NOVEL DIFFUSION IMAGING PREDICTORS OF STROKE RECOVERY

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INTRODUCTION

- 1/3 of stroke patients sustain permanent disability e.g. aphasia[1]
  - Previous neuroimaging and clinical studies underpowered in predicting recovery[2]
- Traditional lesion studies confined within lesion masks[4]
  - Ignores the importance of brain networks
  - Highlighted by: Wernicke conundrum[5]

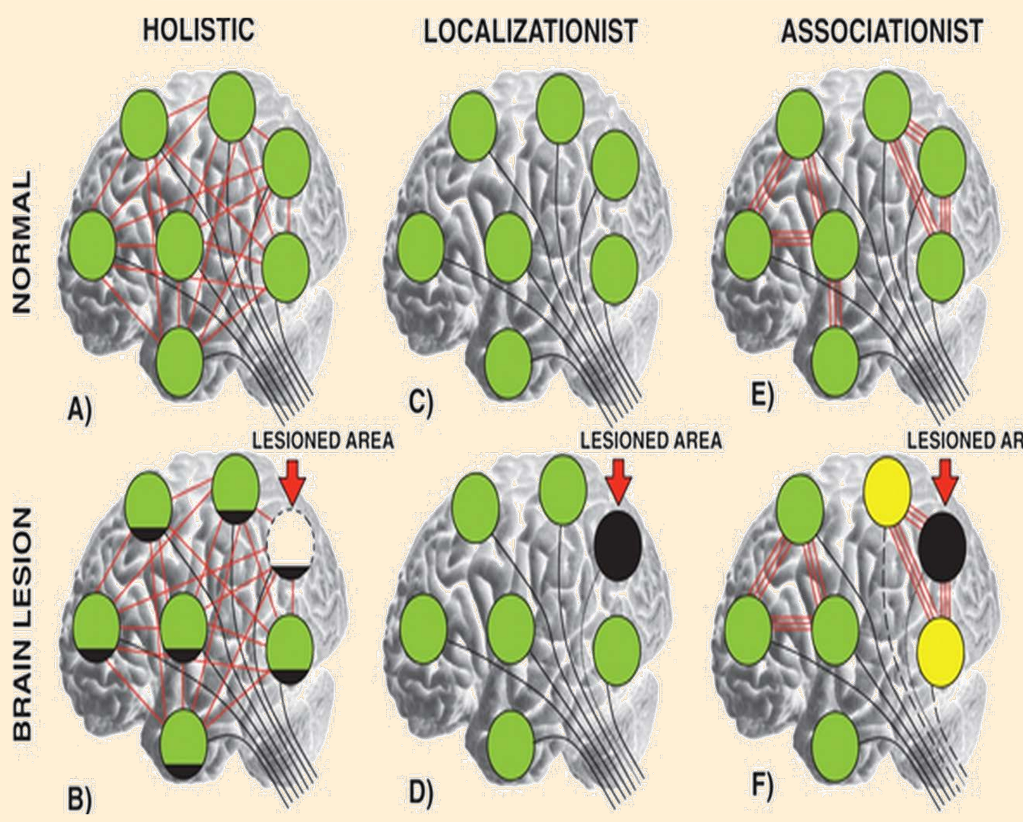

Figure 1: Illustration of the theories of brain function: holism, localizationism, associationism[3].

- Diffusion imaging makes tractography studies possible
- Take into account theories of brain function

AIM

- To support the 3 theories of brain function
  - To address limitations in traditional voxel-based lesion symptom mapping (VLSM)[6]
  - Via tractography, we provide a novel approach in predicting stroke recovery by investigating beyond lesion masks

HYPOTHESIS

- Lesion volume plays a role in recovery (holism)
- Discreet cortical regions significant in predicting recovery (localizationism)
- Areas beyond lesion mask possess predicting potential (associationism)

Methods

- 32 left hemispheric stroke patient
  - Revised Western Aphasia Battery baseline and 6 months follow-up
- Baseline structural MRI
- Manual lesion delineation on T1w via MRIcron
- Aphasia recovery prediction model (1)
  - Lesion volume, sex, age, education, baseline aphasia quotient (AQ)
- VLSM based on:
  - Traditional: T1-weigthted scan (2)
  - Extended: binarized white matter tracts (3)
    - MegaTrack
    - White matter tract extraction using lesion mask as ROI
      - Semi-automatic approach
      - Single dissection applied to "mega" tractography dataset (DWI)
        - 151 subjects, 76 females, age 38.48+17.03
        - Streamlines remapped into standard anatomical space
        - Highly efficient; individual dissection not needed
- Statistical analyses
  - Hierarchical regression analysis
  - Brunner-Munzel test

RESULTS

(1) Aphasia recovery prediction model

Lesion volume, sex, age, education, baseline AQ (aphasia quotient) significant ($R^2 = 0.485$, $F(5,23) = 4.337$, $P = 0.006$) in predicting longitudinal aphasia severity (longitudinal AQ).

(2) Traditional VLSM

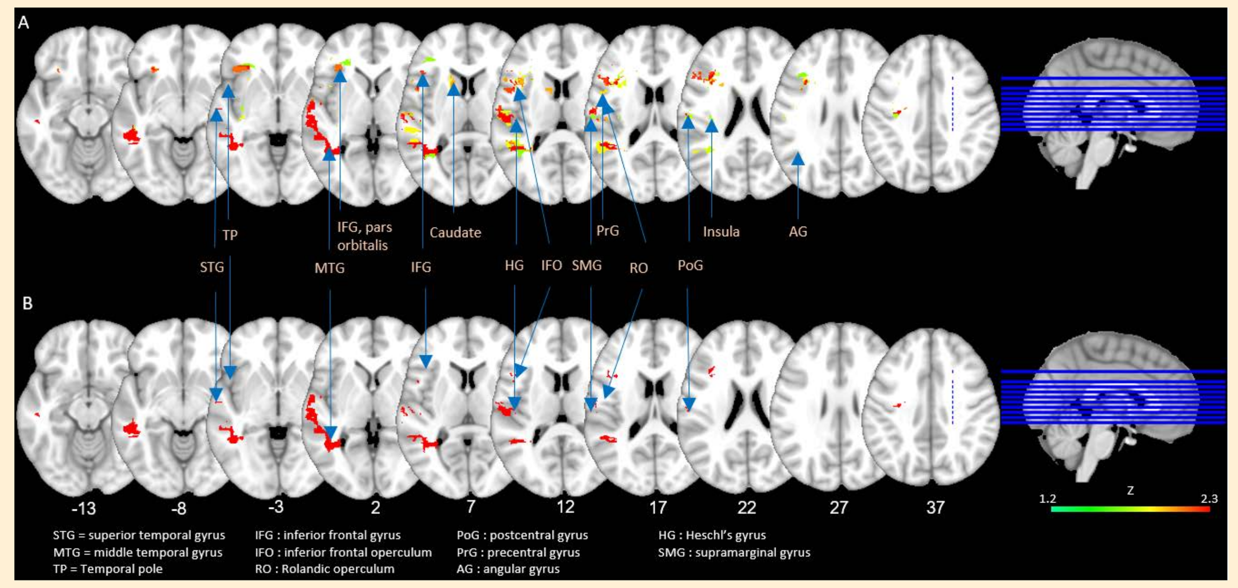

Figure 2: *Based on T1w, VLSM analysis showing significant voxels at two significant levels : A(1.6<Z<2.3, P≤0.05) and B(Z=2.3, P≤0.01).*

(3) Extended VLSM (novel)

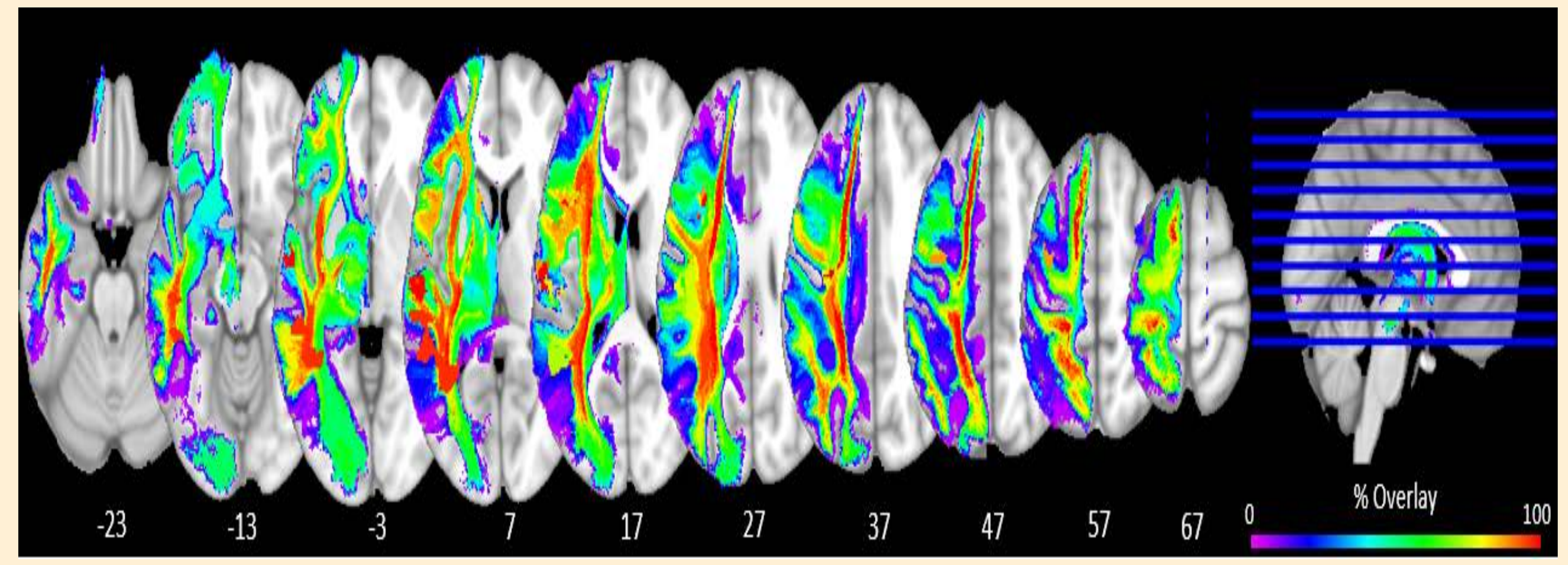

Figure 3: *Percentage lesion overlay maps based on extended lesion masks. Area of maximal overlay were anatomically correspondent to the cingulum, AF, ILF, CC and CST*

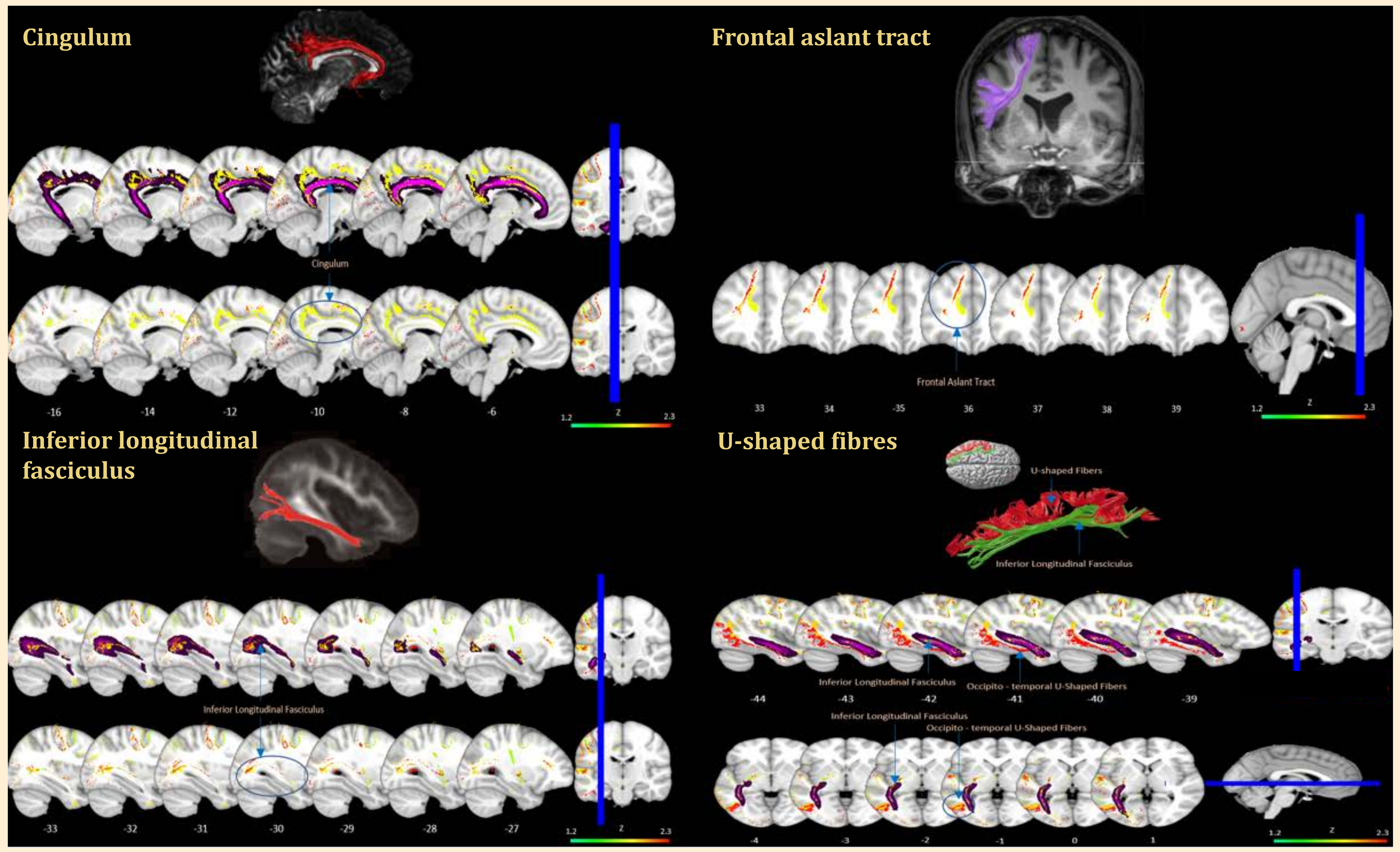

Figure 4: *Extended VLSM analysis based on extended lesion masks extracted via MegaTrack. The significant voxels (1.2≤A≤2.3, p≤0.05) showed clustering around regions which corresponded with atlas maps : Cingulum, FAT, ILF and U-shaped fibres. Indeed, regions beyond lesion masks were implicated in predicting stroke recovery.*

Advantages	Disadvantages
Efficient (semi-automatic)	Reduced accuracy
White matter tract information	Dependent on atlas (no specificity)
Case-control possible	Variation still present

Figure 5: Advantages versus disadvantages of novel approach

CONCLUSION

- We demonstrated a proof of concept to support :
  - All 3 theories of brain function which should be included in lesion studies
  - The implication of damage which extends beyond the lesion masks and should be taken into account for accurate prediction of stroke recovery

Abbreviations

VLSM=Voxel-based lesion symptom mapping, ROI=region of interest, MRI=magnetic resonance imaging, T1w=T1-weighted scan, FAT=frontal aslant tract, ILF=inferior longitudinal fasciculus, DWI=diffusion weighted imaging, AQ=aphasia quotient, AQl=longitudinal aphasia quotient, ROI=region of interest, WM=white matter

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