# Brain Volume Changes in Normal Ageing: a Prospective Study

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## Introduction

Cognitive decline increases with normal ageing and may be due to progressive atrophy. The decline caused by normal ageing is very small annually. An accurate reproducible method is therefore required. We report a prospective study to measure the brain volume changes with sufficient accuracy in T1-weighted images by using SIENA and SIENAX software[1] developed recently by a group from Oxford University. It has been reported that this software is more powerful and more accurate in comparison with other available tools[2]. The purpose of this study is to determine the annual rate of atrophy and investigate the brain and ventricular volume changes in normal ageing using this technique.

## Methods

Participants

One hundred and four healthy adults between fifty and ninety years with no prior neurological or psychiatric disorders were recruited to a prospective study with T1-weighted images at baseline and two years later. Similar number of males and females were recruited in each decade. Baseline data was available for all 104 subjects. Follow-up scans after a delay of two years are in progress. Currently 32 repeat scan data have been collected. The study was approved by the local Ethics Committee. Informed written consent was obtained from all subjects.

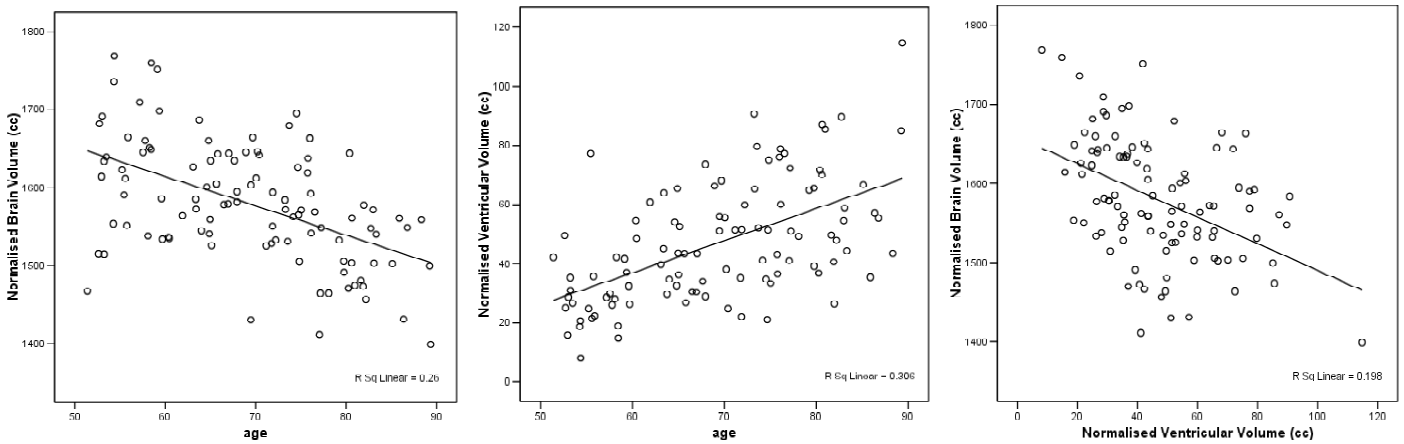
MRI Data Acquisition and Analysis

Participants enrolled in this study underwent a whole brain T1-weighted volume scan acquired on a 1.5T MR Scanner (Signa, GE Medical Systems), with TR = 17ms, FOV = 24x24cm, matrix size = 256x256x92, and voxel size = 0.94x0.94x1.5mm. After a two year delay the same scan was repeated (on the same scanner). SIENAX software[1] was used to calculate normalised brain volume (NBV) (normalised total of grey and white matter) and normalised ventricular volume (NVV) for the cross-sectional data. SIENA software[1] was used to calculate percentage brain volume change (PBVC) after two years from the same subject. Reproducibility was assessed in three subjects with repeat scanning following repositioning of the same subject. Statistical analysis was performed using SPSS software.

## Results

Cross-sectional Results

NBV demonstrates a significant negative correlation with increasing age (Pearson correlation, NBV: $r = -.51$, $p < .001$), while NVV shows a significant positive correlation with increasing age (NVV: $r = .553$, $p < .001$). Results are demonstrated in Figure 1(a) and 1(b) with scatter plots of NBV and NVV against age. Changes in NBV and NVV were significantly highly correlated (Pearson correlation, $r = -.445$, $p < .001$) as can be seen in Figure 1(c).




**(a)** **(b)** **(c)**

**Figure 1**. Normalised brain volume change with age (a), normalised ventricular volume change with age (b), and the variation of normalised brain volume change associated with normalised ventricular volume change (c).

Longitudinal Results

Reproducibility tests from three subjects demonstrated a mean (SD) error 0.1%±0.01%. This result shows that it is reliable to use SIENA to measure longitudinal brain volume change as the typical annual atrophy rate is 0.3% - 0.5%. The longitudinal study from 32 subjects reveals that the mean PBVC is -0.94%±0.73% after two years (equivalent to an annual rate of -0.47%).

## Discussion and Conclusion

The study demonstrates that the brain volume changes are highly associated with increasing age. The reduction of brain volume and increment in ventricular volume are highly correlated. The annual atrophy rate in normal ageing was found to be -0.5% in agreement with previous studies[3].

## Reference

[1]Smith SM, et al; NeuroImage 2002; 17:479-489. [2]Sormani MP, et al; Neurology 2004; 62:1432-1434. [3]Resnick SM, et al; Cerebral Cortex 2000; 10:464-472.

## Acknowledgement

Thanks to Research into Ageing (UK) for the research programme grant support.