

The relationship between functional hearing and verbal reasoning

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Background

Verbal reasoning is an indicator of the ability to think constructively in everyday life, and relies on both fluid (working memory processing) and crystallised (knowledge-based judgement) skills. Recent data (Rönnerberg et al., 2011; Rönnerberg et al., 2014) suggest that a greater degree of hearing loss is associated with poorer episodic and semantic long-term memory (crystallised ability), but not working memory (fluid ability). Therefore, it would seem reasonable to assume that only to the extent that verbal reasoning depends more on crystallised than fluid skills, hearing loss may have a negative association with verbal reasoning.

Using cross-sectional data from the UK Biobank resource, we here examine the effect of functional hearing on verbal reasoning, when controlling for age, gender, and education, and investigate if hearing aid usage mitigates the effect. In addition, using structural equation modelling (SEM), we examine different routes from functional hearing to verbal reasoning.

Methods

Participants: 119,093 40-70 years old born in the UK or Republic of Ireland. Female to male ratio was 54:46 and the average age was 56.1 years.

Verbal reasoning: Multiple-choice responses were collected to written questions on numerical (7 items) and linguistic (6 items) problems presented sequentially during a two-minute period. Percentage correct responses in each domain was extracted (VRN and VRL, respectively).

Functional hearing: Digit triplets test in noise (Smits et al., 2004) was performed unaided. The better ear signal-to-noise ratio for 50% correct (BESRTn) was extracted.

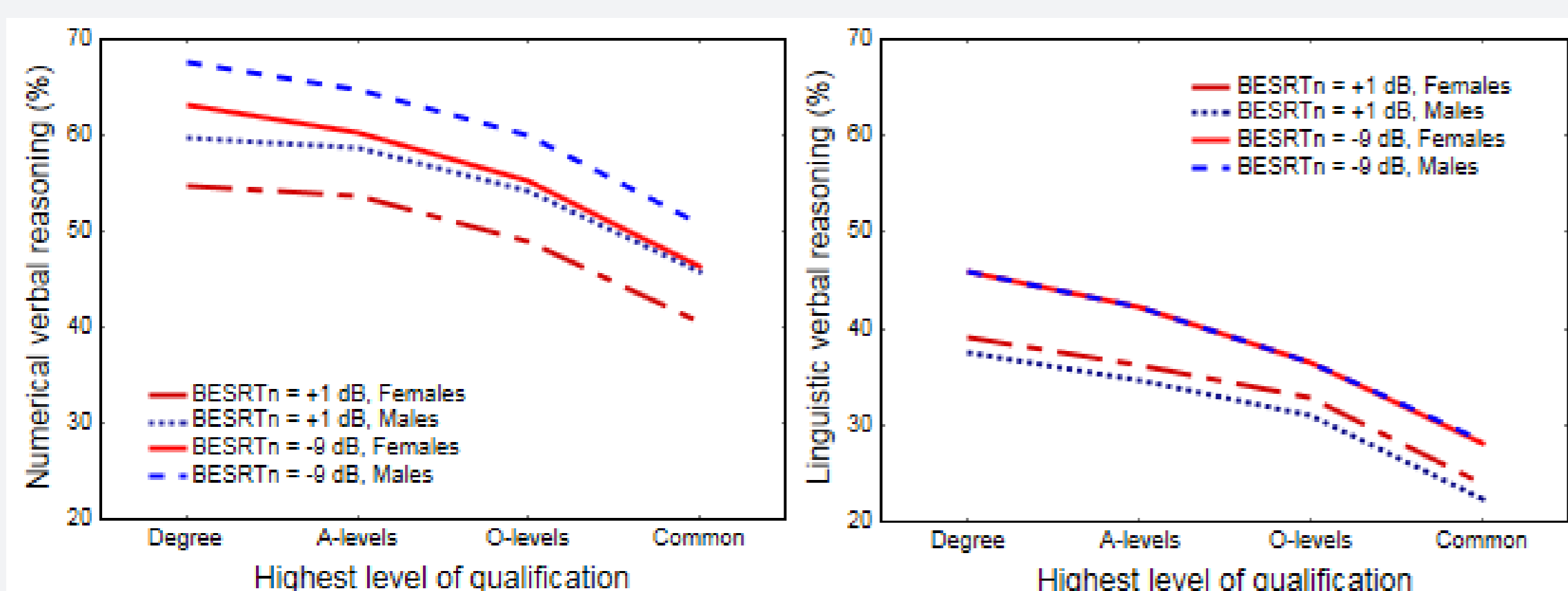
Hearing aid usage: "Do you use a hearing aid most of the time?" The yes/no responses were dichotomised.

Education: Categorized as highest level of qualification (HLQ) where Degree > A-levels > O-levels > Common.

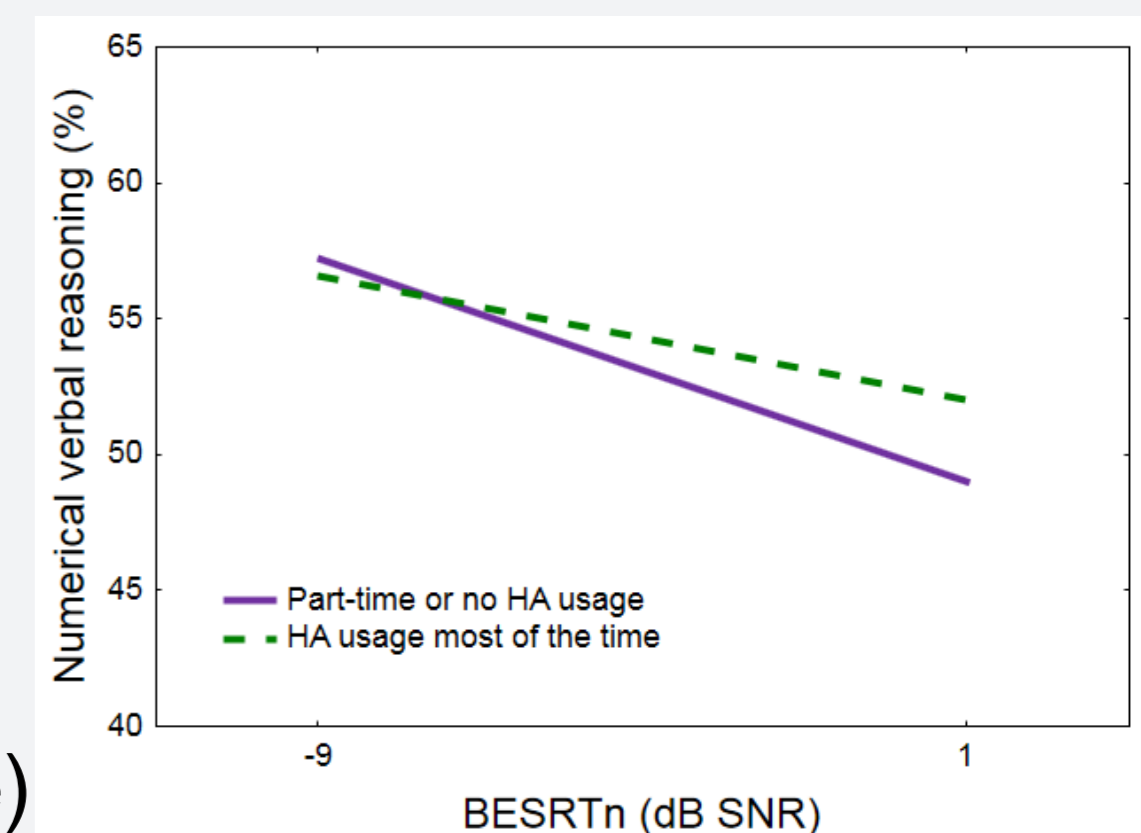
Other variables: A sub-sample of 61,668 participants additionally completed two visuospatial memory tests (VSM and VSPM - measures of "executive function"), and answered questions about time spent on computer (PCUse) and playing computer games (PCGames) (measures of "computer use").

Multi-regression analyses (N = 119,093)

- Poor functional hearing was significantly associated with both reduced numerical and linguistic verbal reasoning scores ($p < 0.001$). Effect $\approx -7\%$ scores per 10 dB SNR.
- Functional hearing significantly interacted with education ($p < 0.01$); a slightly larger negative effect of functional hearing was seen among those with higher levels of qualification.



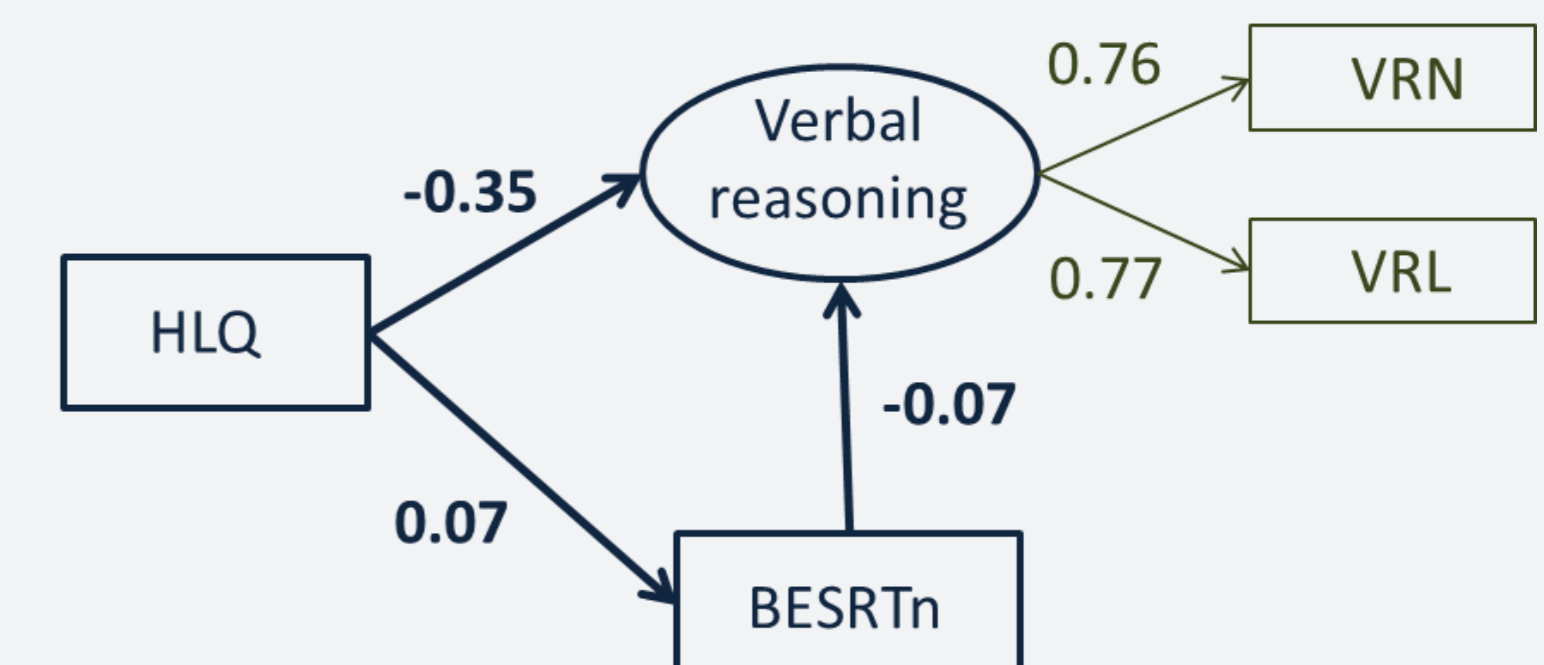
- Further, better education was significantly associated with increased verbal reasoning scores ($p < 0.001$), and males significantly outperformed females in the numerical domain ($p < 0.001$).
- Extensive hearing aid usage significantly interacted with functional hearing ($p < 0.004$); extensive hearing aid usage mitigated the association among those with poor functional hearing. Effect $\approx 3\%$ (more or less hearing aid usage)



SEM analyses (N = 61,668)

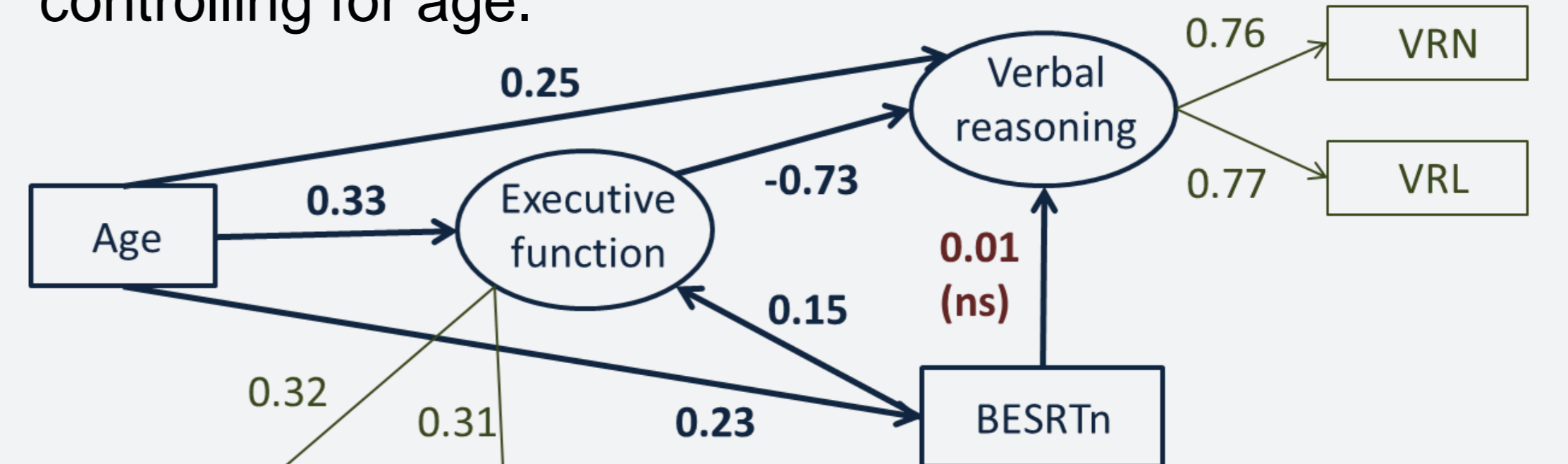
- Confirmed that poor hearing was independently associated with reduced verbal reasoning scores ($b = -0.10$; $p < 0.001$).

- Education partly distorted the association between functional hearing and verbal reasoning



$\chi^2 = 5$; $df = 1$; RMSEA = 0.008; CFI = 1.0; SRMR = 0.002

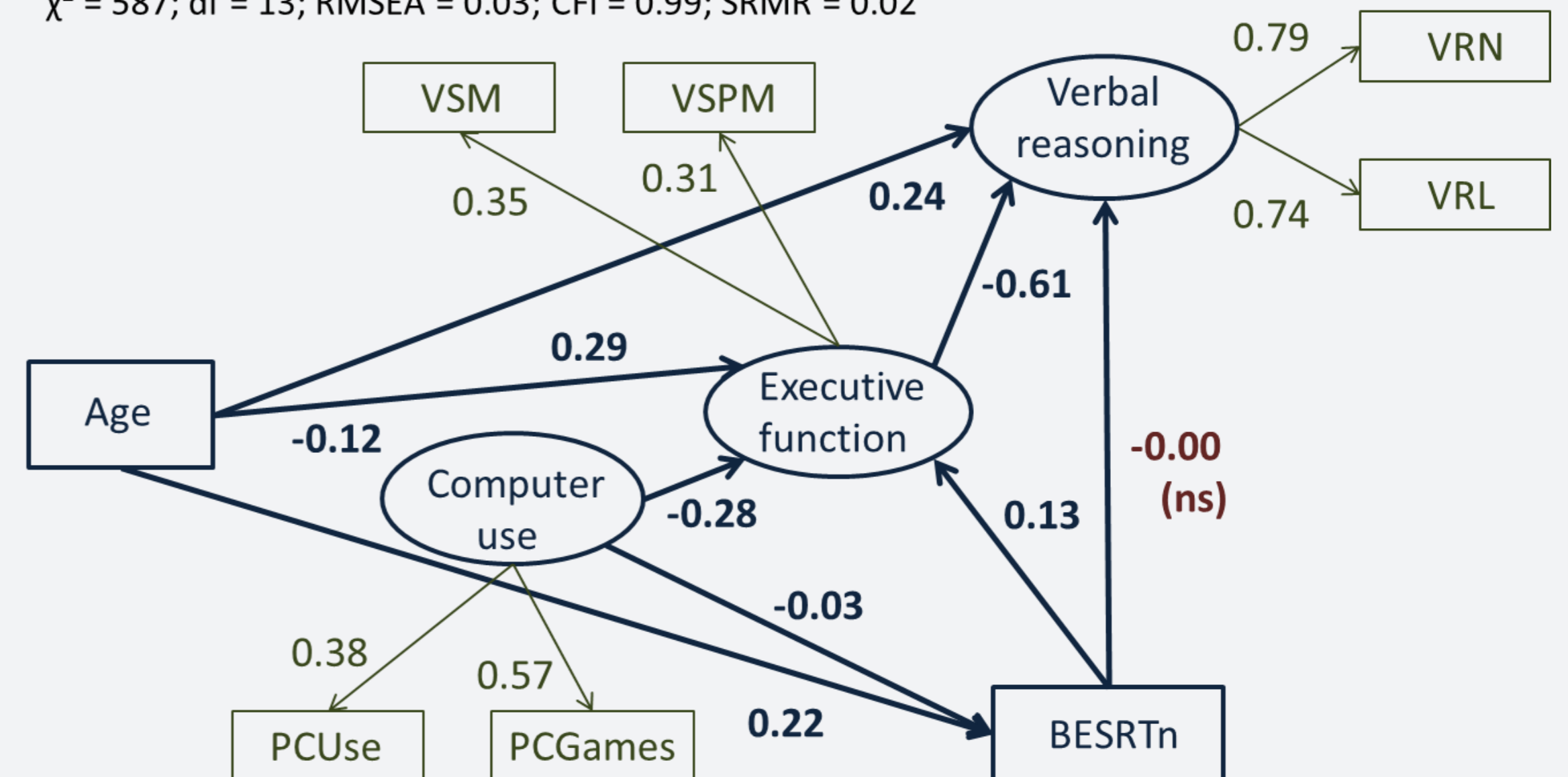
- The executive function completely mediated the association between functional hearing and verbal reasoning when controlling for age.



$\chi^2 = 290$; $df = 5$; RMSEA = 0.03; CFI = 0.99; SRMR = 0.01

- The mediation effect by the executive function was partially distorted by computer usage (esp. playing computer games).

$\chi^2 = 587$; $df = 13$; RMSEA = 0.03; CFI = 0.99; SRMR = 0.02



Conclusions

Functional hearing had a small, but negative effect on verbal reasoning. The effect was significantly reduced among those who used hearing aids extensively, and was completely overcome by good executive function skills, which may be enhanced by playing computer games.