Toward an Integrated Structural-Functional Characterization of the Posterior Superior Temporal Sulcus Abnormalities in Autism Spectrum Disorders

Mariana Lazar[1], Laura Miles[1], and Jeffrey Donaldson[1]
[1]*Department of Radiology, New York University School of Medicine, New York, New York, United States*

Introduction

Autistic Spectrum Disorders (ASD) are complex developmental disorders that are characterized by a wide range of behavioral and cognitive deficits. Evidence suggests both atypical brain microstructure and impaired function and connectivity (1); however, the mechanisms involved are poorly understood. Posterior Superior Temporal Sulcus (PSTS), which is implicated in several areas relevant to ASD, including social communication and language, has been proposed as one primary pathological locus (2, 3). In this abstract we employ a multimodal imaging approach (T1w, diffusion, and functional MRI) to characterize PSTS' microstructure as well as its anatomical and functional connectivity in a group of young adults with a diagnosis of high functioning ASD (IQ>80) versus a group of Typically Developing (TD) subjects.

Methods

Anatomical (T1w), Resting-State Functional MRI (RS-FMRI), and Diffusion Imaging data were collected in 19 young adults with ASD and 19 TD subjects 18 to 25 year old. Several diffusion and FMRI data sets have been discarded due to motion artifacts or subjects not completing the scan resulting in 17 TD and 16 HFA diffusion data sets and 19 TD and 15 ASD RS-FMRI data sets. There were no significant differences between groups (and subgroups included in the diffusion or RS-FMRI analyses) in age and IQ.

Diffusion imaging data has been obtained for two b-values (1000 and 2000 s/mm^2) and b=0 s/mm^2 (with a voxel size = 2.3mm^3). RS-FMRI data was acquired for ~7 min using standard imaging parameters (TR=2s, TE=29ms, voxel size ~3.2mm^3).

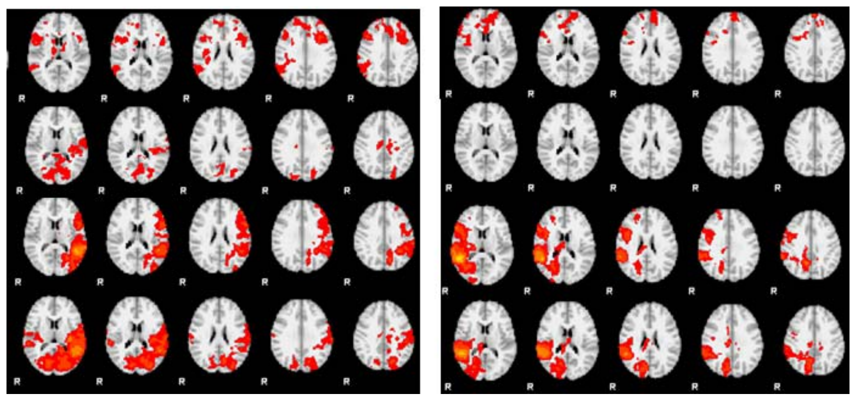

Figure 1. Differences in functional connectivity of the left and right PSTS. From top: TD>ASD, ASD>TD, mean TD, mean ASD.

Anatomical Images: Right and left PSTS were segmented using Freesurfer software package. Cortical thickness (CT) values were obtained as part of Freesurfer's processing pipeline. *Diffusion Images* were processed using the Diffusional Kurtosis Imaging (DKI) formalism (4). Mean (MK), Axial (AK), and Radial Kurtosis (RK) maps and diffusivity maps were obtained for all subjects, with kurtosis values representing measures of microstructural tissue complexity (4). Mean MK, RK, and AK values for right and left PSTS were obtained after registering the Freesurfer ROIs to the diffusion data. *RS-FMRI* data were processed using AFNI and FSL software packages. Preprocessing included slice timing and motion correction, smoothing using a 6mm FWHM Gaussian kernel, temporal bandpass filtering (0.01 Hz < f < 0.1 Hz), regression of the six motion parameters and of the white matter and CSF signals. Seeds for functional connectivity analyses were placed in the right and left PSTS regions.

Table 1: Comparison of structural properties of PSTS and SLF in TD versus ASD

Region		TD	ASD	*p*
Left PSTS	CT	2.57±.12	2.68±.20	.066
	MK	.72±.03	.69±.05	.020
	RK	.73±.05	.68±.06	.013
Right PSTS	CT	2.67±.13	2.80±.13	.013
	MK	.74±.03	.71±.02	.014
	RK	.75±.04	.71±.04	.004
Left SLF	MK	.84±.03	.81±.03	.009
	RK	.90±.05	.84±.04	.003
Right SLF	MK	.85±.04	.83±.04	.081
	RK	.92±.06	.87±.05	.023

Results

Macro and Microstructure: Significantly decreased MK and RK were found in the ASD group for both right and left PSTS (Table 1). Significantly increased CT was found in ASD for right PSTS (Table 1) with close to significant values for the left PSTS. A significant negative correlation was found between CT and MK values in the right PSTS (r=-.695**, p=0.003) with close to significant correlation in the left PSTS (r=-.452, p=0.079) in the ASD but not in the TD group.

Functional Connectivity: Left PSTS exhibits decreased connectivity with regions of the prefrontal cortex, thalamus, caudate nucleus, brainstem region, and contralateral PSTS in ASD versus the TD group (Figure 1). Increased connectivity of left PSTS in ASD is observed with the occipital cortex, insula, fusiform gyrus, superior parietal, and middle cingulate cortex. Decreased connectivity of the PSTS with the prefrontal cortex is also seen for the right hemisphere in the ASD group. No areas of increased connectivity with the right PSTS were found for the ASD group.

Anatomical Connectivity: An atlas approach was used to construct ROIs of right and left Superior Longitudinal Fasciculi (SLF), connecting PSTS with the dorsal prefrontal cortex. Mean MK, RK, and AK values were generated for each subject. Significantly decreased MK and/or RK were found in the ASD group for both right and left tracts (Table 1).

Discussion

We report for the first time decreased PSTS microstructural organization in ASD. Importantly, the decreased microstructural measures correlates with increased cortical thickness in ASD. Functional connectivity patterns of the PSTS are in agreement with current hypotheses (5) and suggest that in young adults with ASD the PSTS may rely less on input from the prefrontal cortex with compensatory increased input from the occipital and fusiform cortices in the left hemisphere. The decreased PSTS-prefrontal functional connectivity may be associated with the observed decreased anatomical connectivity of the corresponding white matter connections. This study underlines the importance of using a multimodal framework to better characterize the brain mechanisms involved in ASD. This framework may be applied as well to other neurodevelopmental disorders.

References: 1. Vissers et al. Neurosci Biobehav Rev. 2011; **2.** Pelphrey et al. J Child Psychol Psychiatry 2011, 52:631; **3.** Redcay. Neurosci Biobehav Rev. 2008 32:123; **4.** Jensen et al. NMR Biomed 2010 23:698; **5.** Schipul et al. Front Syst Neurosci. 2011 5:10.