Developmental Coordination Disorder: A Structural MRI study of Neural Correlates

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LAY SUMMARY: Developmental coordination disorder (DCD) is one of the most common disorders in childhood. Children with DCD have normal IQ and no evidence of physical impairment yet show profound difficulties with tasks requiring motor coordination. Despite the prevalence and severe effects, the causes of DCD are essentially unknown. In order to improve our understanding of DCD so it can be more effectively treated, we need to explore the precise mechanisms underlying the condition. This study uses magnetic resonance imaging (MRI) to investigate if there are any links between structural differences in the brain and ability in tasks designed to assess motor skill within a group of children diagnosed with DCD.

INTRODUCTION

-Role of specific brain areas in DCD has long been postulated with particular evidence for the cerebellum [1] and parietal lobe [2] amongst others.

-The underlying aetiology of the disease is poorly understood. Most studies of DCD have been restricted to behavioural or physiologic measurements.

-This study is the first to use structural MRI to investigate the hypothesis that DCD has neural correlates in brain morphometry.

METHODS

Participants: 14 boys aged 8.5-12.9 years who met the clinical criteria for DCD partly assessed using the Movement Assessment Battery for Children (Movement-ABC) [3].

Behavioural Measures: Two psychometric measures were taken as the overall score from self-reporting questionnaires: the Movement-ABC and the Aberdeen Motor Development Questionnaire (AMDQ).

Kinematic Measures: A separate specific motor skill test involved a figure-of-8 tracing task [4]. A number of spatial response parameters were recorded:

Path length (PL)	total distance travelled
Path time (PLT)	time taken to travel the length of the path
Y-axis gain (y-gain)	difference in frequency of moving dot and frequency of participant's movement in the y-axis
X-axis gain (x-gain)	difference in frequency of moving dot and frequency of participant's movement in the x-axis
Normalised jerk (NJ)	differentiation of velocity with time
Root mean Square error (RMS error)	average error between correct and actual position
Standard deviation of error (STD error)	variation of error between correct and actual position

Imaging: 3T MR scanner (Philips Achieva X-Series). T1-weighted TFE sequence (TR=8.1ms, TE=3ms, NEX=1, flip angle 8°, m atrix 256 x 256 x 160, FOV 256 x 256 mm, voxels 1x1x1 mm). Whole brain voxel-based analysis was performed. Images segmented into grey and white matter maps. Segments warped to average subject space using DARTEL [5]. Output images normalised to MNI space, scaled to preserve volume, re-sampled to 1.5mm isotropic voxels and smoothed with an 8mm FWHM isotropic Gaussian kernel.

Statistical analysis:

-Multiple regressions of measured signal on the psychometric data were performed within SPM8 [6].

-36 correlations were carried out (9 behavioural measures, GM/WM, increase/decrease).

-To control for type I error, cluster-level p values, already corrected for regional multiple comparisons, were further Bonferroni corrected. Statistical significance was therefore set at cluster-level corrected p=.001 (0.05/36=.0014).

-p values thresholded at <.01 are reported as trends.

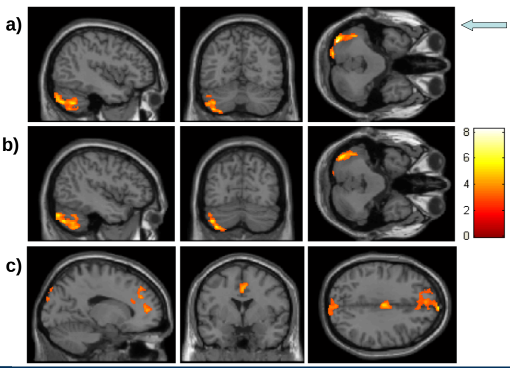

Figure 1: Correlations between grey matter volume and figure-of-8 parameters (p values are cluster level FWE corrected):
a) RMS error - negative correlation left cerebellar posterior lobe (p<0.001),
b) STD error - negative correlation left cerebellar posterior lobe (p=0.002),
c) x-gain – positive correlation medial frontal cortex (p<0.001) and visual cortex (p<0.001)

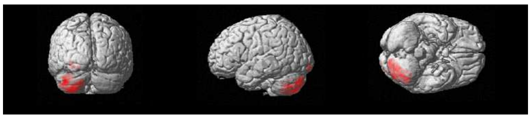

Figure 2: Negative correlations between grey matter volume and figure-of-8 RMS error scores in the left cerebellum (p<.001, corrected for multiple comparisons).

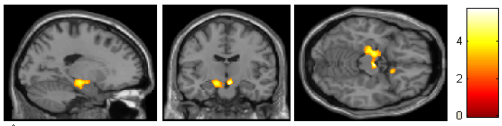

Figure 3: Positive trend between GM volume and Movement-ABC scores in parahippocampal gyrus (p=0.004)

RESULTS

-A negative correlation between relative regional GM volume and RMS error was seen in the left cerebellar posterior lobe (fig. 1).

-Significant positive correlations were seen with x-gain in left frontal lobe and left occipital lobe.

-A trend level negative correlation with STD error in the left cerebellar posterior lobe.

- Positive correlation between Movement-ABC scores and GM volume at trend level in the left parahippocampal gyrus.

-No correlations at either significance or trend level for AMDQ scores.

-No significant or trend-level correlations between regional WM volumes and any of the behavioural or kinematic measures.

	Figure of 8 parameters				
	RMS error	PLT	x-gain		STD error
Cluster size (voxels)	3848	1799	5370	3028	2218
Cluster level corrected p	< .001	.006	< .001	< .001	.002
Peak MNI coordinates (x,y,z)	-36,-81,-39	-60,-30,-26	-2,47,29	-33,-81,3	-38,-71,-51
Peak MNI coordinate region	Left cerebellar posterior lobe	Left cerebrum inferior temporal lobe	Left medial frontal gyrus	Left cerebrum middle occipital gyrus	Left cerebellar posterior lobe

Table 1: Description of clusters where significant or trend level correlations between figure-of-8 parameters and GM were seen

CONCLUSIONS

-The figure-of-8 tracing parameters allow for specific analysis of a particular skilled motor task. The significant correlation between GM volume and RMS error scores in the left cerebellar posterior lobe is suggestive of the role of the cerebellum in DCD. The similar pattern at trend-level for STD error provides additional evidence of this.

-The results show a clear distinction between neural correlates of general position accuracy given by RMS error and the x-gain frequency error. The medial frontal cortex (MFC) is known to be involved in representation of action [7]. The correlation seen here between the x-gain parameter and GM volume provides some evidence that the MFC is important for action monitoring and correction, and is distinct from the cerebellar role in accuracy and precision.

-This study provides the first neuroimaging evidence that regional grey matter structure plays a role in DCD. This study has looked at neuro-correlates of motor skill within a DCD population. Results suggest grey matter volumes in specific brain areas are correlated with performances in motor tasks within the DCD population. To increase our understanding of the nature of DCD, further studies are required to compare between groups of DCD and typically developing children.

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