

Structural connectivity of Heschl's gyrus and planum temporale in children with autism

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Summary

We report an exploratory, structural connectivity-focused follow-up expanding upon our findings of structural differences in Heschl's gyrus (HG) and planum temporale (PT) in children with and without autism spectrum disorder (ASD). Impairments in hearing, language, and communication are prevalent in individuals with ASD¹⁻³. Functional MRI studies of auditory cortex have found that ASD is associated with reduced functional connectivity between temporal and non-temporal regions⁴⁻⁶ and atypical activation in early auditory processing regions⁷⁻¹⁰.

Here, we used probabilistic tractography seeded from manually delineated HG and PT to investigate group differences in connection strength and laterality, as well as the relationship between connectivity laterality and ASD symptom severity. **We found that L HG/PT–frontoparietal connectivity tended to be greater in ASD, with increased left-lateralization in ASD associated with greater communication impairment.**

Methods

Participants: Retrospective analysis of pediatric structural scans obtained from the *Brain Imaging of Language Development* study¹¹

- **ASD:** n=37, 5.9–17.6 years (mean=11.3), 31M / 6F; diagnosis confirmed by ADOS
- **TD:** n=64, 5.3–18.0 years (mean=10.3), 32M / 32F
- T1-weighted and diffusion-weighted MRI were collected via the 3T Siemens Trio MRI scanner at the Martinos Center at MIT
- Social Responsiveness Scale: Social Communication (SC) Score

Region of interest labeling: Using cortical reconstruction from FreeSurfer¹² (v6.0.0), manual labeling of HG and PT was performed on the inflated surface

Tractography: Probabilistic Tractography using FSL Protrackx^{13,14} was conducted from HG or PT seeds to frontal and parietal region targets (Desikan-Killiany atlas¹⁵)

- **Deterministic tractography** using BrainSuite¹⁶ was performed for visualization; the whole brain tractogram was filtered with each auditory cortical region
- **Connectivity Index (CI)** as $\log(\text{streamlines reaching target}) / \log(\text{total streamlines})$ was the dependent measure, which accounts for different seed area sizes¹⁷
- **Laterality Index (LI)** as $(\text{left CI} - \text{right CI}) / (\text{left CI} + \text{right CI})$; larger LI values indicate greater seed-target connectivity in the LH relative to the RH homolog

Statistical tests: Group differences assessed by repeated measures ANOVA & target-specific LME models. ASD brain-behavior relationships assessed via LME for SC ~ LI, controlling for age, sex, & total intracranial volume. Uncorrected *p*-values.

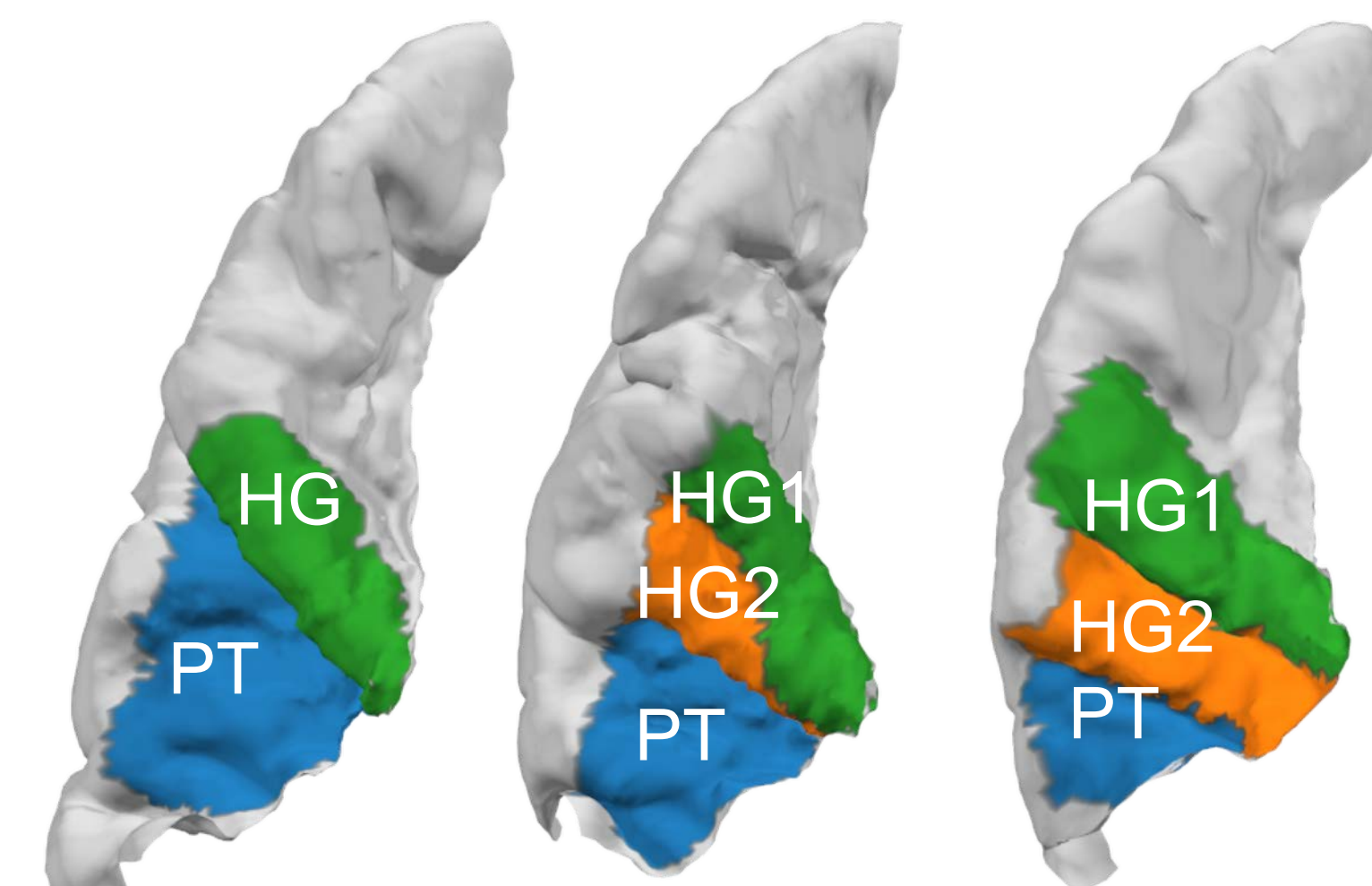
Discussion

Prior findings of auditory cortical structure differences (not shown): Bilateral HG surface area was greater in ASD vs. TD, with greater leftward asymmetry. Intracortical myelination (ICM; T1/T2) was also greater in left HG in ASD vs. TD, and increased ICM was associated with greater social communication impairment.

Connectivity findings: Children with ASD have greater left-lateralized connectivity between Heschl's gyrus and frontoparietal regions, and the degree of left-lateralization is positively associated with their communication impairment severity. Increased left-lateralization parallels our findings of greater surface area and myelin content in left HG¹⁸. The relatively reduced RH connectivity may reflect differences in predominately right-lateralized processes like emotional prosody and voice identity recognition^{19,20}, both of which may be impaired in ASD^{9,10,21}. Similarly, another study with this dataset found that white matter microstructure (increased fractional anisotropy) of right inferior longitudinal fasciculus was related to slower speech rate²². The pattern of aberrant RH brain structures and communication impairments suggests that RH contributions to communication may be more important than indicated by the classical literature²³⁻²⁵.

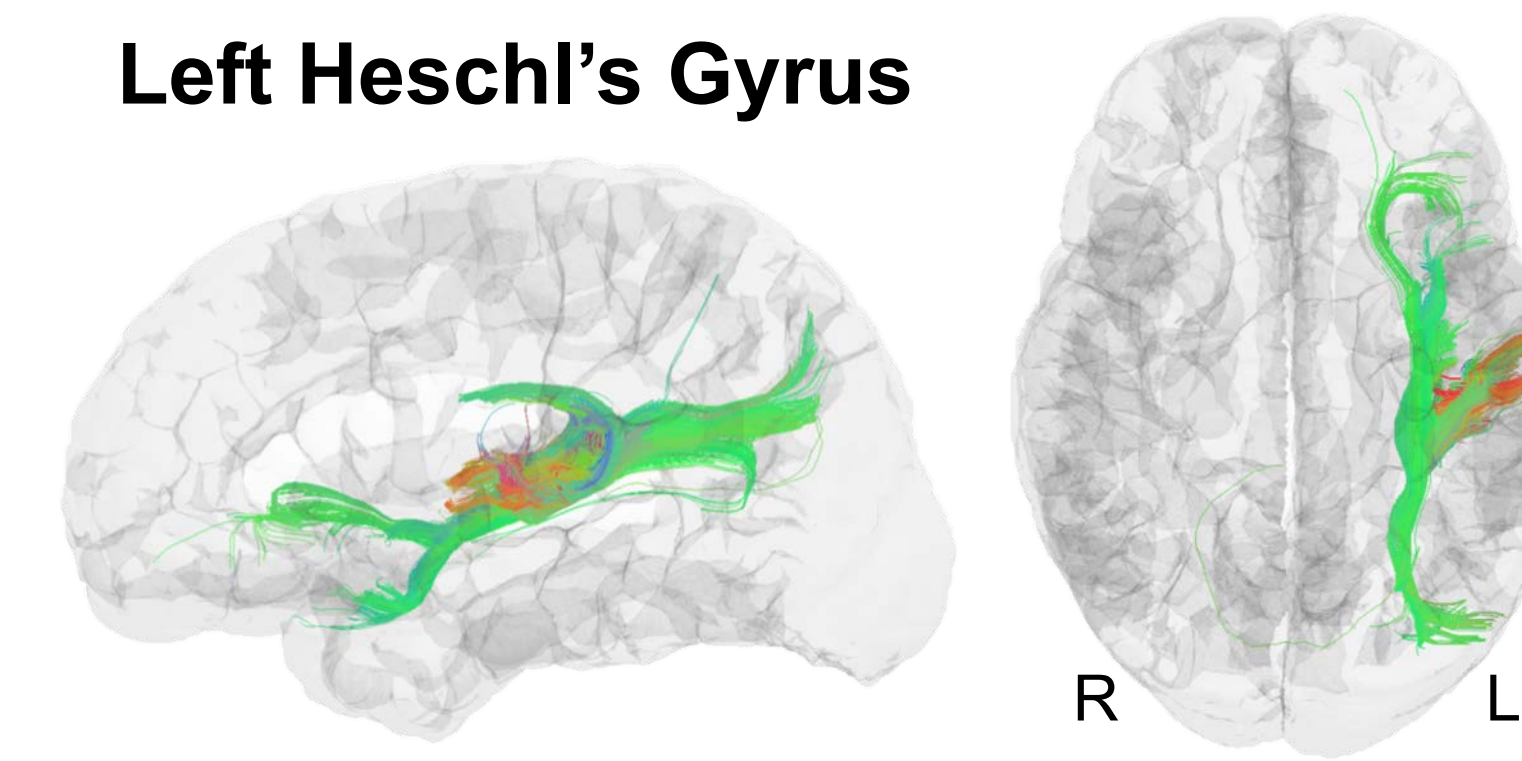
Auditory area labeling and tract reconstruction

Variation in superior temporal anatomy

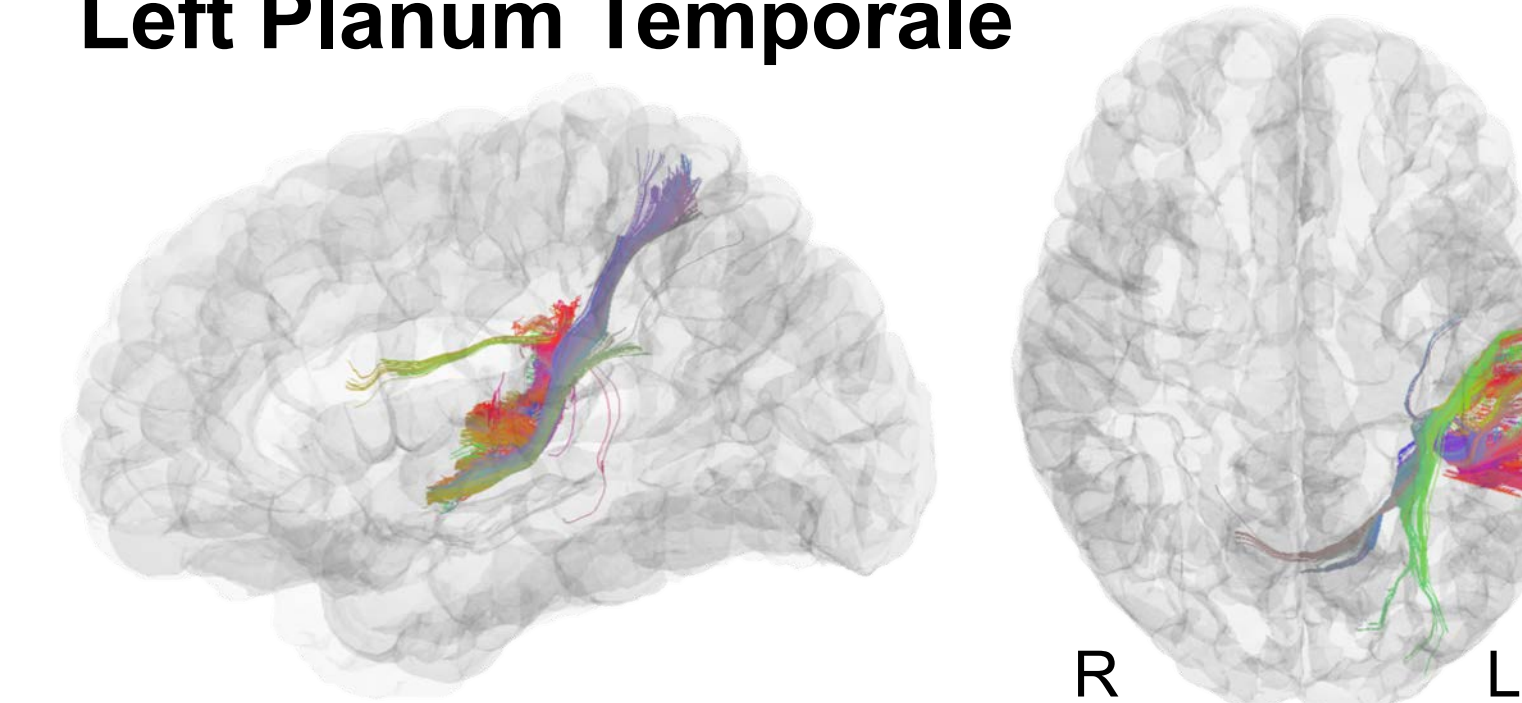


Three representative configurations of superior temporal cortical curvature: *single HG* (left), *common stem duplication* of HG (middle), and *complete posterior duplication* of HG (right), along with PT.

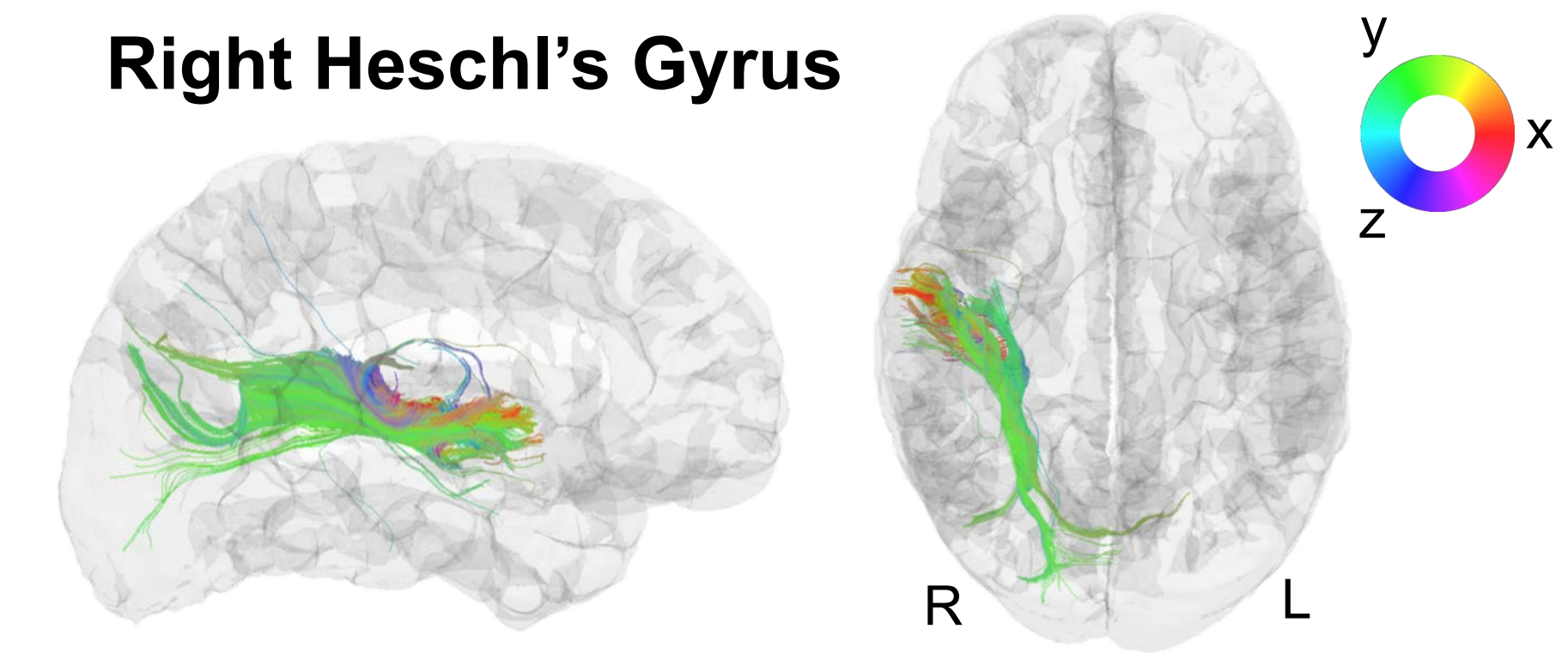
Left Heschl's Gyrus



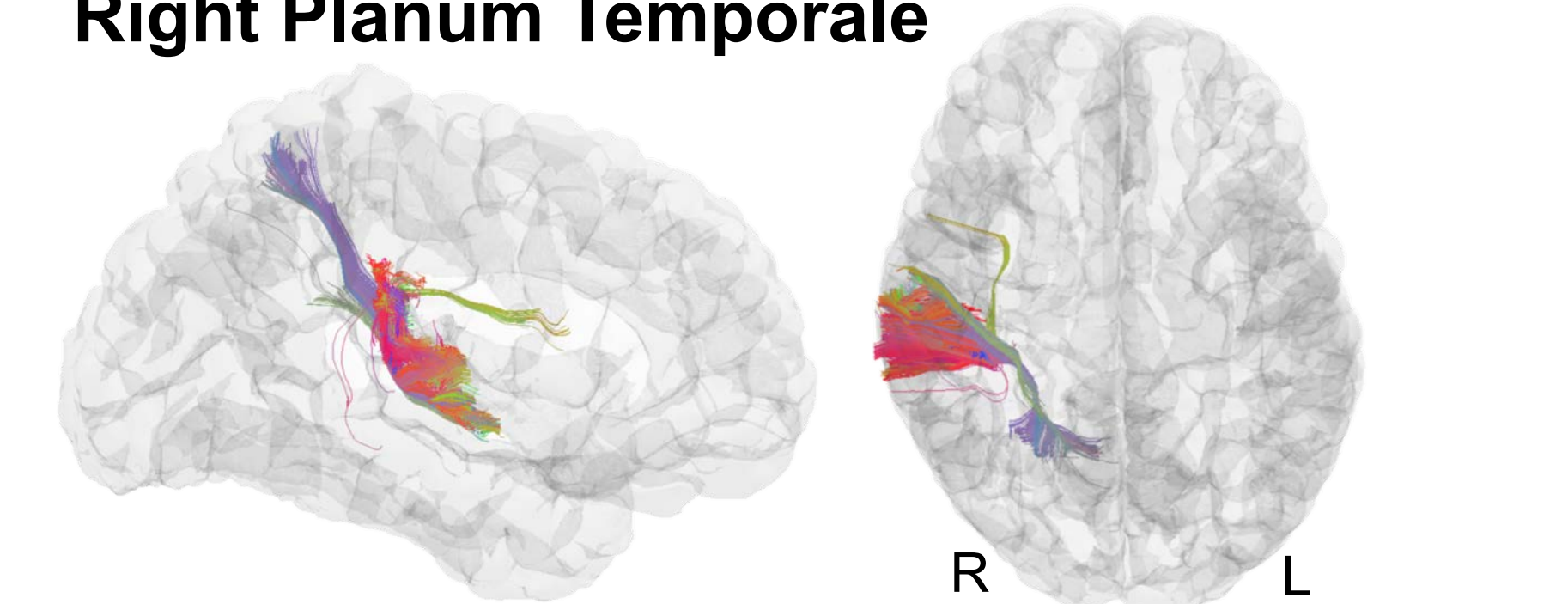
Left Planum Temporale



Right Heschl's Gyrus

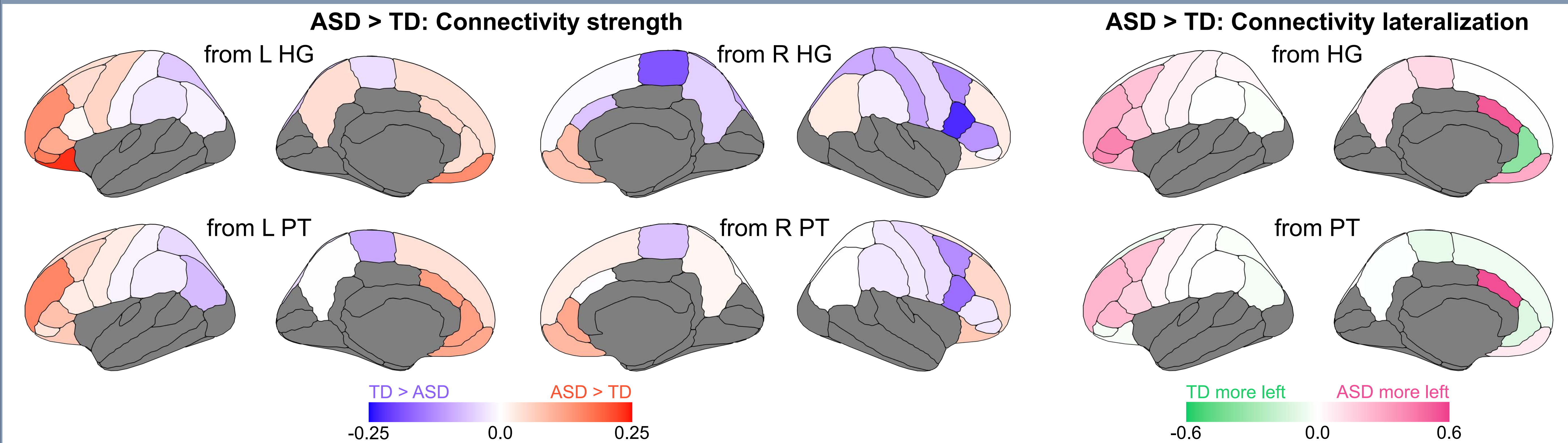


Right Planum Temporale



Representative deterministic tractograms by hemisphere filtered with either HG or PT.

Group differences in auditory – frontoparietal connectivity



L HG / PT (CI)

- Increased CI to frontal regions in ASD
- Decreased CI to parietal regions in ASD
- Group differences (by seed): *n.s.*
- Seed–target tests: *n.s.*

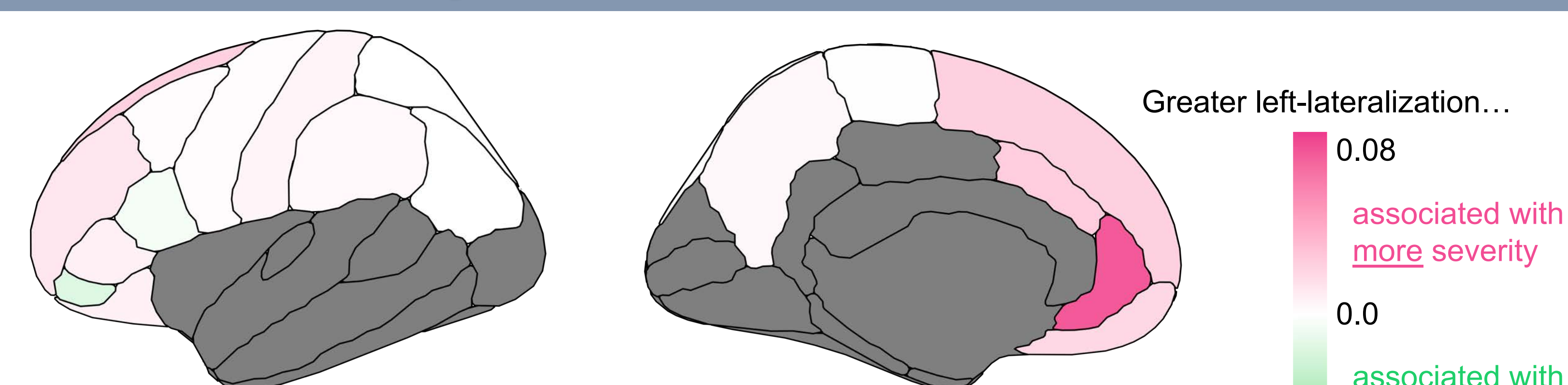
R HG / PT (CI)

- Generally decreased CI (except to SMG, SFG, aMFG, OFC)
- Group differences (by seed): *n.s.*
- Target-specific tests: Less R HG to R IFGpo connectivity (in ASD) ($p < 0.05$)

HG/PT–frontoparietal connectivity is more left-lateralized in ASD

- Group differences: HG: $p < 0.05$, PT: *n.s.*
- Target-specific tests: (ASD) greater left-lat. for HG & IFGpo, precentral gyrus ($p < 0.05$)

Connectivity – behavior correlations in ASD



Increased left-lateralization of connectivity from HG to rostral ACC and SFG is associated with more severe communication impairment in ASD ($p < 0.05$)

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Acknowledgments

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