquire T1- and diffusion-weighted MRI images of the whole head. Diffusion images were acquired with 100 distinct directions, 50 at each of two b-values (1000 and 2000 s/mm²), at 2-mm spatial resolution, with multiband acceleration factor of 3. We used probabilistic tractography (ProbtrackX) to reconstruct fibre tracts for each participant, and mean FA was extracted for each tract separately. These data were compared independently for each tract (AF, FAT, UF and ECF) using two-way repeated measures ANOVAs, with a within-subjects factor of hemisphere and a between-subjects factor of group (DLD or control). Intracranial volume was used as a covariate of no interest due to the gender imbalance between the groups.

Results:
The two groups did not differ by mean FA across the whole brain (mean ± SD: DLD = 0.27 ± .013; controls = 0.27 ± .008) or intracranial volume (DLD = 1503 ± 152 cc; controls = 1469 ± 125 cc). Boys had significantly larger intracranial volumes than girls (t(58) = 3.93; p < .001; boys 1547 ± 128 cc; girls = 1426 ± 111 cc), as expected. For the language tracts, FA was significantly lower in the DLD group than in the control group in the AF (F(1, 57) = 6.49, p = .014; DLD = 0.51 ± 0.02; controls = 0.52 ± 0.02). There was a trend towards significance for the group difference in mean FA for the ECF (p = .06; DLD = 0.47 ± 0.02; controls = 0.48 ± 0.02). These differences were the same across hemispheres. There were no group differences in the FAT or UF.

Discussion:
This preliminary analysis indicates that children with DLD have abnormal microstructure of the arcuate fasciculus in both hemispheres. The arcuate fasciculus is part of the dorsal auditory processing stream connecting the posterior temporal and prefrontal cortex. The extreme capsular fasciculus, part of the ventral processing stream, also showed a trend towards lower FA in the DLD group. It remains to be seen whether the extent of these structural deficits relates to the language deficits observed in children with DLD. Furthermore, it is unknown whether these differences are a cause or consequence of language impairment.