What are the major determinants of late-life fluid intelligence?

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Background

The main predictor of late life cognitive ability is childhood intelligence (CIQ). The main diseases leading to cognitive impairment are Alzheimer's disease (which results in brain atrophy) and cerebrovascular disease (which results in white matter hyperintensities "WMH"). Brain atrophy and WMH can be regarded as age-related brain "burden". We have previously demonstrated that education and occupation contribute to maintenance of cognitive ability in late life or cerebral "reserve". Defining how these reserve factors counter burden is crucial in understanding the process of cognitive decline.

Purpose

To test the hypothesis that the association between childhood and late-life cognitive ability is modified by positive (reserve) and negative (burden) factors and model their relative contributions.

Methods

Participants
234 people (age range 67-69) were recruited to an MRI study of cognitive ageing. All participants were members of the Aberdeen 1936 birth cohort.

MR imaging and processing
MRI was carried out on a 1.5T scanner (GE NVi) using T2 axial, FLAIR and 3D T1 sequences. Brain volumes (BV) were extracted using an automated segmentation technique (SPM, http://www.fil.ion.ucl.ac.uk/spm). Cerebrovascular disease (WMH) was assessed by an experienced rater using the Scheltens' scale, intelligence was measured at age 11, using the Moray House Test (CIQ) and at age 68, using Raven's Standard Progressive Matrices (RPM). Education duration and employment grade were determined at interview. An overview of the study design is shown in **Figure 1**.

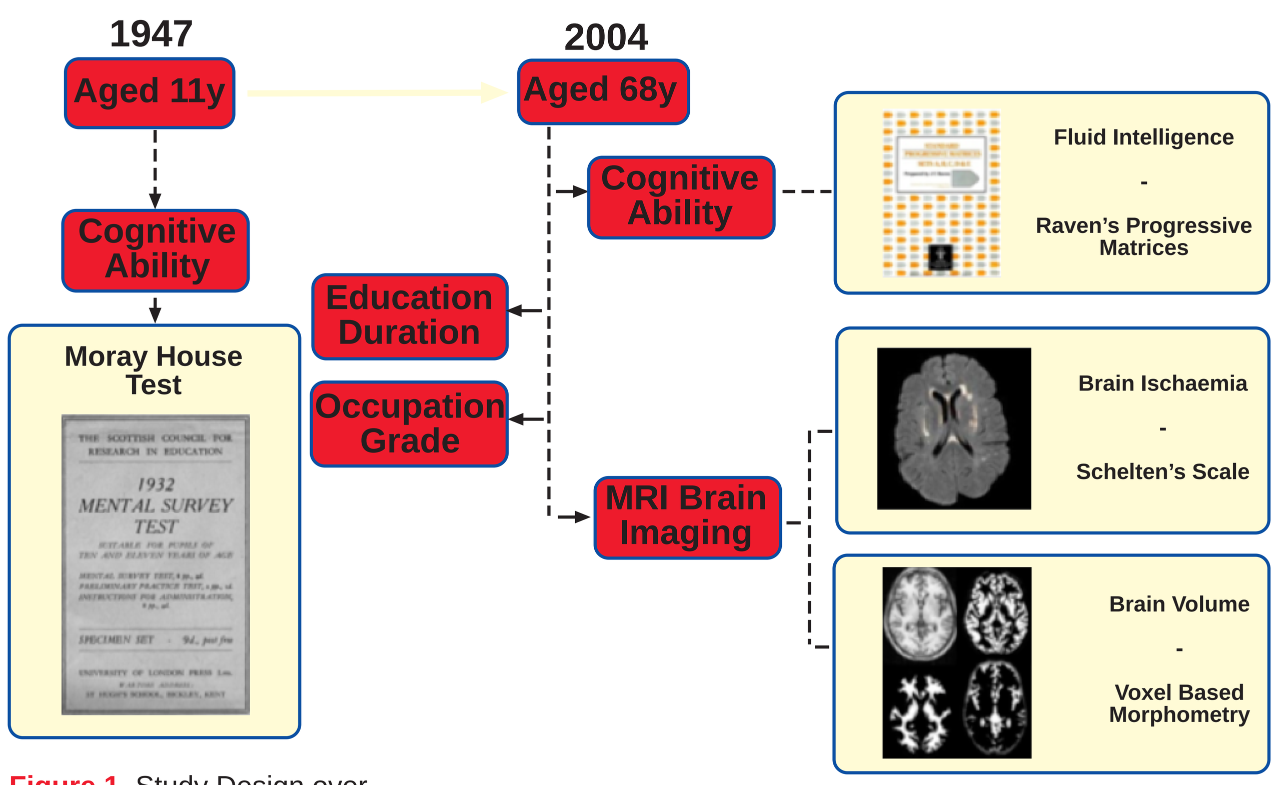

Figure 1. Study Design over 57 years.

Statistical analysis
Structural equation models (SEM) were constructed a priori and analysed using AMOS 18.

Results

Using SEM we found: CIQ had a direct effect on RPM, education duration and employment grade; education had a direct effect on occupation and RPM; gender and WMH had a direct effect on RPM. The model produced an excellent fit to the data (chi squared 2.704, df 6, NFI 0.996, RMSEA 0.000). The results indicated that WMH had a significant negative influence ($p<0.05$) on RPM within the model, while CIQ and education had a positive influence. These results are summarised in **Figure 2.**

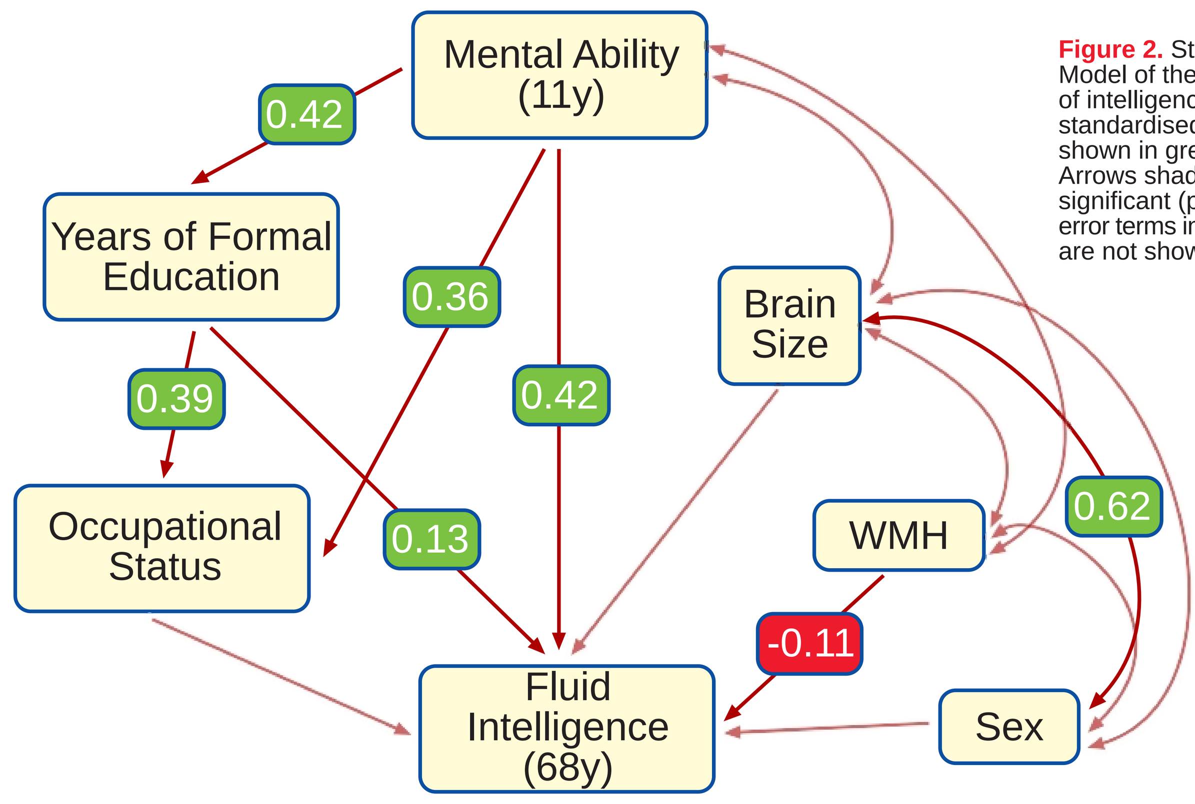

Figure 2. Structural Equation Model of the major determinants of intelligence at age 68. Positive standardised regression weights shown in green, negative in red. Arrows shaded light red are non-significant ($p>0.05$). For clarity, error terms included in the analysis are not shown.

Discussion

The relationship between childhood intelligence and late-life cognitive ability is modified by positive and negative factors. Education appears to be acting as a proxy of reserve in the presence of the burden brought about by MRI measures of cerebrovascular disease, which, at age 68, had a more significant negative effect on late life cognition than whole brain atrophy.

Conclusions

- WMH have a negative influence on late life fluid intelligence.
- Education acts as independent proxy of cognitive reserve.
- This positive influence enables retention of fluid intelligence in the presence of the negative influence of brain WMH.
- Whole brain volume does not have an influence on late life fluid intelligence at age 68.