3D Mapping of the Lateral Ventricles in Autism

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We used two segmentation methods (surface-based maps and automated volumetry) to visualize the 3D profile of lateral ventricle abnormalities in autism. We first used manual segmentations to create statistical 3D maps, based on anatomical surface meshes, encoding morphological variability in ventricular shape in normal and autistic children. We also used an automated method on the same samples of subjects, which identifies tissue classes, corrects for partial volume effects, and extracts the lateral ventricles.

Methods. 42 T1-weighted 3D MP-RAGE MRI volumes (1.2-mm isotropic) were acquired at 3T from 20 autistic boys (age: 9.4 yrs.+/-3.4SD) and 22 controls (10.4 yrs.+/-2.4SD). All subjects were matched for age, height, gender and social background, but not for full-scale IQ (autistic: 91.4 +/-14.2; controls: 103.0+/-9.6).

Scans were normalized by affine transformation to ICBM standardized stereotaxic space. For the manual method, one rater, blind to age, gender, and diagnosis, delineated the lateral ventricles using a standardized protocol with known reliability. We focused on the superior and occipital horns due to the minimal CSF in the inferior horns. Ventricular volumes were mapped using a 3D distance field to measure the distance of each surface boundary point to a 3D medial curve derived for the structure. Ventricular surface meshes were spatially registered and averaged across subjects in each diagnostic group. Shape differences and spatial patterns of

volumetric deficits were visualized using color-coded statistical maps. Shape differences, visualized in the average anatomical maps, were assessed using surface-based nonparametric regression and permutation tests to compute a null distribution for the total surface area of suprathreshold statistics.

For the automatic method, a fuzzy tissue classifier was used to segment brain tissues in the MR images. Mathematical morphology operators were then used to extract the lateral ventricles while correcting for partial volume effects on their boundaries. The procedure, which is fast and unsupervised, was applied to the 42 MRI volumes. Group differences in ventricular volumes were assessed with multivariate regression.

Results. Compared to healthy controls, the autistic group showed left ventricular reduction in the total superior horn volume (p=0.035), and more specifically in the left occipital horn (p=0.012). Also the right frontal horn was significantly reduced in autism (p=0.030). Permutation tests run on specific regions of interest showed that the right (p=0.026) and left (p=0.015) frontal horn as well as the left occipital horn (p=0.010) were significantly reduced in the disorder.

Conclusion. We are the first to map lateral ventricle deficits in autism, comparing two segmentation methods. Automatically-computed volumes were comparable with those derived manually, and surface maps visualized the deficit profile in 3D. Previous studies on ventricular abnormalities in autism are inconsistent showing either an enlargement, or no deficit. The ventricular volume deficit may be secondary to subcortical white matter expansion [1], or may be associated with the exaggerated growth in brain size reported in infants with autism.

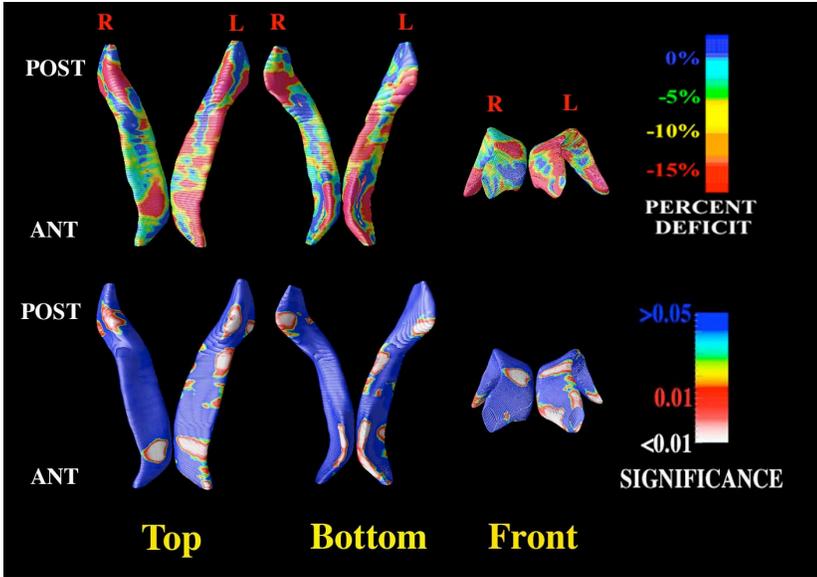References: [1] Herbert et al., Ann Neurol. 2004; 55(4):530-40. [2] Barra et al., JMRI, 2002; 15:16-22.

Table 1: Lateral ventricle volumes (superior/occipital horns only) in autistic subjects and controls

LV component (mm³)	AUT (n=20) †	CTL (n=22) †	Scaled to ICBM Space		Unscaled	
			t	P	t	p
Total volume left	6264.02 (±3567.16)	8415.00 (±3871.73)	1.9	**.0346**	1.8	**.0359**
Total volume right	5784.35 (±2635.71)	7420.98 (±4213.39)	1.5	.0719	1.5	.0731
Volume right frontal horn	3033.80 (±1611.29)	4178.50 (±2166.76)	1.9	**.0305**	2.0	**.0263**
Volume right occipital horn	2750.54 (±1636.39)	3242.48 (±2132.54)	0.8	.2051	0.7	.2327
Volume left frontal horn	3776.93(±3448.36)	4738.96(±2014.04)	1.1	.1354	1.1	.1442
Volume left occipital horn	2487.09 (±1083.36)	3676.03 (±2029.42)	2.3	**.0123**	2.3	**.0128**

Abbreviations: AUT, autistic; CTL, controls; LV, lateral ventricles.
† Values are mean (SD).