

## Cognitive reserve attenuates 6-year decline in executive functioning after stroke

IHLE, Andreas, *et al.*

### Abstract

**Aims:** We investigated whether the longitudinal relationship between history of stroke and subsequent decline in executive functioning over 6 years differed by cognitive reserve. **Methods:** We analyzed longitudinal data from 897 older adults (mean age, 74.33 years) tested on the Trail Making Test (TMT) in two waves 6 years apart. Participants reported information on key frequently used proxies of lifelong cognitive reserve accumulation (i.e., education, occupation, and leisure activity engagement), and history of stroke. **Results:** There was a significant interaction of stroke with leisure activity engagement on latent change in executive functioning. Specifically, only for individuals with low (but not those with high) leisure activity engagement, history of stroke significantly predicted a steeper subsequent decline in executive functioning across 6 years (i.e., increases in TMT completion time). **Conclusion:** The detrimental aftereffects of stroke on subsequent decline in executive functioning may be attenuated in individuals who have accumulated greater cognitive reserve through leisure activity engagement across their life.

### Reference

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**- Short Report -**

**Cognitive Reserve Attenuates Six-Year Decline in Executive Functioning  
after Stroke**

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Short Title: Stroke and Cognitive Reserve

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## **Abstract**

**Aims:** We investigated whether the longitudinal relationship between history of stroke and subsequent decline in executive functioning over six years differed by cognitive reserve.

**Methods:** We analyzed longitudinal data from 897 older adults ( $M = 74.33$  years) tested on the Trail Making Test (TMT) in two waves six years apart. Participants reported information on key frequently-used proxies of lifelong cognitive reserve accumulation (i.e., education, occupation, and leisure activity engagement) and history of stroke.

**Results:** There was a significant interaction of stroke with leisure activity engagement on latent change in executive functioning. Specifically, only for individuals with low (but not those with high) leisure activity engagement, history of stroke significantly predicted a steeper subsequent decline in executive functioning across six years (i.e., increases in TMT completion time).

**Conclusion:** The detrimental aftereffects of stroke on subsequent decline in executive functioning may be attenuated in individuals who have accumulated greater cognitive reserve through leisure activity engagement across their life.

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## Introduction

Stroke is a major risk factor for cognitive impairments and cognitive decline in old age [1]. Notably, considerable inter-individual differences regarding this relationship exist. Yet, to understand the mechanisms underlying post-stroke cognitive deficits, the factors contributing to pre-stroke architecture of cognitive networks are often ignored, even though they reportedly play a decisive role in the manifestation of cognitive impairments in neurodegeneration [2]. In this regard, cognitive reserve may be a crucial factor. In general, the cognitive reserve concept, which was originally developed to account for individual differences in the course of aging and neurodegenerative diseases, postulates that lifelong cognitive stimulation builds up a buffer that is instrumental for coping with brain damage in order to preserve cognitive functioning in aging [3]. Frequently-used proxies of cognitive reserve are education in early life, cognitively demanding jobs in midlife, and leisure activity engagement across adulthood, which contribute to the accumulation of cognitive reserve [3]. These cognitive-reserve proxies are for example related to better executive functioning in healthy older adults [4-8].

Notably, it has been suggested that cognitive reserve may help to overcome cognitive impairments related to neurological changes following stroke [2, 9]. Yet, reviews on this issue point out that the investigation of cognitive reserve in stroke is still insufficient and that future research needs to investigate for example the role of stimulating activity engagement as proxy of cognitive reserve and its effect on rehabilitative outcomes after stroke [9]. Specifically, to the best of our knowledge, there is no empirical longitudinal investigation to date regarding the role of cognitive reserve in modifying the long-term aftereffects of stroke on decline in executive functioning over a broader time frame. This gap in the literature is particularly troubling, as longitudinal research is needed to evaluate whether cognitive reserve not only modifies the cross-sectional association between stroke and executive functioning at a given point in time, but also the longitudinal relationship between stroke and the long-term rate of

decline in executive functioning. Moreover, to be able to derive concrete implications with respect to the different contributions to the accumulation of cognitive reserve across the lifespan it needs to be identified which of the key proxies (education, cognitive demand of jobs, or leisure activity engagement) may play the most important role in this context. To address these major gaps in the literature, we investigated whether the longitudinal relationship between history of stroke and subsequent decline in executive functioning over six years as measured through performance changes in the Trail Making Test (TMT) differed by key frequently-used proxies of lifelong cognitive reserve accumulation (i.e., education, cognitive demand of jobs, and leisure activity engagement).

## **Materials and Methods**

### **Participants**

We analyzed data from 897 individuals who participated in the two waves of the Vivre-Leben-Vivere (VLV) survey [10]. Respondents were first interviewed during 2011 (Wave 1; W1) and again in 2017 (Wave 2; W2) using face-to-face computer-assisted personal interviewing (CAPI) and paper-pencil questionnaires. For further details regarding the rationale, design, recruitment, materials, and procedures of the VLV survey see [6, 10, 11]. Mean age of these respondents in W1 was 74.33 years ( $SD = 6.50$ , range 64-96); 51.4% were men.

### **Materials**

In both waves, we administered the Trail Making Test parts A and B (TMT A and TMT B, respectively [12]). Participants reported in W1 whether they had a history of stroke in the past. We used the Cognitive Reserve Index questionnaire (CRIq [13]) to assess proxies of accumulated cognitive reserve across the lifespan in terms of education, cognitive demand of jobs, and leisure activity engagement.

## Statistical Analyses

Using latent change score modeling, we modeled latent executive functioning factors of TMT completion time in W1 (constructed from TMT parts A and B in W1) and W2 (constructed from TMT parts A and B in W2) as well as a latent change in executive functioning variable regarding change in TMT completion time from W1 to W2. We included the following covariates to predict latent change: history of stroke in W1, the proxies of cognitive reserve (education, cognitive demand of jobs, and leisure activity engagement), age in W1, sex, and the interactions of history of stroke in W1 with the proxies of cognitive reserve. We also included interrelations of all covariates to take the dependencies among them into account.

## Results

The latent change score model provided a very good statistical account of the data ( $\chi^2 = 26.97$ ,  $df = 17$ ,  $p = .059$ ,  $CFI > .99$ ,  $IFI > .99$ ,  $RMSEA = .03$ ,  $SRMR = .02$ ).

Older age in W1 significantly predicted a larger increase in TMT completion time from W1 to W2 (i.e., steeper decline in executive functioning,  $\beta = .36$ ,  $p < .001$ ). Greater past leisure activity engagement across adulthood significantly predicted a smaller increase in TMT completion time from W1 to W2 (i.e., smaller decline in executive functioning,  $\beta = -.13$ ,  $p = .002$ ). Education, cognitive demand of jobs, sex, and history of stroke per se did not predict changes in TMT completion time ( $ps > .146$ ). Notably, there was a significant interaction of stroke with past leisure activity engagement ( $\beta = -.15$ ,  $p = .002$ ). Specifically, for individuals with low past leisure activity engagement ( $-1 SD$ ), history of stroke in W1 significantly predicted a larger subsequent increase in TMT completion time from W1 to W2 (i.e., steeper decline in executive functioning,  $\beta = .16$ ,  $p = .004$ ). In contrast, for individuals with high past leisure activity engagement across adulthood ( $+1 SD$ ), this longitudinal relationship between history of stroke and subsequent decline in executive functioning was

not significant ( $\beta = -.11$ ,  $p = .143$ ). Besides that, no other interactions of history of stroke in W1 with the proxies of cognitive reserve on latent change in TMT completion time were observed.

## **Discussion**

Present longitudinal results have important implications. As the primary study on the role of cognitive reserve for long-term stroke-related decline in executive functioning, using latent change score modeling (extracting measurement-error variance) we demonstrated a substantial interaction of stroke with past leisure activity engagement on latent change in executive functioning. Specifically, for individuals with low past leisure activity engagement, history of stroke in the first wave of data collection predicted a steeper subsequent decline in executive functioning across six years (i.e., indicated by increases in TMT completion time). In contrast, for individuals with high past leisure activity engagement across adulthood, this longitudinal relationship between history of stroke and subsequent decline in executive functioning was not evident. These findings corroborate the conceptual view that cognitive reserve may help to reduce the neuropsychological aftereffects of stroke [2, 9]. In this regard, the present longitudinal study extends prior cross-sectional studies with longitudinal data regarding stroke-related decline in executive functioning over six years. Specifically, the longitudinal latent change score modeling approach in the present paper implies a highly novel and important advancement to investigate the role of cognitive reserve in modifying the long-term aftereffects of stroke on decline in executive functioning over a broader time frame. Disentangling the individual contributions to cognitive reserve accumulation across the lifespan, we found that (in contrast to education and cognitive demand of jobs) leisure activity engagement played the key role in this context. Thereby, our observations dovetail with findings that greater leisure activity engagement contributes to cognitive reserve and is associated with better performance and reduced decline in executive functioning [5, 14-16]



and are therefore of public importance [17, 18]. In this regard, the present study further elucidates leisure activity engagement as crucial cognitive-reserve proxy contributing to the build-up of a buffer prior to stroke that will be later instrumental for coping with stroke-related brain damage. Thereby, present results help to better understand the mechanisms underlying individual differences in long-term development of executive functioning after stroke.

In conclusion, present results suggest that the detrimental aftereffects of stroke on subsequent decline in executive functioning may be attenuated in individuals who have accumulated greater cognitive reserve through leisure activity engagement across their life. Therefore, especially a lifelong stimulating activity engagement is crucial for building up cognitive reserve in order to promote the maintenance of executive functioning after stroke. Future longitudinal research will have to include a larger set of cognitive abilities as well as medical reports on history of stroke.

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### **Statement of Ethics**

All participants gave their written informed consent for inclusion in the study before participating. The present study was conducted in accordance with the Declaration of Helsinki, and the study protocol had been approved by the ethics commission of the Faculty of Psychology and Social Sciences of the University of Geneva (project identification codes: CE\_FPSE\_14.10.2010 and CE\_FPSE\_05.04.2017).

## **Disclosure Statement**

The authors have no conflicts of interest to disclose.

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## **Author Contributions**

AI, ERG, and BRG formulated the research question, analyzed the data, and wrote the manuscript. BC, SS, and SC were involved in writing the manuscript. MK formulated the research question, conceptualized the study, supervised the data collection, and participated in writing.

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