Multimodal and unimodal MRI tractography for the identification of language-associated fiber bundles in clinical settings

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Introduction

Combining MRI modalities helps specify brain architecture supporting cognitive functions. For preoperative planning of awake craniotomies in language-sensitive regions, *neurosurgeons use fMRI activation to guide dMRI tractography[1]*. We aim to assess the robustness of modern standardized tractography protocols[2] for *delineating fiber bundles of the language system with and without fMRI*. Therefore, we test (1) fiber bundle agreement via cross-correlations within and between subjects, and (2) tract-based differences in connection strength, to determine the effectiveness of uni-modal and multimodal tracking approaches.
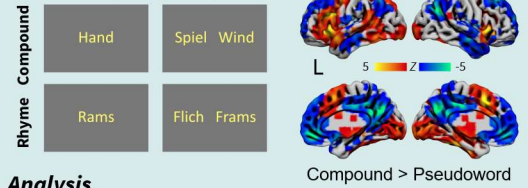
Methods

Participants
- 20 neurotypical participants (10 females)
- Age 18 to 35 years
- Handedness LQ 70 to 100[3]

MRI data acquisition
- 3T Prisma Fit, 64 channel head coil
- MPRAGE, $(1\text{ mm})^3$
- GE-EPI, $(2\text{ mm})^3$, 4×451 vols, TR 1.5 s
- SE-EPI, $(2\text{ mm})^3$, 64 dwi, b 1000 s/mm², TR 7.5 s

Language Paradigm

Compound	Hand	Spiel	Wind
Rhyme	Rams	Flich	Frams

Compound > Pseudoword
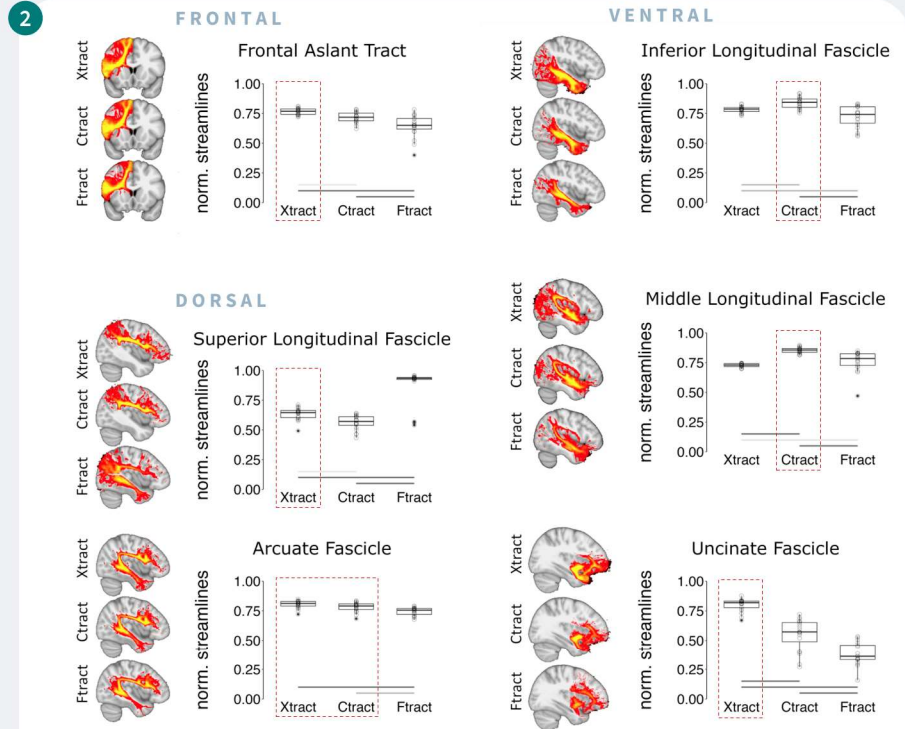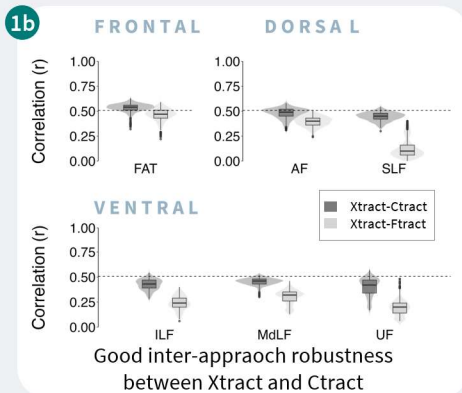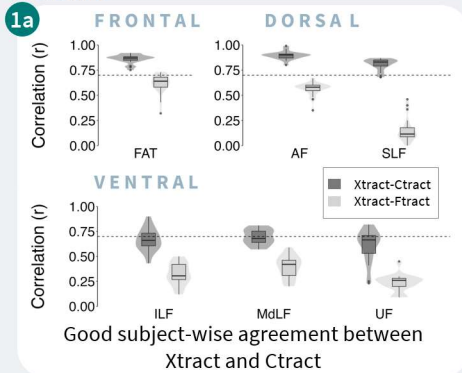
Analysis
- Individual contrast maps via GLM analyses (FSL)
- Individual <u>left hemisphere tract maps</u> via
  - **Xtract** - Standardized protocol
  - **Ctract** - Standardized protocol + individual, functional, anatomically constrained cortical seed masks
  - **Ftract** - Individual, functional, anatomically constrained cortical seed masks

Results

1a

FRONTAL — FAT | DORSAL — AF, SLF | VENTRAL — ILF, MdLF, UF

Legend: Xtract-Ctract, Xtract-Ftract

Good subject-wise agreement between Xtract and Ctract

1b

FRONTAL — FAT | DORSAL — AF, SLF | VENTRAL — ILF, MdLF, UF

Legend: Xtract-Ctract, Xtract-Ftract

Good inter-approach robustness between Xtract and Ctract

2

FRONTAL — Frontal Aslant Tract | VENTRAL — Inferior Longitudinal Fascicle
DORSAL — Superior Longitudinal Fascicle | Middle Longitudinal Fascicle
Arcuate Fascicle | Uncinate Fascicle

(Xtract, Ctract, Ftract; norm. streamlines)

Frontal and dorsal tracts showed the strongest connectivity for the standardized protocol, while ventrally the ILF and MdLF benefited from the combined tractography protocol.

Conclusion

- Left FAT, SLF, and UF were best reconstructed with the standardized protocol.
- Left AF reconstruction was similarly good with both the standardized and the combined protocol.
- The two ventral tracts (left ILF, MdLF) benefited from the combined approach.
- Thus, unimodal approaches provide satisfactory results for dorsal language pathways and speech motor structures, while multimodal approaches may improve ventral pathway reconstructions.
- Differentiated analysis approaches can make a significant difference and might improve clinical outcomes.

3

Xtract and Ctract show robust agreement with the HCP population[2]

(Xtract-HCP, Ctract-HCP, Ftract-HCP)
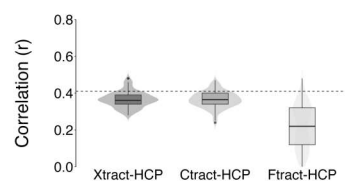
Distributions of the average subject-wise cross correlations, i.e. average across tracts for each subject, with the HCP cohort (threshold of 30%).

References

1. Jarret, J. et al. (2022). A methodological scoping review of the integration of fMRI to guide dMRI tractography. What has been done and what can be improved: A 20-year perspective. Journal of Neuroscience Methods, 367, 109435.

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