NODDI Measures Appear to be Sensitive to Both Age and Gender

Chandana Kodiweera[1], Andrew Alexander[2], and Yu-Chien Wu[3]

[1]Dartmouth Brain Imaging Center, Dartmouth College, Hanover, NH, United States, [2]Waisman Brain Imaging Lab, University of Wisconsin, Madison, Wisconsin, United States, [3]Center for Neuroimaging, Indiana University, Indianapolis, Indiana, United States

Target Audience: MRI scientists who focus on diffusion imaging of brain microstructures

Purpose: Fractional anisotropy (FA) from diffusion tensor imaging (DTI) [1] in the brain white matter may depend on fiber orientation as well as axonal density [2]. The Neurite Orientation Dispersion and Density Imaging (NODDI) [2] model estimates these two tissue specific quantities which are named as orientation dispersion index (odi) and intracellular volume fraction (icvf). In this abstract, we present results from the analysis of odi, icvf and FA in 48 ROIs to recognize the effect of gender in normal aging. A multiple-shell diffusion acquisition scheme (one bo, five shells of 375, 1500, 3375, 6000 and 9375 s/mm2 b-values and 6, 21, 24, 24 and 50 directions in each shell respectively), Hybrid Diffusion Imaging (HYDI) [3], was used in this study.

Methods: HYDI data were acquired on a 3T GE-SIGNA scanner with an 8-channel head coil and ASSET parallel imaging on 52 right-handed healthy volunteers (18-71 years old) which included 29 females and 23 males. The Diffusion Weighted (DW) pulse sequence was an SS-SE-EPI sequence with cardiac gating. TR was between 10-15 heart beats (12-15 s). The other MR parameters were: TE = 122 ms, δ/Δ=45/56 ms, voxel size=2x2mm2, 40 slices with slice thickness=3mm, SENSE factor=2 and a total scan-time of about 24 min. NODDI was processed using all the five shells of the HYDI data while FA measure (DTI) was done with the first two shells. The figure 1 shows sample maps. JHU white matter atlas was used to generate 48 ROIs [4]. The ROIs were transformed into the subject space for the analysis. For each subject, means of odi, ficvf and FA were calculated on 48 3D ROIs. Then the means were linearly regressed against age using gender as the covariate as in ***measure = b0 + b1*age + b2*gender + b3*(age*gender).*** The functions ***aoctool*** and ***multcompare*** in MATLAB were used to do covariance analysis and multiple comparisons respectively.

ACR	Anterior corona radiata	PCR	Posterior corona radiate
ALIC	Anterior limb of internal	PCT	Pontine crossing tract
BCC	Body of copus callosum	PLIC	Posterior limb of internal
CGC	Cingulum (cingulate gyrus)	PTR	Posterior thalamic radiation
CGH	Cingulum (hippocampus)	RLIC	Retrolenticular part of internal
CP	Cerebral penduncle	SCC	Splenium of corpus callosum
CST	Corticospinal tract	SCP	Superior cerebellar penduncle
EC	External capsule	SCR	Superior corona radiate
Fx	Fornix (column and body of	SFO	Superior fronto-occipital
Fx_ST	Fornix / Stria terminalis	SLF	Superior longitudinal fasciculus
GCC	Genu of corpus callosum	SS	Sagital stratum
ICP	Inferior cerebellar penduncle	TAP	Tapatum
MCP	Middle cerebellar penduncle	UNC	Uncinate fasciculus
ML	Medial lemnisus		

Table 1: Nomenclature of ROIs

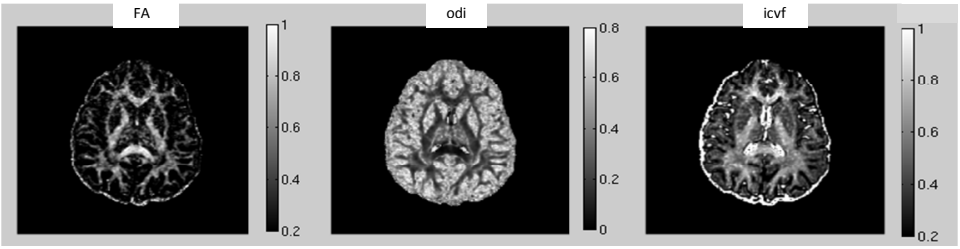

Figure 1: axial view of FA, odi and icvf

Results: A summary of the regression analyses is shown in the Table 2. Significant age and gender effects (p-value ≤ 0.05) are highlighted in green and blue respectively. The odi and icvf measures in many ROIs appear gender sensitive in aging. FA had significant changes over age in 30 ROIs. However, only one ROI showed significant FA difference in gender and one in age*gender interactions. The NODDI measure, odi, had significant changes over age in 32 ROIs. Moreover, odi was also sensitive to the gender and age*gender interactions in many ROIs. Icvf showed significant changes over age in 9 ROIs. Interestingly, icvf also had quite a few ROI with significant gender differences and age*gender interactions.

Discussion and Conclusion: Mostly FA has a negative correlation with aging while odi and icvf show positive correlations. While FA-measures with aging do not appear to be affected by gender, NODDI measures, odi and icvf do appear to be sensitive to gender. This suggests that gender should be considered in future NODDI studies. Aging of gender- sensitive ROIs, such as rate of change of neurite density with aging, differs in the two genders. Further analyses are underway to understand these differences.

References: ***1***. Peter J. Basser et al. Biophysical Journal 1994;66:259-267. ***2***. Hui Zhang et al NeuroImage 2012;61:1000-1012. ***3***. Wu and Alexander NeuroImage 2007;36:617-629. ***4***. Kenichi Oishi et al NeuroImage 43 (2008) 447-457.

ROI	FA			odi			icvf		
	age	gen	a*g	age	gen	a*g	age	gen	a*g
ACR-L	-1			1					
ACR-R	-1			1					
ALIC-L									
ALIC-R				1					
BCC	-1			1					
CGC-L				1					
CGC-R				1					
CGH-L				1			1		
CGH-R				1			1		
CP-L	-1			1					
CP-R	-1			1					
CST-L									
CST-R									
EC-L									
EC-R				1			1		
Fx	-1						1		
Fx-ST-L	-1			1			1		
Fx-ST-R	-1			1			1		
GCC	-1								
ICP-L							1		
ICP-R							1		
MCP				-1					
ML-L									
ML-R									
PCR-L	-1			1					
PCR-R	-1			1					
PCT									
PLIC-L	-1			1					
PLIC-R	-1			1					
PTR-L	-1			1					
PTR-R	-1			1					
RLIC-L	-1			1					
RLIC-R	-1			1					
SCC	-1			1					
SCP-L									
SCP-R	1								
SCR-L	-1			1					
SCR-R	-1			1					
SFO-L	-1			1					
SFO-R	-1			1					
SLF-L				1					
SLF-R	-1			1					
SS-L	-1			1					
SS-R	-1			1					
TAP-L	-1								
TAP-R	-1						-1		
UNC-L	-1			1					
UNC-R	-1			1					

Table 2: Linear regression results; significant ROIs in aging, gender and age*gender interactions shows in green, blue and orange respectively. The numbers -1 and 1 indicate negative and positive correlations with aging.