Morphology of the posterior superior temporal plane and language abilities in autism

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Summary

Autism spectrum disorder (ASD) is a prevalent developmental disorder characterized by social and communication impairments. Structures in the superior temporal plane, including Heschl's gyrus (HG) and planum temporale (PT) play key roles in social and linguistic communication. However, the morphology of the superior temporal plane is highly variable, and automated, curvature-based parcellations of HG and PT are notoriously inaccurate. Here, we manually labelled HG and PT to investigate whether the morphology or morphometry of these structures differs in ASD vs. neurotypical (NT) children, and how they related to language skills in ASD.

Our Findings:

1. HG is significantly larger bilaterally in ASD than NT (both volume and surface area), but no group difference in cortical thickness.
2. Groups did not differ in volume, surface area, or thickness of PT.
3. There were few brain-behavior correlations in these regions:
   1. Cortical thickness in PT was negatively related to SCQ in ASD.
   2. More right-lateralized HG gray matter volume was associated with higher SCQ scores in ASD.

Methods

Subjects: Brain scans and neuropsychological assessments from *N*=109 children aged 5-18 years; are included in this study. Of these, n=70 were neurotypical controls (NT), and n=39 were diagnosed as autistic (ASD), confirmed by ADOS.

(x̄ ± sd)	NT	ASD
Age	10.2 ± 3.3	11.3 ± 3.1
Sex	34 F / 36 M	7 F / 32 M
KBIT	114.9 ± 14.4	107.4 ± 16.9
CELF (CLS)	116.5 ± 11.2	96.6 ± 19.8
ADOS (CSS)	1.2 ± 0.6	6.2 ± 2.5
SRS (Raw)	25.5 ± 17.5	88.5 ± 26.7
SCQ (Total)	4.0 ± 3.5	18.2 ± 8.5

MRI Data Acquisition: T1-weighted MRI scans were collected via the 3T Siemens Trio MRI scanner at the Martinos Center at MIT. Data were deidentified prior to automatic and manual analyses, which were carried out blind to participant group.

MRI Data Analysis: Cortical reconstruction and parcellation were performed via the default stream in *FreeSurfer* 6.0.0. Manual corrections to the pial and white matter boundaries were performed based on the output of *Qoala-T*. Manual labelling of Heschl's gyrus (HG) and planum temporale (PT) was first performed on the inflated cortical surface. A complete posterior duplication (CPD) or the posterior half of a common stem duplication (CSD) were labelled as HG2. These labels were transformed into the volume, masked by the cortical ribbon, and manually corrected to conform to standard volumetric anatomical landmarks for the borders of these structures. For statistical analyses, both HG1 and HG2 of a CSD were included in HG, whereas HG2 from a CPD was included as part of PT. Statistical models of group differences and within-group correlations include IQ (KBIT), Age, Sex, and Intracranial Volume (ICV) as covariates to control for the known effects of these factors on brain size and cortical thickness.

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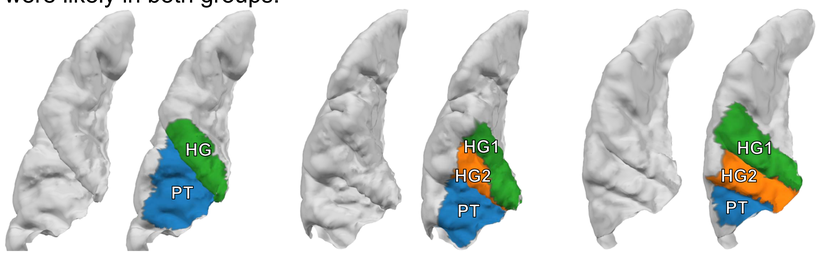
Superior Temporal Morphology

There was no difference between groups in the prevalence of the various HG configurations (via chi-square tests). Duplications were likely in both groups.

	NT		ASD	
Morph.	**LH**	**RH**	**LH**	**RH**
SHG	59% (41)	57% (40)	67% (26)	41% (16)
CSD	17% (12)	27% (19)	28% (11)	33% (13)
CPD	24% (17)	16% (11)	5% (2)	26% (10)

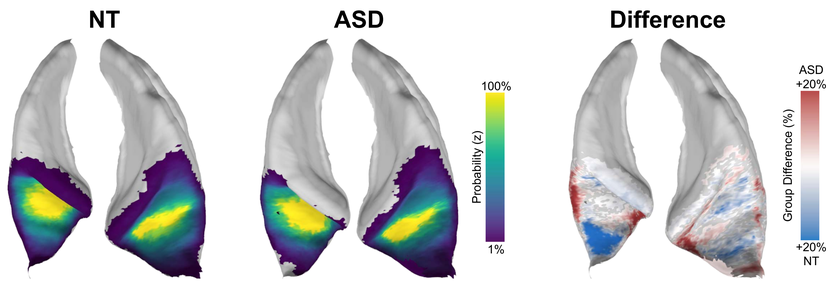


Single Heschl's Gyrus (SHG) | **Common Stem Duplication (CSD)** | **Complete Posterior Duplication (CPD)**

Planum Temporale Morphometry

PT was larger in the left vs. right hemisphere in both groups; cortical thickness decreased with age. PT volume, surface area, and cortical thickness did not differ between ASD and NT.

ANOVA: F (p)	Volume	Surface Area	Thickness
Group	0.01 (0.94)	0.00 (0.98)	0.38 (0.54)
Hemi	**3.60 (0.06)**	**4.77 (0.03)**	**9.15 (0.003)**
Age	**9.34 (0.003)**	**3.79 (0.05)**	**28.96 (5e-7)**
KBIT	1.05 (0.31)	0.63 (0.43)	0.90 (0.35)
Sex	0.88 (0.35)	2.64 (0.11)	**3.82 (0.05)**
ICV	**17.10 (8e-5)**	**13.82 (0.0003)**	**7.37 (0.008)**
Group x Hemi	0.61 (0.44)	0.46 (0.50)	1.00 (0.32)

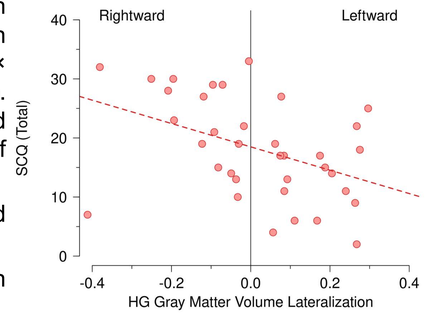


Brain–Behavior Relationships

Modelling the relationship between HG gray matter volume and SCQ in ASD children revealed a Thickness × Hemisphere interaction ($p < 0.005$). Higher SCQ scores were associated with greater rightward lateralization of HG volume (and surface area).

Overall PT thickness was associated with SCQ scores in ASD ($p < 0.05$).

There were no correlations between neuroanatomy and CELF scores.

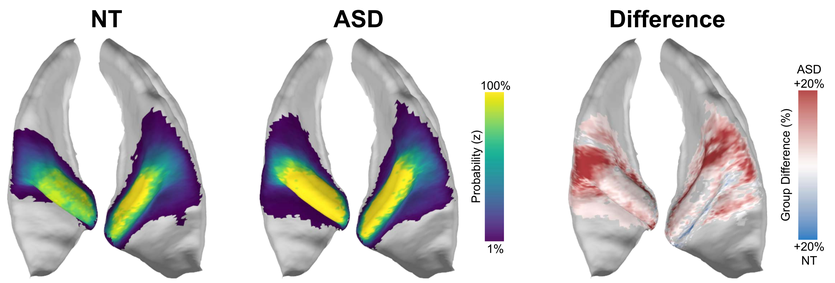


Heschl's Gyrus Morphometry

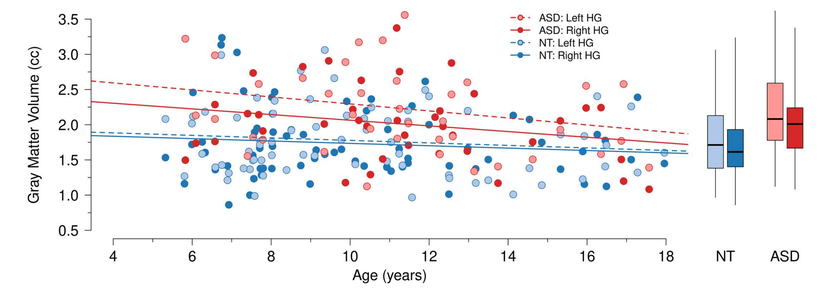
HG was significantly larger bilaterally in ASD vs. NT (volume and surface area).

Overall, HG tended to have greater cortical surface area in the left hemisphere, while being thicker on the right.

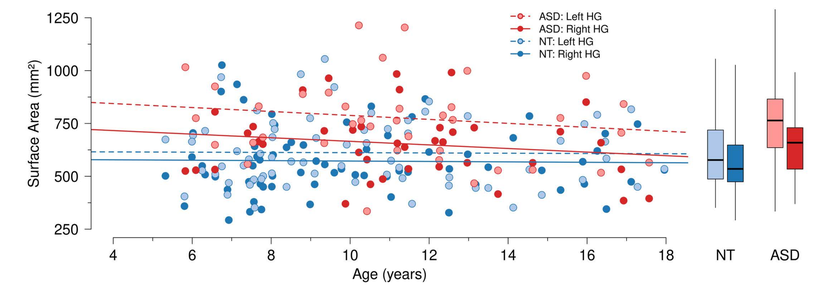
ANOVA: F (p)	Volume	Surface Area	Thickness
Group	**17.52 (6e-5)**	**15.06 (0.0002)**	1.66 (0.20)
Hemi	**3.40 (0.07)**	**12.90 (0.0005)**	**40.37 (5e-9)**
Age	**4.12 (0.04)**	0.36 (0.55)	**13.54 (0.0004)**
KBIT	1.31 (0.25)	1.38 (0.24)	0.24 (0.62)
Sex	0.10 (0.75)	0.84 (0.36)	**10.16 (0.002)**
ICV	**16.23 (0.0001)**	**12.41 (0.0006)**	**5.76 (0.02)**
Group x Hemi	1.57 (0.21)	**3.33 (0.07)**	**2.39 (0.09)**



Gray Matter Volume



Cortical Surface Area



Cortical Thickness