Frontal Lobe Intraconnectivity

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

S.R. Cox1,2,*, B.S. Aribisala1,2,4,5, K.J. Ferguson2,6, S.E. MacPherson2,7, S. Muñoz Maniega1,2,5, M.C. Valdés Hernández1,2,5, N.A. Royle1,2,8, A.M.J. MacLullich1,8, J.M. Starr2,8,9, I.J. Deary2,3, J.M. Wardlaw1,2,5, M.E. Bastin1,2,9

1Brain Research Imaging Centre, University of Edinburgh, UK, 2Centre for Cognitive Ageing and Cognitive Epidemiology, University of Edinburgh, UK, 3Department of Psychology, University of Edinburgh, UK, 4Department of Computer Science, Lagos State University, Lagos, Nigeria, 5Scottish Imaging Network, A Platform for Scientific Excellence (SINAPSE), School of Clinical Sciences, University of Edinburgh, UK, 6Endocrinology Unit, University of Edinburgh, UK, 7Geriatric Medicine Unit, University of Edinburgh, UK, 8Alzheimer Scotland Dementia Research Centre, University of Edinburgh, UK.

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.
- T1-W scan (resolution 1x1x1.3 mm), 1.5 T GE scanner
- DTI scan (resolution 2x2x2mm), 1.5T GE scanner

Structural Images

- Seven gyral frontal regions were manually segmented on T1-W with Analyze 8.1 using a protocol published elsewhere with excellent reproducibility (intra-rater ICCs > .96).
- Brain extraction (multi-spectral in Analyze).
  - T1-weighed and FLAIR volumes were fused using an image fusion tool
  - Brain extracted using object extractor tool
  - Masks from this process then applied to T1-W

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 T1-W) 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 lobe 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 reports of healthy younger participants.
- Individual variation in connection probability and tract FA (Fig. 3) was high, particularly for lateral and cingulate 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


Variation in connectivity and FA were tightly related across frontal lobe tracts (p<.05, p=.000001)