QUANTITATIVE HIGH ANGULAR RESOLUTION DIFFUSION IMAGING (HARDI) ASSESSMENT OF THE AUDITORY RADIATION IN AUTISM

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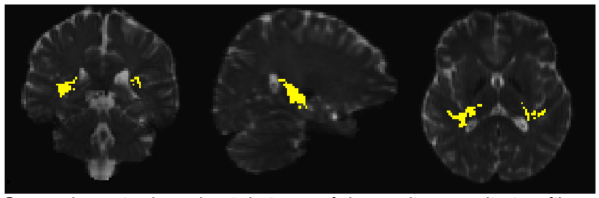
Introduction: Dysfunction of the auditory system has been implicated in autism spectrum disorders (ASD). Magnetoencephalography and diffusion MR have been previously used to detect latency of the auditory evoked field and abnormal asymmetry of superior temporal gyrus microstructure in ASD [1, 2]. Quantitative assessment of the auditory radiation with diffusion MRI may improve our understanding of the neurobiological basis of ASD. However, this primary sensory tract crosses other white matter tracts, necessitating the use of high angular resolution diffusion imaging (HARDI) for fiber tracking and measurement. This study applies quantitative HARDI fiber tracking of the auditory radiation to determine microstructural changes in ASD.

Methods:

This study included 10 typically developing (TD) children (mean age 11.8 ± 2.2 years) and 13 children (mean age 11.9 ± 2.7 yrs) diagnosed with ASD. All subjects were right-handed. HARDI was acquired at 3T on a Siemens Verio with 64 gradient directions, b=3000 s/mm^2, TR/TE=16.9s/110ms, parallel acceleration of 2, and 2x2x2mm voxels. HARDI imaging time was approximately 18 minutes. High-resolution T1-weighted anatomical MPRAGE volumes were also acquired. Probabilistic HARDI fiber tracking using the solid-angle q-ball reconstruction was used to delineate auditory radiations from Heschl's gyrus to the medial geniculate nucleus [3]. The starting and filter regions were generated with Freesurfer's white matter parcellation of the T1-weighted volumes and registered to the b=0 echo planar volume with FLIRT. Voxels containing fiber tracks were used to measure tract-specific HARDI derived generalized fractional anisotropy (GFA) and DTI parameters including fractional anisotropy (FA), mean diffusivity (MD), parallel diffusivity, and transverse diffusivity. Transverse diffusivity is the mean of the minor eigenvalues. The probabilistic fiber tracking information is incorporated by weighing the tract-specific mean by the number of fiber trajectories passing through each voxel. Left to right hemisphere asymmetry within each subject was measured as a percent difference: $\frac{(L-R)}{(L+R)/2}*100$.

Results:

HARDI fiber tracks of the auditory radiation were successfully generated for each of the subjects (figure). Significant changes in the hemispheric asymmetry of GFA, FA, and transverse diffusivity were detected between the typically developing and ASD subjects (table). FA switched from higher in the left hemisphere in TD subjects to lower on the left in ASD subjects. GFA was higher in the left hemisphere of TD subjects and increased in degree of asymmetry in ASD subjects. Transverse diffusivity switched from lower in the left hemisphere in TD subjects to higher in the left hemisphere in ASD subjects. No significant changes in asymmetry were detected with mean diffusivity or parallel diffusivity.



Coronal, sagittal, and axial views of the auditory radiation fiber tracks (yellow) in a 14 year old typically developing male.

Discussion/Conclusions:

HARDI fiber tracking is necessary to perform fiber tracking of the auditory radiation and obtain measures of microstructure specific to the volume occupied by the tract. This work demonstrates the feasibility of conducting quantitative HARDI fiber tracking of the auditory radiation. Shifts in asymmetry of both traditional DTI parameters and the HARDI based GFA were detected. The change in FA asymmetry is consistent with prior studies of the superior temporal gyrus [2]. The alteration of GFA asymmetry indicates a change in white matter complexity or degree of fiber crossings within the auditory radiation.

	% Asymmetry Positive= Left higher		*p-value*
	TD	ASD	
GFA	0.58	7.01	0.048*
FA	6.23	-5.60	0.005*
MD	-1.82	0.096	0.40
Parallel Diff.	0.93	-2.17	0.17
Trans. Diff.	-4.46	2.38	0.038*

References:

1) Roberts, TP, et. al., Autism Res., 2010 Feb; 3(1):8-18.
2) Lange, N, et. al., Autism Res., 2010 3(6):350-8.
3) Berman, JI. et.al., Neuroimage., 2008; 39(1):215-222.