

# **A new approach to examining the role of white matter tracts in language disorders**

Isaev D.Yu., Ivanova M.V., Dragoy O.V., Akinina Yu.S., Petryshevskii A.G., Fedina O.N.,  
Dronkers N.F.

National Research University HSE, Moscow, Russia  
Center for Speech Pathology and Neurorehabilitation, Moscow, Russia  
VA Northern California Health Care System, Martinez, California, USA

## **Introduction and Aims**

Historically in the quest for the neural basis of language, most of the emphasis has been placed on the role of specific brain areas. However a growing literature is pointing towards the importance of white matter tracts in understanding the neural mechanisms of language processing and determining the nature of language deficits and recovery patterns in aphasia (Dick, Bernal, & Tremblay, 2014). Fractional anisotropy (FA), extracted from diffusion-weighted (DW) scans, is often used as a measure of the integrity of white matter tracts. In the current study, we investigated the feasibility of a new processing approach for extracting FA values from specific tracts using DW scans from individuals with aphasia coupled with atlases in MNI space. We investigated the feasibility of using this method to detect differences in tract integrity between the two hemispheres and between the patient and the control groups.

## **Methods**

Thirty-seven right-handed individuals with different types of aphasia due to left hemisphere stroke and nine age-matched healthy volunteers participated in our study.

DW data were acquired with a 1.5T Siemens Avanto scanner: acquisition matrix=70x70; FOV=192x192 mm<sup>2</sup>; TR=6000ms; TE=95ms; b=1000 s/mm<sup>2</sup>; 20 directions with two repetitions, slice thickness=2.7mm, resulting in 2.7x2.7x2.7 isovoxel.

Raw anatomical and DW data for each participant was preprocessed using the following steps:

1. Eddy current correction, tensor estimation and computation of FA maps in FSL.
2. Transformation of T1 image in SPM-8 by orienting the y-axis along the anterior commissure – posterior commissure line and reslicing the T1 image to MNI dimensions. The resulting image is referred to as rT1\_acpc.
3. Creation of the lesion mask on the rT1\_acpc image in Photoshop.
4. Co-registration of the FA map to rT1\_acpc space using the linear co-registration tool FLIRT in FSL.
5. Computation of the transformation matrix of rT1\_acpc image to MNI space using linear and non-linear co-registration tools (FLIRT and FNIRT) with cost function masking in the lesioned area.
6. Application of the inverted transformation matrix computed in step 5 to tracts of interest taken from the John Hopkins University white-matter tractography atlas (with 25% threshold). Four tracts – Inferior Fronto-Occipital Fasciculus (IFOF; left and right) and the Arcuate Fasciculus (AF; left and right) – were selected.
7. Extraction of FA values for each voxel of each tract in rT1\_acpc image space and calculation of mean FA values for each tract.

## **Results and Discussion**

Healthy controls had significantly higher FA values in both left and right IFOF tracts and left AF. No significant differences were found for the right AF. We also compared the IFOF and AF between the two hemispheres in the two groups. For the control group there were no significant differences between the integrity of the tracts in two hemispheres, while in aphasia the right hemisphere tracts had significantly higher FA values. Overall the novel processing approach resulted in reliable isolation of tracts in native space for individuals with various left hemisphere lesions and enabled extraction of FA values for the whole tract rather than just a specific point within the tract. Our study demonstrated the feasibility of this processing approach for investigating the integrity of white matter tracts in individuals with aphasia, for whom the more traditional methods of FA data analysis, such as TBSS, are not appropriate because of the inability to extract tract skeletons due to the lack of data in the lesion area and varying lesion location.

*Table 1.* FA values for left and right AF and IFOF for the aphasia and the control groups.

Tract	Mean value		Standard deviation		25%-75% Quantile		Mann-Whitney p-value
	Aphasia	Controls	Aphasia	Controls	Aphasia	Controls	
IFOF_ Left	0.3092	0.3848	0.0558	0.0229	0.2672-0.3577	0.3670 - 0.3986	< .0001
IFOF_ Right	0.3652	0.3895	0.0274	0.0174	0.3485-0.3812	0.3766 - 0.4013	.0083
AF_ Left	0.2859	0.4203	0.0868	0.0157	0.2315-0.3431	0.4145-0.4280	< .0001
AF_ Right	0.3950	0.4054	0.0388	0.0267	0.3664-0.4232	0.3805-0.4281	.4285

*Note.* IFOF - Inferior Fronto-Occipital Fasciculus; AF - Arcuate Fasciculus.