

Cognitive & Behavioral Assessment

Further education improves cognitive reserve and triggers improvement in selective cognitive functions in older adults: The Tasmanian Healthy Brain Project

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Abstract

Introduction: The strong link between early-life education and subsequent reduced risk of dementia suggests that education in later life could enhance cognitive function and may reduce age-related cognitive decline and protect against dementia.

Methods: Episodic memory, working memory, executive function, and language processing performances were assessed annually over 4 years in 359 healthy older adults who attended university for a minimum of 12 months (intervention) and were compared against 100 healthy adult controls.

Results: Multiple group latent growth curve modeling revealed a significant improvement in language processing capacity over time in the intervention group. No changes were detected for episodic memory, working memory, or executive function.

Discussion: These results suggest that complex mental stimulation resulting from late-life further education results in improved crystallized knowledge but no changes to fluid cognitive functions.

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Keywords:

Cognitive reserve; Education; Aging; Neuropsychological; Crystallized function; Fluid function; Episodic memory; Working memory; Language processing; Executive function

1. Introduction

Interventions designed to enhance and protect cognitive function are a promising non-pharmacological approach to delaying and preventing Alzheimer's disease (AD). The positive benefits of such interventions presumably occur due to an increase in cognitive reserve (CR; [1,2]). Education,

occupational attainment, and leisure activities have been shown to make both independent and overlapping contributions to CR [3]. Consequently, recent research has sought to provide a multidimensional measure of CR [4–6] to assess the relationship between CR and cognitive functioning. Bonner-Jackson *et al.* [6] found that higher levels of reserve are associated with a reduced rate of decline in executive function over time in prodromal Huntington's disease. Furthermore, individuals with high CR are able to sustain a higher degree of brain damage before the same level of clinical symptoms that are expressed as in individuals low in CR [5]. However, in healthy older adults or in advanced stages of AD neuropathology, it appears that CR

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does not influence cognitive performance [5]. Rather, CR may act as a buffer between cognitive function and brain pathology only in the early stages of AD [5].

Several studies report that CR can be enhanced or modified through environmental and lifestyle factors. Education is receiving increased research attention as a potentially modifiable lifestyle factor for reducing age-related cognitive decline (ARCD), albeit the focus has been on early-life educational attainment. Enhancement of CR through education is thought to be a result of the development of new cognitive strategies in the individual [7]. Higher levels of educational attainment at younger ages is associated with reduced risk of dementia [8], and the level of educational attainment moderates the relationship between brain pathology and neuropsychological test performance in memory, language, speed of processing, and visuospatial skills [9–11]. Higher levels of educational attainment are associated with reduced rates of decline in information processing speed [12], memory [12,13], and general mental status [12,14]. However, previous research has also questioned this relationship, reporting that the rate of decline across memory [15–17], processing speed [18,19], language processing [15,20,21], and visuospatial skills [13,20] is constant regardless of level of educational attainment. Despite this, reviews of the literature indicate that higher levels of education in early adulthood are associated with superior performance on measures of cognitive function [22,23].

While there is ongoing debate and research into the relationship between educational attainment in early life and cognitive performance in later life, studies have not yet examined the potential benefit of further formal education in late adulthood in enhancing or maintaining cognitive function, potentially also contributing to resilience to decline in AD. The Tasmanian Healthy Brain Project (THBP) is designed to assess the impact of university-level education on CR and cognitive function in healthy older adults [24]. We have recently demonstrated that further education leads to a measurable increase in current CR among older adults who undertake further education [25]. The aim of the present article was to examine if the observed increase in CR among older adults undertaking further education is associated with a change in cognitive function over time.

2. Method

2.1. Participants

The THBP (Summers et al., 2013) is a prospective longitudinal study of older adults engaging in university-level education. The THBP sample was recruited progressively from 2011 to 2014 and has undertaken annual comprehensive assessments. Data analyzed in the present article were collected from 459 adults aged between 50 and 79 years who had participated in the THBP as of the 31 December, 2014. Inclusion criteria for entry into the THBP were that

participants were aged 50–79 years at the time of entry and were healthy. Participants were excluded from entry into the THBP if they reported a diagnosis of a condition that is independently associated with impairments to cognitive function (dementia; multiple sclerosis; prior head injury requiring hospitalization; epilepsy; cerebrovascular complications including stroke, aneurysm, transient ischemic attacks; poorly controlled diabetes; poorly controlled hypertension or hypotension; other neurological disorders [e.g., cerebral palsy or spina bifida]; chronic obstructive pulmonary disease; heart disease; partial or total blindness; deafness; current psychiatric diagnosis) and those who presented with a medical, neurological, or psychiatric disorder that could potentially impair cognition were precluded from entry into the THBP. The project was approved by the Human Research Ethics Committee (Tasmania) Network, and further details of the study protocol have been previously published (see Summers *et al.* [24]).

On entry into the THBP, participants opted (non-random assignment) to participate in either a further education group (intervention) or a no further education group (control). All participants undertook baseline assessment before commencing in the THBP. Those in the intervention group ($n = 359$) then completed a minimum of 12 months of part-time or full-time university study, with a minimum study load of two units at undergraduate or postgraduate levels. The remaining 100 participants in the control group did not undertake any further formal education and served as a no-intervention reference group. Previous growth mixture modeling analysis of longitudinal change in CR revealed two latent classes within each of the control and the intervention groups. The latent classes identified were improved CR (55.7% of control group, 92.5% of intervention group) and stable CR (43.3% of control group, 7.5% of intervention group) [25]. Owing to insufficient sample size ($n < 100$) in the intervention stable CR subgroup (7.5% of intervention, $n = 15$), it was not possible to analyze potential differences between improved and stable CR intervention groups in cognitive function [26]. To minimize statistical bias, the 15 stable CR cases from the intervention group were excluded from the present analysis. No significant differences in cognitive performances were identified between the stable CR and improved CR subgroups of the control sample. As these control subgroups performed at equivalent levels of cognitive function, they were collapsed into a single control group for the purposes of these analyses (see [Supplementary Material 1](#)). Examination of the equivalent full-time study load (EFTSL) completed by each participants in the intervention group over the first four phases of the THBP indicates that they completed on average 110.48 EFTSL (standard deviation = 83.89, 95th confidence interval [CI] = 101.59–119.38). One unit of full-time study is 12.5% EFTSL, indicating that participants in the intervention group completed on average 8.84 full-time equivalent

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