Frontal Lobe Intraconnectivity: Short-range tract characteristics in old age

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Introduction

- The frontal lobes
  - facilitate our most complex thinking
  - contain multiple cytoarchitecturally and functionally discrete regions
  - regions interact via complex, short-range white matter (WM) connections

- The frontal lobes are particularly prone to age-related structural decline
  - This may partially explain age-related cognitive ability decline in the elderly
  - Most studies of the frontal lobes focus on various frontal cortical areas.
  - Yet, the WM connecting these regions remains relatively under-researched
  - It is unclear how individual differences in the number of connections and WM integrity in the frontal lobe vary in older age.

Aims

- Measure connectivity among frontal regions in older adults.
- Characterise variation in the number, density and integrity of these tracts.

Methods

Subjects & MR Imaging

- Eighty eight males from Lothian Birth Cohort 1936, mean age 73.7 ± 1 yr.
- Community-dwelling, MMSE>24, HADS<11, not on antidepressants.
- T1W scan (resolution 1x1x1.3 mm), 1.5 T GE scanner
- DTI scan (resolution 2x2x2mm), 1.5 T GE scanner

Structural Images

- Seven gyral frontal regions were manually segmented on T1W with Analyze 8.1 using a protocol published elsewhere with excellent reproducibility (intra-rater ICCs > .96).

- Brain extraction (multi-spectral in Analyze).
  - T1W-weighted and FLAIR volumes were fused using an image fusion tool.
  - Brain extracted using object extractor tool.
  - Masks from this process then applied to T1W

Diffusion Tensor Images

- Motion & eddy current distortion corrected by registering all diffusion-weighted volumes to the 1st undistorted b0 image.
- DT-MRI reconstruction used interpolated streamline and fractional anisotropy (FA) computation in DTI Toolkit.
- Segmented frontal lobe regions then transformed to DT-MRI space (via T1W) using FLIRT.
- Site-to-site connection performed in TrackVis® (www.trackvis.org). Tracts connecting each pair of manually-segmented frontal ROIs were isolated.

- Primary measures were:
  - Connection Probability ( # tracks connecting each pair of regions / the total # frontal tract tracks).
  - Mean FA values of the connecting tracts.
  - Coefficient of variation (CoV) was used to index tract variation across individuals.

Results

- Tracts (Fig. 1) and connectivity profiles (Fig. 2) concurred with previous anatomical reports of healthy younger participants.
- Individual variation in connectivity and tract FA (Fig. 3) was highly, particularly for lateral and circinate regions.

Conclusions

- The results show that the measures of connections involving cingulate and lateral frontal regions are highly variable in older age.
- This is a promising approach from which to examine the relationship between cognitive ability and the number, density and integrity of short range frontal lobe connections in old age.
- Longitudinal data or comparison with a younger group would help to determine if this variability is a feature of ageing, rather than pre-existing individual differences.
- More advanced tractography algorithms such as those based on probabilistic methods with 2 fibre populations per voxel will be investigated.

References