Diffusion Two-Tensor Tractography Study on Inter-Hemispheric Connection between Bilateral Heschl's Gyrus in Schizophrenia

H. P. Ng[1,2], M. Kubicki[1,3], J. Malcolm[1], Y. Rathi[1,3], P. Pelavin[1], R. W. McCarley[3], and M. E. Shenton[1,3]

[1]Psychiatry Neuroimaging Lab, Brigham and Women's Hospital, Harvard Medical School, Boston, Massachusetts, United States, [2]Singapore Bioimaging Consortium, Agency for Science, Technology and Research, Singapore, -, Singapore, [3]Clinical Neuroscience Division, VA Boston Healthcare System, Harvard Medical School, Brockton, Massachusetts, United States

Introduction

Heschl's gyrus (HG) is primary auditory cortex, which plays a crucial role in auditory perception. Previous studies suggest that decrease in HG volume is linked to schizophrenia [1, 2]. These factors serve as motivation for the current study to investigate the inter-hemispheric connection between bilateral HGs in normal subjects (NC) and schizophrenics (SZ) using measures derived from diffusion tensor imaging (DTI). This is the first study we are aware of that investigates these connections. Furthermore, as the single-tensor streamline tractography was unable to find these connections reproducibly throughout the population, we employed a recent method of filtered two-tensor tractography [3].

Methods

This two-tensor tractography study includes 17 male SZ and 14 male NC, group matched for age, right-handedness, IQ, and parental socioeconomic status. The magnetic resonance images (MRI) were acquired using a 3T GE scanner. The parameters for structural MRI acquisition are: TR=7.48ms TE=3ms FOV=256mm, 176 axial slices with 1mm thickness each and the parameters for DTI acquisition are: 51 directions, TR=17000ms TE=78ms FOV=24cm, 144×144 encoding steps, 85 axial slices with 1.7mm thickness each. The structural MRI and DTI data for each subject were non-linearly registered and Freesurfer (http://surfer.nmr.mgh.harvard.edu) segmentation was performed on the former to facilitate the extraction of bilateral HGs white matter as the regions of interest (ROI). These ROIs were used to extract the inter-hemispheric connections of interest (**Fig. 1**) from two-tensor whole-brain tractography. Mean fractional anisotropy (FA), mode trace, parallel and perpendicular diffusivity were then computed for each subject.

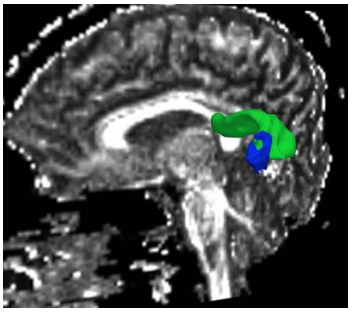

Fig.1: Inter-hemispheric connection between bilateral HGs through the corpus callosum

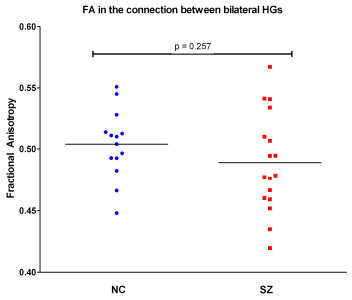

Fig.2: Between-group differences in mean FA

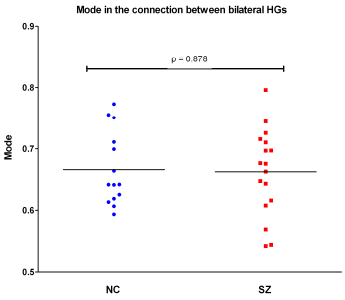

Fig.3: Between-group differences in mean mode

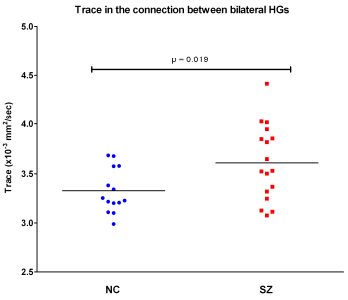

Fig.4: Between-group differences in mean trace

Results and Discussion

The mean values for FA (**Fig. 2**), mode (**Fig. 3**), trace (**Fig. 4**), parallel (**Fig. 5**) and perpendicular diffusivity (**Fig. 6**) for NC and SZ are collated in **Table 1**. Statistically significant between-group differences were observed for mean trace, parallel and perpendicular diffusivity with p-values at 0.019, 0.010 and 0.032 respectively (**Figs. 4-6**). The results are within expectations that NC have higher FA and lower trace compared to SZ as these two observations are commonly linked to healthier white matter in the human brain.

As noted previously, single-tensor streamline tractography was unable to reliably reproduce these tracts, so we turned to a recently proposed method of filtered tractography [3]. Unlike streamline tractography which independently estimates the tensor model at each step, filtered tractography takes into account estimates made in previous steps allowing it to learn and suppress signal noise for a more accurate estimate. Furthermore, this increased stability allows the use of a two-tensor model capable of tracing through crossings and branchings not found with the single-tensor model.

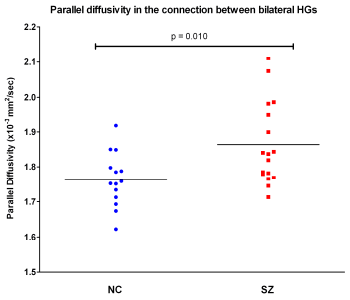

Fig. 5: Between-group differences in mean parallel diffusivity

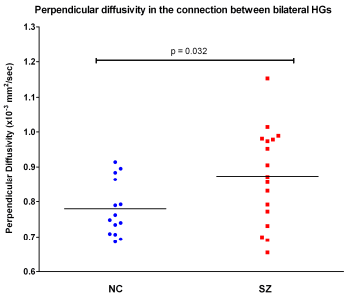

Fig. 6: Between-group differences in mean perpendicular diffusivity

	FA	mode	trace (×10^{-3})	parallel diffusivity (×10^{-3})	perpendicular diffusivity (×10^{-3})
NC	0.5038	0.6666	3.322	1.763	0.7799
SZ	0.4890	0.6629	3.609	1.864	0.8734

Table 1: Collated mean FA, mode, trace, parallel and perpendicular diffusivity

Conclusions

These findings suggest that the diffusivity in bilateral HG connections differ between NC and SZ. Future studies are needed to confirm these findings and to evaluate patients early in the course of their illness, as well as to evaluate further the localization of differences between groups and their association with positive and negative syndrome scale (PANSS) for schizophrenia.

Acknowledgements

The first author would like to thank the Agency for Science, Technology and Research (A*STAR), Singapore for funding him through the A*STAR Graduate Scholarship (Post-Doc) administered by A*STAR Graduate Academy. This work was supported by: National Institutes of Health (NIH) R01 MH 50747 to MES and U54 EB005149 to MK; Department of Veterans Affairs VA Merit Award to MES and RWM; Center for Intervention Development and Applied Research P50 MH080272 to MES and RWM.

References

[1] Hirayasu, Y., McCarley, R.W., Salisbury, D.F., Tanaka, S., Kwon, J.S., Frumin, M., Snvderman, D., Yurgelun-Todd, D., Kikinis, R., Jolesz, F.A., Shenton, M.E., 2000. Planum temporale and heschl gyrus volume reduction in schizophrenia: a magnetic resonance imaging study of first-episode patients. Arch. Gen. Psychiatry 57 (7), 692-699.

[2] Kasai, K., Shenton, M.E., Salisbury, D.F., Hirayasu, Y., Onitsuka, T., Spencer, M.H., Yurgelun-Todd, D., Kikinis, R., Jolesz, F.A., McCarley, R.W., 2003. Progressive decrease of left heschl gyrus and planum temporale gray matter volume in first-episode schizophrenia: a longitudinal magnetic resonance imaging study. Arch. Gen. Psychiatry 60 (8), 766–775.

[3] Malcolm, J., Shenton, M.E., Rathi, Y., 2009. Neural tractography using an unscented kalman filter. Inf. Process. Med. Imaging, 126-138.