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Entropy of FA maps identifies healthy elderly individuals with family history of dementia

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Introduction

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- With aging and disease the structure of the brain changes
  - Shrinkage
    - Frontal lobes (mental ability)
    - Hippocampus (memories)
  - Cortical Thinning – decrease in synaptic connections
  - White matter reduction – fibres that facilitate communication
  - White matter lesions
- Important to identify the difference
  - Early intervention
- Difficult due to confounding factors
  - Head size
  - Functional reserve
  - Education
  - Occupation
- Family history is a know risk factor for dementia

Diffusion Imaging

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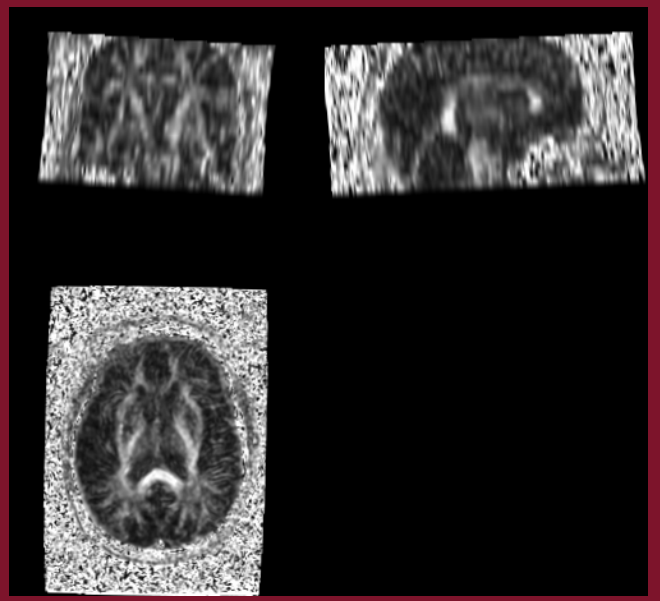
- Can detect subtle changes
- Image contrast depends on water mobility
- Directionality
  - Fractional Anisotropy
- Mobility
  - Apparent diffusion coefficient



Fractional Anisotropy Image

Entropy in Imaging

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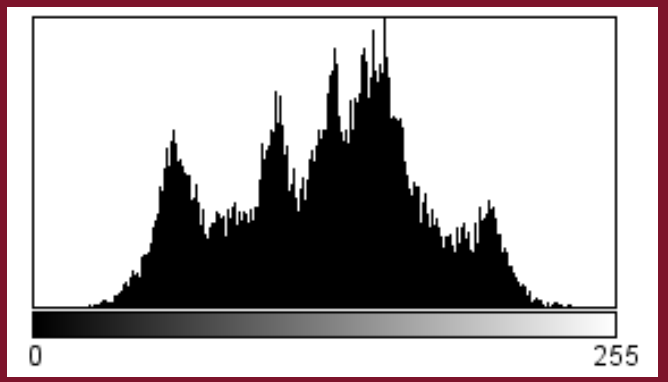
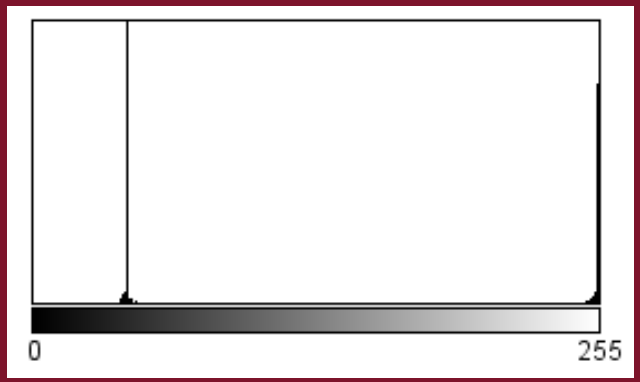
- Image histograms taken
- Histogram entropy used to describe image complexity/texture

$$Entropy = -\sum n \log(n)$$

Probability that a pixel exits in a particular bin



Complex / high entropy image and histogram



Simple / low entropy image and histogram

Imaging

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- Aberdeen 1936 birth cohort
  - Community living individuals born in 1936
- 245 underwent MRI
- 3DT1W
- Diffusion tensor – 6 directions
- 234 have useable DTI data
- Fractional Anisotropy (FA) maps made with DTI Studio

Spatial localisation I

- Image processing problem
- Changes in ageing
  - Shrinkage
  - lesions
- Structurally highly variable
- Locating common regions difficult
- Large differences from standard brain templates
- A mechanism to spatially map standard brain regions onto an elderly brain was required

Spatial localisation II

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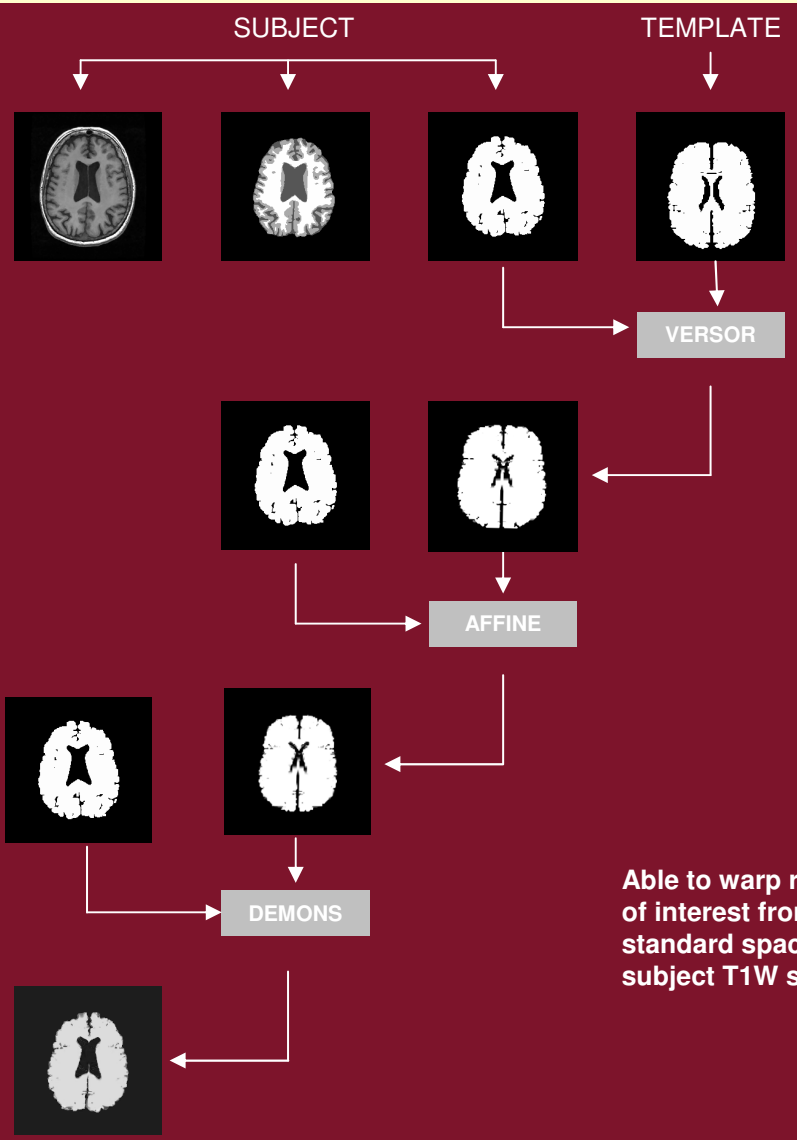
- T1W images:
  - Smoothed (FSL SUSAN)
  - Segmented (FSL FAST)
  - Scalp stripped (FSL BET)
  - Mask created
- Wake Forest pickatlas tool
  - Open source
  - Talairach standard brain
- Sequential registration method (ITK C++ Library)
  - Rigid
  - Affine
  - Deformable



Able to warp regions of interest from standard space to subject T1W space

Spatial localisation III

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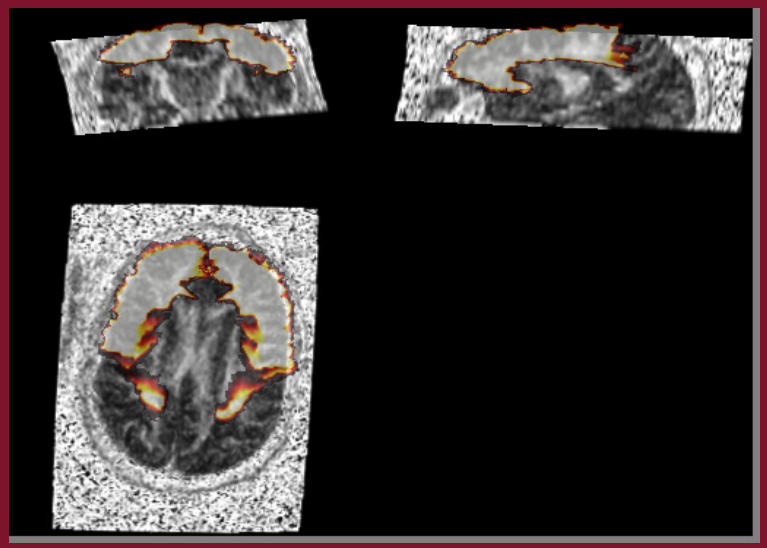
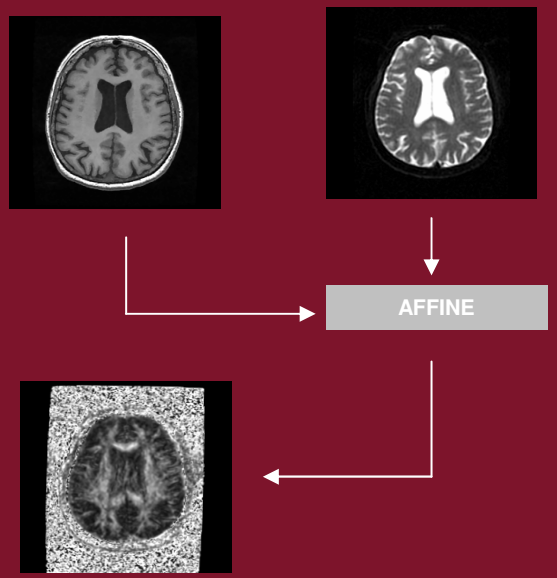
- b=0 diffusion image registered to T1W image
- Transform applied to FA map



Transformed standard space lobe in subject space



Able to warp regions of interest from standard space into subject FA map

Analysis

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- Frontal, temporal, occipital, parietal lobe masks created using Wake Forest pickatlas tool
- Each lobe warped to each subject's T1W image
- Each FA map registered to each T1W
- Regional histogram entropy measured for the FA in each lobe for each subject
- Family history (FH) defined as having a parent or grandparent with dementia
- General Linear modelling was used to test for family history difference
  - Dependent variable: Imaging Measure of entropy
  - Factors: Familial history of dementia, Gender
  - Covariates: Total Intracranial Volume (TICV), Age at imaging

Results

- Using GLM significant association between FH and parietal and occipital lobe entropy ($p<.01$).
- In addition we found an association with gender.
- There was no association found with age at imaging or TICV.
- Analysis of the mean FAs show no significant associations.

Conclusions

- There is significantly less entropy (complexity) in maps of FA in the parietal and occipital lobes of non-demented older individuals with a family history of dementia.
- We believe that this may reflect early structural changes due to neurodegenerative disease.

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