

Structural asymmetry of the Arcuate Fasciculus is not associated with functional lateralization for language, nor with handedness

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Introduction

- Among the major association tracts within the language system, the Arcuate Fasciculus (AF) was found to be extremely lateralized to the left hemisphere¹⁻² and was extensively examined for a relationship with handedness and functional language lateralization³⁻⁵
- However, it was suggested that asymmetry of the in vivo AF is not always reliably detected and depends on the chosen tractography pipeline⁶
- The **goals**: to **reconstruct** white matter tracts **with a novel hybrid tractography algorithm** that combines the strengths of both probabilistic and deterministic tractography⁷
- to **test** whether there is a **correlation** between macrostructural and microstructural **metrics of the AF** and **functional language lateralization** measures, **handedness**

Methods

- 50 healthy Russian participants (20 right-handers, 20 left-handers and 10 ambidexters; 18 males; mean age= 24.38)
- **Functional MRI** acquisition (Siemens 3T Magnetom Vario TR/TE =7 s/30 ms), sentence completion task
- **Diffusion MRI** acquisition (TR/TE = 3700 ms/101ms; 64 directions (b=1500 s/mm²) + 1 image b=0 s/mm²; (2 mm)³ resolution)
- **Quantitative Imaging Toolkit (QIT)** for an automatized reconstruction based on a **hybrid tractography algorithm**:
 - 1) Input Fiber Volume and Bundle Query
 - 2) Exploration Stage: Probabilistic Tracking and Creating Compartment Priors (angle threshold - 85 degrees, 10 seeds/voxel, min vol. fraction 0.075)
 - 3) Exploitation Stage: Optimal Compartment Assignment (Bayesian graphical model with priors) and Streamline Integration⁷
- **3 segments of the AF**: anterior, posterior, long

References

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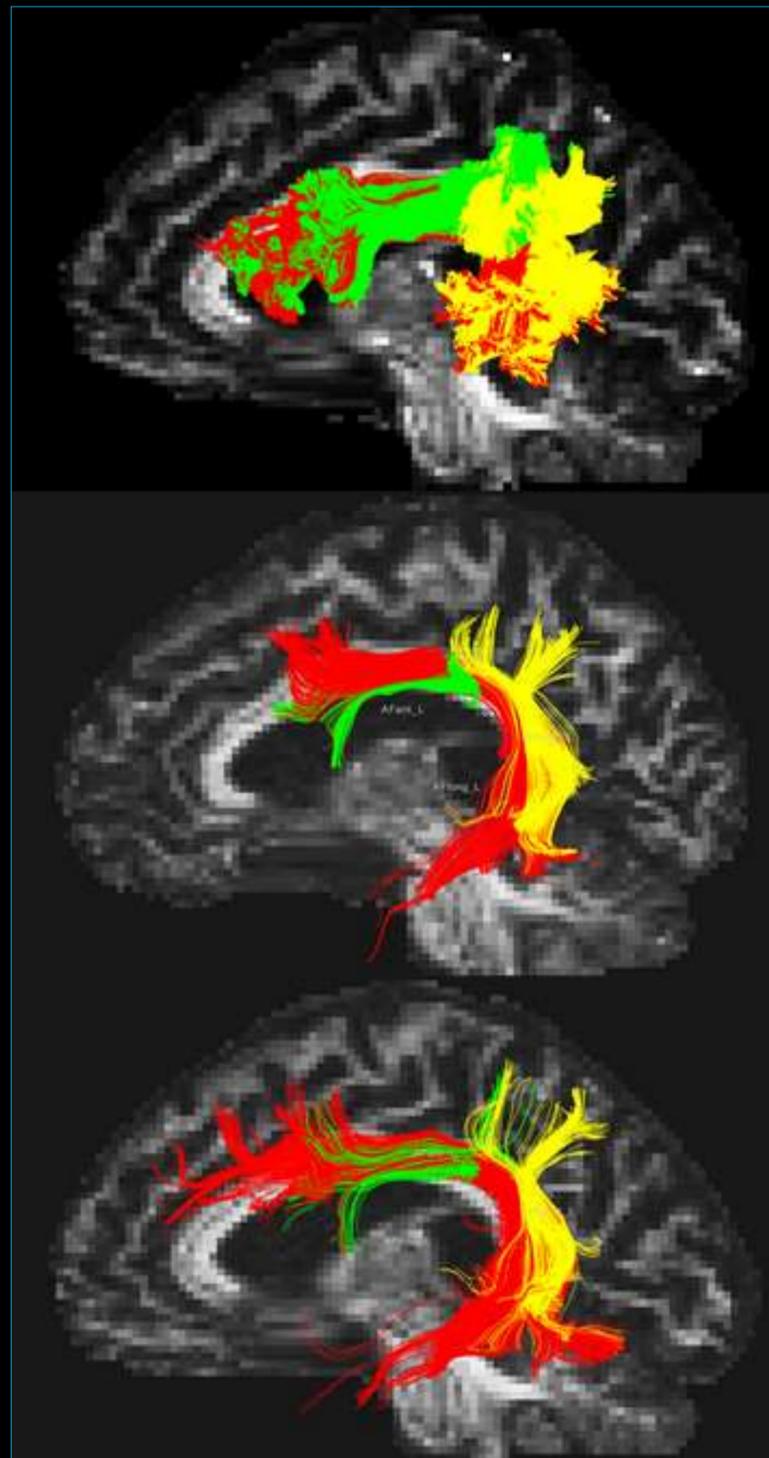


Figure 1. The AF of the same participant reconstructed by the hybrid approach (top) vs. DTI approach (middle) and CSD approach (bottom)

Methods (continued)

- **Laterality indices (LIs)**: DTI (all metrics) computed by a formula (left - right) / (left + right); **fMRI**: LI-Toolbox SPM
- **Handedness scores** ranged from -100 to +100, Edinburgh Handedness Inventory⁸

Results

- Significant correlation between **functional LIs** (fMRI) and **handedness** scores ($r = 0.391, p = 0.005$)
- No significant correlation between anatomical LIs of the AF (mean volume) and functional LIs (fMRI) ($r = 0.113, p = 0.434$). Same results for other metrics of the AF
- No significant correlation between anatomical LIs of the AF (mean volume) and handedness scores ($r = 0.137, p = 0.341$). Same results for other metrics of the AF
- **Left dominance of the AF in 94% of participants** (47 out of 50) regardless of their handedness and functional lateralization for language

Discussion

- The present study demonstrated **an overall significant leftward asymmetry of the Arcuate Fasciculus** regardless of degree of handedness or functional language lateralization using a novel hybrid tractography algorithm for tracts reconstruction
- Results provide evidence that structural asymmetry of the AF does not correlate with “language lateralization” registered with fMRI
- The absence of such a relation is strikingly in line with the robust knowledge about left-hemisphere language dominance in 96% of population, based on the Wada-test⁹. These findings have important implications for the clinical evaluation of language function and suggest serious reconsidering of fMRI-based language lateralization assessment

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