Cognitive Reserve Mediates the Relation between Openness to Experience and Smaller Decline in Executive Functioning

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Keywords
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Abstract
\textbf{Aims:} We investigated the mediating role of leisure activity engagement in the longitudinal relation between openness to experience and subsequent change in executive functioning over 6 years as measured through performance changes in the Trail Making Test (TMT). \textbf{Methods:} We analyzed longitudinal data from 897 older adults (mean = 74.33 years in the first wave) tested on TMT parts A and B in two waves 6 years apart. Participants reported information on leisure activity engagement and openness to experience. \textbf{Results:} Latent change score modeling revealed that 37.2\% of the longitudinal relation between higher openness to experience in the first wave of data collection and a smaller subsequent increase in TMT completion time from the first to the second wave (i.e., a smaller decline in executive functioning) was mediated via a higher frequency of leisure activities in the first wave. \textbf{Conclusion:} Individuals with higher openness to experience show greater activity engagement in old age. By enhancing their cognitive reserve, this activity engagement may finally result in smaller subsequent decline in executive functioning.
Introduction

The cognitive reserve concept postulates that cognitive stimulation (such as leisure activities) builds up a buffer that is instrumental for preserving cognitive functioning in aging [1]. Empirically corroborating the predictions of the cognitive reserve concept, both cross-sectional and longitudinal evidence, for example, showed that engaging in leisure activities in old age contributes to the accumulation of cognitive reserve and is related to better performance and reduced decline in executive functioning in old age [2–4].

Recently, investigation of the role of certain personality dimensions, such as openness to experience [5], has become a focus in cognitive reserve research. In general, the personality dimension openness to experience reflects (among others) the degree of intellectual curiosity, creativity, and preference for variety [6]. Interestingly, engaging in leisure activities has for example been found to be greater in individuals with higher openness to experience [5, 7]. Moreover, several studies provided evidence for the relation between higher openness to experience and better cognitive functioning [8–10].

To explain those findings, it has been suggested that individuals with a high level of openness to experience more frequently and/or more intensively engage in stimulating activities that provide learning opportunities and that this activity engagement in turn improves cognitive ability levels [11]. Consistent with this view, combining the interplay of the aforementioned relationships in one overarching framework, Ihle et al. [12] found that greater activity engagement mediates the relation between higher openness to experience on the one hand and better performance status in cognitive functioning on the other. Yet, there is no longitudinal investigation to date regarding the mediating role of leisure activity engagement in the relation between openness to experience and cognitive decline. This gap in the literature is particularly troubling, as longitudinal research is needed to evaluate whether the outlined mediation framework not only holds for cognitive performance status at a given point in time, but also for longitudinal changes in cognitive functioning with aging. To address this major gap in the literature, we investigated the mediating role of leisure activity engagement in the longitudinal relation between openness to experience and subsequent change in executive functioning over 6 years as measured through performance changes in the Trail Making Test (TMT), taking into account age, sex, and education (being an early-life marker of cognitive reserve [1–3]) as covariates.

Methods

Participants

We analyzed data from 897 individuals who participated in the two waves of the Vivre-Leben-Vivere (VLV) survey [13–15]. 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 [12–16]. Mean age of the respondents in W1 was 74.33 years (SD = 6.50, range 65–96), and 51.4% were men.

Materials

In both waves, we administered the Trail Making Test parts A and B (TMT A and TMT B, respectively [17]). We asked participants in W1 about their engagement in 18 leisure activities [12], for which we calculated an overall measure of frequency of leisure activity engagement in W1 (possible range 0 “never” to 4 “every day or almost every day”) [18]. We assessed openness to experience in W1 using the Big Five Inventory (possible range 1–5) [19].

Statistical Analyses

We conducted latent change score modeling [20] using the R package lavaan [21]. Specifically, we modeled latent executive functioning factors of TMT completion time in W1 (constructed from scores in
TMT A and TMT B in W1 and W2 (constructed from scores in TMT A and TMT B in W2) as well as a latent change in executive functioning variable regarding change in TMT completion time from W1 to W2. We enforced strong factorial invariance on the factor loadings, with intercepts of all indicators being fixed to zero to assure that the same executive functioning factor was assessed at both waves [22]. We included the following covariates to predict latent change: frequency of leisure activities in W1, openness to experience in W1, age in W1, sex, and years spent for formal education. We also included interrelations of all covariates to take the dependencies among them into account. With this latent change score model, we tested the outlined mediation framework. Specifically, we investigated whether the longitudinal relation between openness to experience in W1 and subsequent change in executive functioning from W1 to W2 was mediated via frequency of leisure activities in W1 (see Fig. 1 for a general illustration), taking into account age, sex, and education as covariates. Importantly for evaluating mediation, the applied approach allowed simultaneously estimating the residual direct (nonmediated) relation between openness to experience and subsequent change in executive functioning (i.e., the coefficient of path c) and the indirect (mediated) relation via frequency of leisure activities (i.e., the product of the coefficients for paths a and b), including their significance.

**Results**

**Descriptive Statistics**

Mean completion time in the TMT A was 55.23 s (SD = 24.40) in W1 and 56.03 s (SD = 24.37) in W2. Mean completion time in the TMT B was 115.13 s (SD = 44.80) in W1 and 108.90 s (SD = 45.40) in W2 (see [23] for normative data with regard to similar demographic characteristics in terms of age and education as in the present study showing similar average completion time in TMT A and TMT B). Comparing both waves, there were no statistically significant differences in the average completion time in neither TMT A nor TMT B (p > 0.145, respectively). The mean frequency of leisure activities score in W1 was 1.28 (SD = 0.38). The mean openness to experience score in W1 was 3.66 (SD = 0.94). The mean of years spent for formal education was 13.46 (SD = 3.96).

**Latent Change Score Modeling**

The latent change score model provided a very good statistical account of the data ($\chi^2 = 21.01$, df = 12, $p = 0.050$, CFI = 0.99, IFI > 0.99, RMSEA = 0.03, and SRMR = 0.02).

A higher frequency of leisure activities in W1 significantly predicted a smaller subsequent increase in TMT completion time from W1 to W2 (i.e., a smaller decline in executive functioning, $\beta = -0.13$, $p = 0.004$). Older age in W1 significantly predicted a larger subsequent increase in TMT completion time from W1 to W2 (i.e., steeper decline in executive functioning, $\beta = 0.31$, $p < 0.001$). Sex ($\beta = -0.05$, $p = 0.268$) and education ($\beta = 0.02$, $p = 0.613$) did not predict changes in TMT completion time. There was no residual direct (nonmediated) relation between openness to experience in W1 and subsequent changes in TMT completion
time ($\beta = -0.03, p = 0.453$). Yet, higher openness to experience in W1 was related to a higher frequency of leisure activities in W1 ($\beta = 0.15, p < 0.001$). Importantly, 37.2% of the longitudinal relation between higher openness to experience in W1 and a smaller subsequent increase in TMT completion time from W1 to W2 (i.e., a smaller decline in executive functioning) was exerted indirectly via a higher frequency of leisure activities in W1 as mediator ($\beta = -0.02, p = 0.016$).

**Discussion**

The present study investigated the mediating role of leisure activity engagement in the longitudinal relation between openness to experience and subsequent decline in executive functioning over 6 years as measured through performance changes in the TMT. First of all, regarding decline in executive functioning across 6 years, we observed that a higher frequency of leisure activities pursued in the first wave of data collection longitudinally predicted a smaller subsequent decline in executive functioning (i.e., indicated by a smaller increase in TMT completion time). Thus, our findings are consistent with studies suggesting that greater activity engagement in old age contributes to cognitive reserve and is associated with reduced decline in executive functioning [4]. Moreover, consistent with the literature [5, 7], we found that engaging in leisure activities was greater in individuals with higher openness to experience.

Notably, and most importantly, with regard to the interplay of these relationships, we found that activity engagement mediated between openness to experience on the one hand and changes in executive functioning with aging on the other. Specifically, a higher frequency of leisure activities pursued in the first wave of data collection mediated about a third of the longitudinal relation between higher openness to experience in the first wave and a smaller subsequent decline in executive functioning (i.e., indicated by a smaller increase in TMT completion time). In this regard, the present findings confirm the recent empirical cross-sectional observation that greater activity engagement mediates the relation between higher openness to experience on the one hand and better performance status in cognitive functioning on the other [12]. Importantly, our study extends such cross-sectional evidence with longitudinal data regarding decline in executive functioning over 6 years.

In conclusion, the present results suggest that individuals with higher openness to experience show greater activity engagement in old age. By enhancing their cognitive reserve, this activity engagement may finally result in smaller subsequent decline in executive functioning in aging.

In the context of the latter notions, we acknowledge that the present correlative study does not allow drawing causal inferences. Thus, we cannot fully disentangle a potentially protective effect of activity engagement on subsequent cognitive decline from alternative explanations related to the potential self-selection of older adults with better cognitive abilities to maintain an active lifestyle. Yet, an important strength of the present study is that our analyses are based on cognitive longitudinal change scores and took into account the baseline cognitive level in the first wave of data collection (when activity engagement was assessed), it is less probable that the observed relation between activity engagement and a smaller subsequent cognitive decline is due to individuals who reduced activity engagement because of cognitive decline. Furthermore, we acknowledge that the current study is limited by a relatively short assessment of executive functioning. Thus, future longitudinal studies will have to examine whether the present pattern of results holds also for a broader range of executive functions.
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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 has been approved by the ethics commission of the Faculty of Psychology and Social Sciences of the University of Geneva.

Disclosure Statement

The authors have no conflicts of interest to disclose.

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