Reproducibility of hippocampus and amygdala volume measures using the FSL tool FIRST: a multi centre perspective

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Background

- Populations are ageing around the world
- Identifying factors that protect against the degenerative effects of ageing on cognitive ability is of increasing importance
- Changes to the hippocampus and amygdala have been associated with:
  - Alzheimer's disease
  - age-related changes to cognitive processes such as memory and information processing speed

Background (cont'd)

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- Larger subject cohorts → improved statistical value, therefore want to combine data sets from multiple sites
- Requires robust testing of the reproducibility of data across multiple sites

This study aims to test across site and within site variability in volume measurement of the hippocampus and amygdala

Subjects and Methods

- Fourteen healthy volunteers were imaged using T1-weighted MRI
- Three 1.5T GE scanners used, at Aberdeen, Glasgow & Edinburgh
- Two visits on separate occasions by each volunteer

Subjects and Methods

- Automatic segmentation was performed on the amygdala and hippocampus
- Segmentation technique based on Active Shape Modelling, fitting imaged data to statistical models
  - (using FSL software developed by FMRIB)
- No explicit corrections were made for scanner differences
- FSL FIRST software performs intensity normalisation

Subjects and Methods

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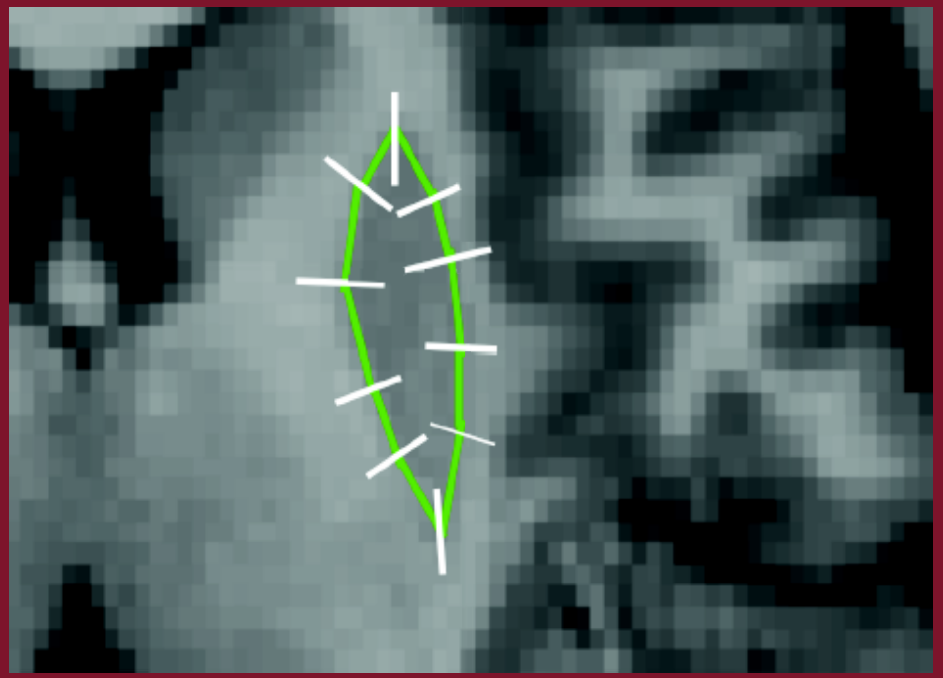

Active Shape Modelling, illustrating intensity profiles, centred at each vertex and aligned with surface normal

[Patenaude, B., D.Phil. Thesis, University of Oxford, 2007]

Subjects and Methods

- Recommended settings for the FIRST algorithm were used (40 degrees of freedom and z = 3)
- Volumes of organs calculated from segmented images
- Additionally, hippocampus ROIs were manually segmented on a subset, by an experienced, trained observer

Results

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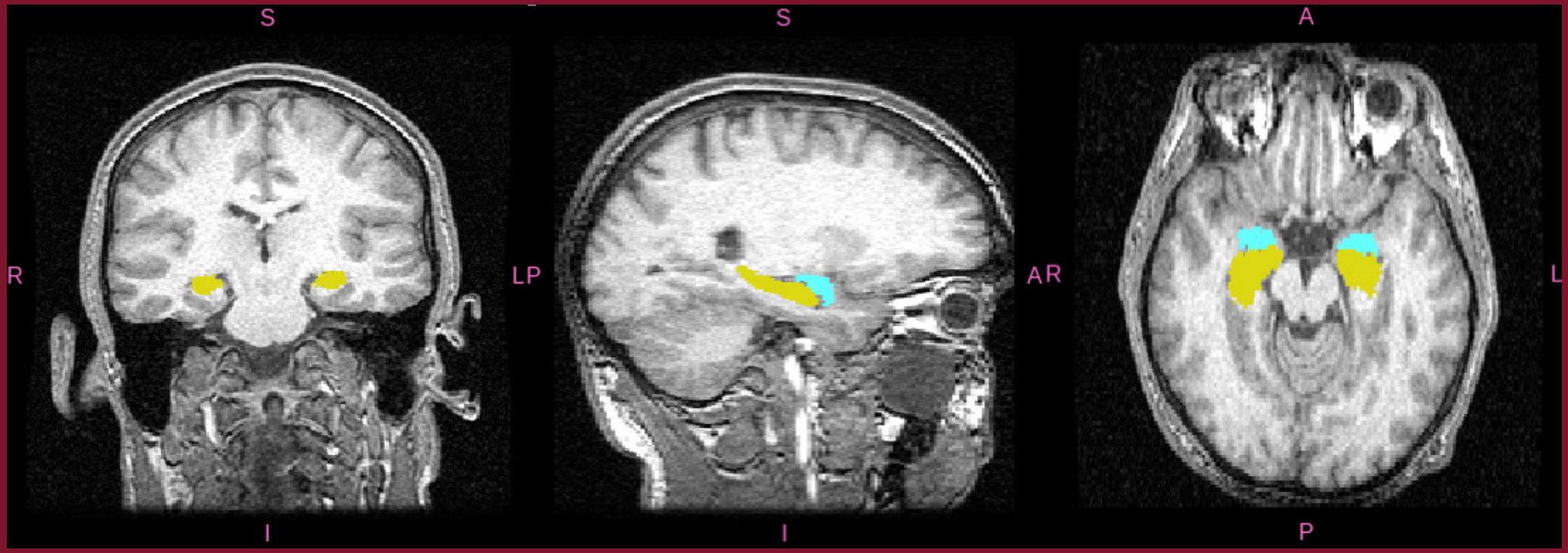

Automatically segmented hippocampus (yellow-green) and amygdala (turquoise)

Results (cont'd)

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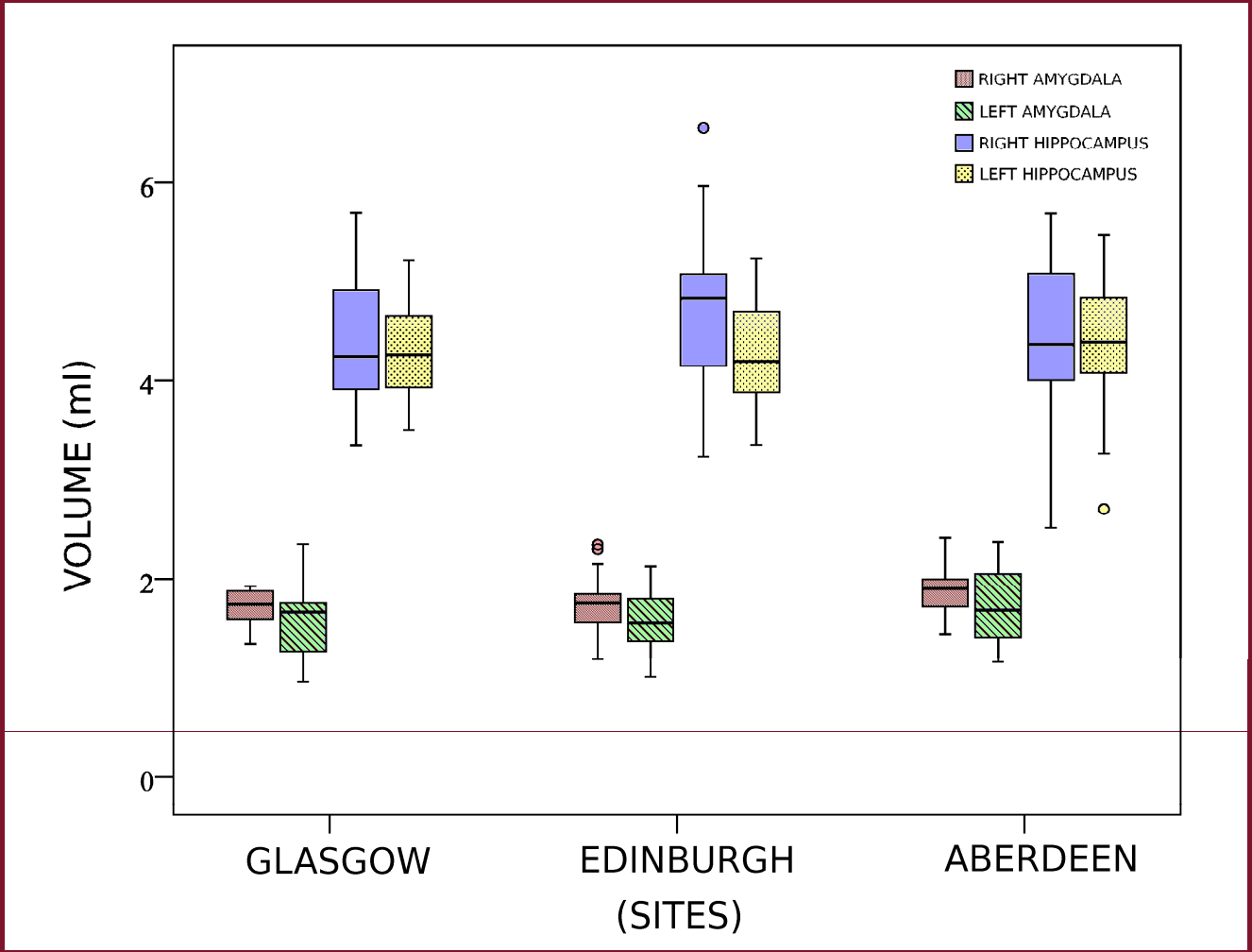
Bar and whisker plot of volumes measured at all three sites



Results (cont'd)

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Reproducibility of the volume measurements

- Ratio of differences to mean of measurements was calculated:

$$r = |V_1 - V_2| / \tfrac{1}{2} (V_1 + V_2)$$

- Using Student's t-test, no significant differences ($p > 0.05$) found between hippocampus ROIs, either between sites or visits
- True for both automatic and manual methods
- Manually segmented hippocampal volumes correlated to, but significantly smaller than, automatically segmented volumes ($p < 0.05$)

Results (cont'd)

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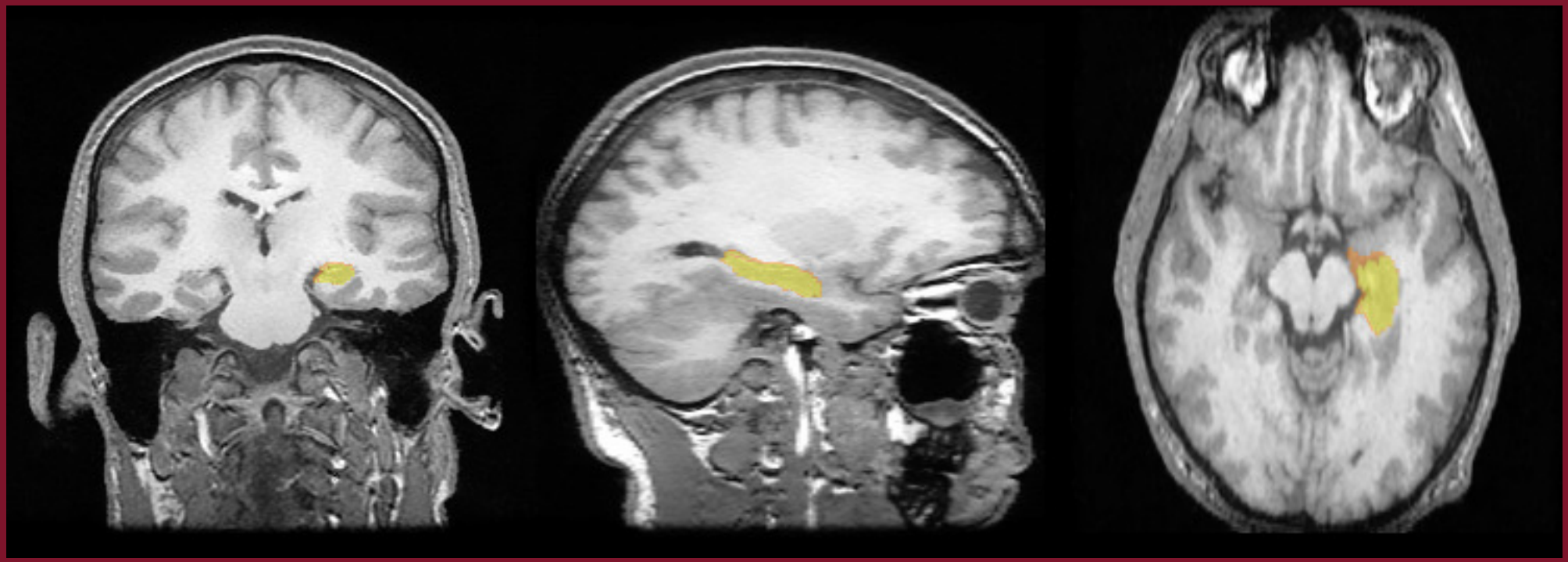

Manual (yellow-green) and automatic (pink) segmentations of left hippocampus

Conclusions

The study has demonstrated that the automated segmentation and volume measurement methods used can reliably measure amygdala and hippocampal volumes broadly independently of the providing institution

Further Work

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- Additional pre-processing to cross-calibrate & correct for scanner differences
- Calibration of software tools to provide better agreement between automated and manual segmentation methods