INTRODUCTION

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

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).
- 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
  - Lesion volume, sex, age, education, baseline aphasia quotient (AQ)
  - VLSM based on: Traditional T1-weighted scans
  - Extended: binarized white matter tracts
    - 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 years
      - 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

3. Extended VLSM (novel)

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.

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).
Figure 3: Percentage lesion overlay maps based on extended lesion masks. Area of maximal overlay were anatomically correspondent to the cingulum, AF, ILF and U-shaped fibres.
Figure 4: Extended VLSM analysis based on extended lesion masks extracted via MegaTrack. The significant voxels (1.25≤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.
Figure 5: Advantages versus disadvantages of novel approach

Advantages
- Efficient (semi-automatic)
- White matter tract information
- Case-control possible

Disadvantages
- Reduced accuracy
- Dependent on atlas (no specificity)
- Variation still present

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, WM=white matter

5. Kah Long Aw, supervised by Prof. Marco Catani.

References: