Lower axon density in residual temporal white matter is related to semantic paraphasia prevalence

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BACKGROUND

- Wallerian degeneration is common after ischemic stroke
- **Hypothesis:** Does axon density relate to confrontational naming performance?
- Dual stream model of language[1]:
  Dorsal stream: **phonological** component of language
  Ventral stream: **semantic** component of language
- Traditional dMRI results can be hard to interpret.
  - Biophysical models are necessary to overcome this drawback
  - White matter tract integrity model (WMTI)[2]: Calculate axonal water fraction (AWF)

$$AWF = \frac{K_{max}}{K_{max}+3}$$

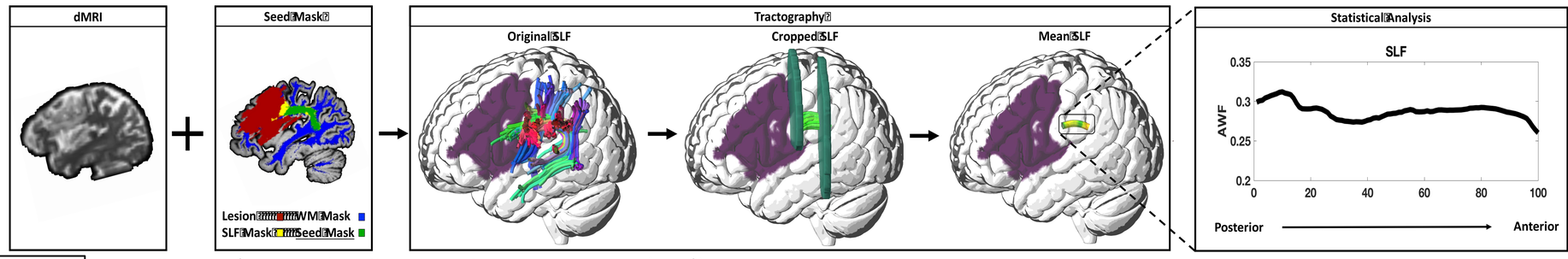
Figure 1: Cartoon depicting the axonal water fraction (AWF), which is the amount of water in the axons relative to the total amount of water (axonal + extracellular space)

METHODS

Subjects

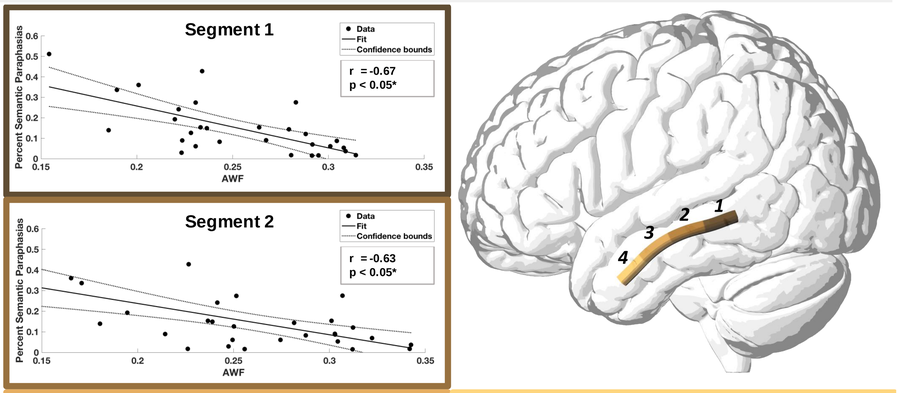
- 32 subjects with chronic stroke-induced aphasia
- Philadelphia Naming Test (PNT)

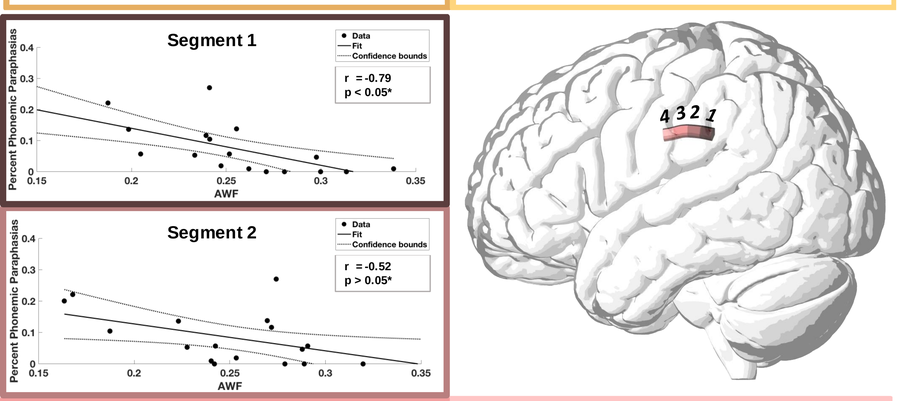
Image Analysis Pipeline



- Collect DKI[3] Images (30 directions, b=0, 1000, 2000 s/mm^2).
- Calculate diffusion and kurtosis tensor using DKE[4] and calculate AWF from maximal directional kurtosis.
- Create seed mask from JHU SLF/ILF atlas, WM from SPM12 and the lesion.
- Perform DKI tractography[5] using the DKE fiber tracking toolbox and the seeding region.
- Crop tracts to study middle segment using JHU ROIs[6].
- Combine 3D location of **ipsilateral SLF and ILF** with AWF maps to study metrics along the tract.
- Average AWF values are related to percent semantic/phonemic paraphasias in different segments (nodes 1:25/25:50/ 51:75/76:100)

RESULTS





Semantic Paraphasias

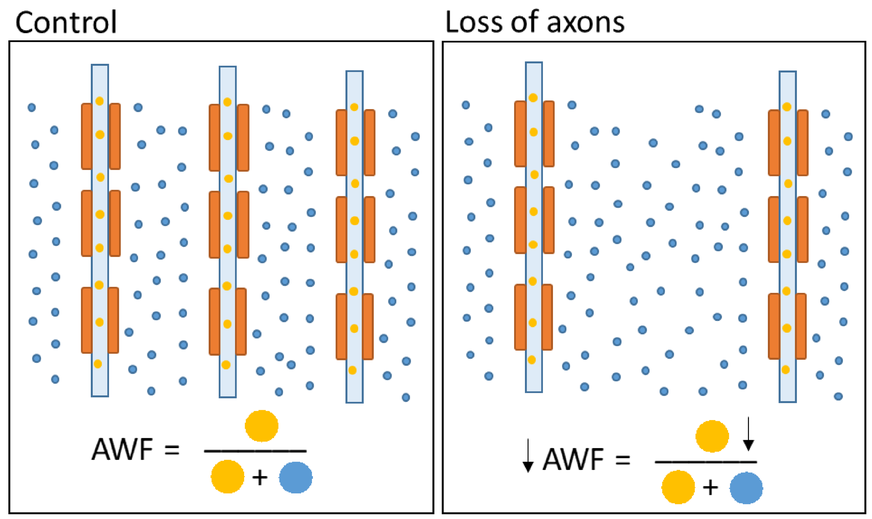
Axon density posterior ILF is significantly related to % **semantic** but not % phonemic paraphasias (corrected for lesion overlap).

Phonemic Paraphasias

Axon density posterior SLF is significantly related to % **phonemic** but not % semantic paraphasias (corrected for lesion overlap).

Figure 2: (top) Relationship between percent semantic paraphasias and average AWF in 4 different segments along the ILF. (bottom) Relationship between percent phonemic paraphasias and average AWF in 4 different segments along the SLF.

DISCUSSION



Decrease in AWF is likely driven by a loss of axons.

CONCLUSION

- There is a double dissociation between the dorsal and ventral stream.
  - ILF axon density → Lexical selection
  - SLF axon density → Form Encoding
- Help explain post-stroke naming impairments and identify potential anatomical targets for treatment.

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