Cerebellar Morphology in Developmental Dyslexia

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Introduction
Developmental dyslexia is now well established as a disorder of neurobiological origin. Evidence has now emerged to directly implicate the cerebellum in some aspects of dyslexic dysfunction [1,2]. Morphological differences have been found in the cerebral cortex of those with dyslexia but there is no published material extant on the morphology/asymmetry of the cerebellum. Therefore, we quantified cerebellar asymmetry in developmental dyslexia by the comparison of relative amounts of tissue on the left and right sides of the cerebellum as well as relative amounts of grey and white matter on each side.

Methods
Images were acquired at 85.2 MHz from 11 males with prior histories of developmental dyslexia, and 9 similarly-aged male controls using a quadrature head birdcage coil. T1 weighted coronal images were acquired as a single contiguous set of 16 slices across the cerebellum. (TR 803 ms, TE 13 ms, matrix 256x192, FOV 25.6 cm, slice thickness 5 mm, slice separation 5 mm.) The proportion of left grey and right grey matter as well as the proportion of the left and right white matter of the total cerebellum were determined. The proportion of the left and the right hemisphere of the entire cerebellum was also analysed. Asymmetry indices were determined using proportional measures from the left grey compared to the right grey indices, using methods described previously [3]. All ratings were conducted by persons blind to the subjects' diagnosis and the study aims. Proton magnetic resonance (STEAM) spectra (TE = 136 ms, TR = 2.4 s) were obtained bilaterally in the cerebellum. Phonological decoding skill was measured using nonword reading. Handedness was assessed using both the Annett Questionnaire of hand preference and Annett's Peg Moving Task.

Results
Cerebellar symmetry was observed in the dyslexics but there was significant asymmetry (right grey matter > left grey matter) in controls (Fig. 1).

Figure 1: Box plots showing relative amount of grey matter in left and right cerebella of dyslexics and controls

Inspection of relative volumes revealed that this was due to a significant left/right asymmetry present in controls (left grey/total volume median = 0.35 vs right grey/total volume median = 0.39 in controls, P = 0.05, Wilcoxon Signed rank test) which was absent in dyslexics (0.38 vs 0.38, P = 0.9)

The pegboard measure of handedness skill was significantly correlated with the left grey/right grey ratio (Fig. 2).

Figure 2: Relationship between relative amount of grey matter and peg moving time (left minus right). Filled squares, dyslexic subjects; empty squares, control subjects.

The degree of cerebellar symmetry was correlated with the severity of dyslexics’ phonological decoding deficit. Those with more symmetric cerebella made more errors on the nonsense word reading measure. This was supported by the finding that nonsense word reading time correlated significantly (Spearman’s rho = 0.76 P = 0.026) with the grey matter asymmetry ratio (left grey/total volume) in dyslexics but not in controls (Spearman’s rho = 0.29, P = 0.47). Left cerebellar metabolite ratios correlated significantly with the degree of cerebellar asymmetry (P < 0.05) in controls. This relationship was absent in developmental dyslexics.

Discussion
Cerebellar morphology reflects the higher degree of symmetry found previously in the temporal and parietal cortex of dyslexics. The relationship of cerebellar asymmetry to phonological decoding ability and handedness, together with our previous finding of altered metabolite ratios in the cerebellum of dyslexics, lead us to suggest that there are alterations in the neurological organisation of the cerebellum which relate to phonological decoding skills, in addition (I) to motor skills and handedness.

References