The Relation between Education and Later Life Cognitive Performance

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Abstract

While exploring the progression of cognitive diseases, there have been many ideas about the relationship between cognitive performance and education. This literature review aims to offer a comprehensive view of how various aspects of education can impact one's cognitive performance later in life. One aspect is the amount of education a person received: it was found that the more education an individual has, the slower their later-life cognitive decline (Alley et al, 2007). Another aspect was the age at which education was attained and the quality of the education (Contador et al., 2017, Seblova et al.). Better teachers, and a strong childhood education are all correlated with higher cognitive performance (Contador et al., 2017, Seblova et al.). A relation between socioeconomic status and cognitive health is also prevalent(Zahodne et al., 2015). At a certain point, cognitive performance is correlated with income, rather than with education (Zahodne et al., 2015).

Effect of Quantity of Education on Later-Life Cognitive Decline

As scientists have explored cognitive decline, they have investigated whether the amount of education that an individual receives in their life slows the rate of cognitive decline (Alley et al., 2007). There are two main theories that scientists have come up with during their investigation into education and cognitive decline: the cognitive "reserve" theory, which suggests that education protects against cognitive decline, and the cognitive "compensation" theory, which suggests that education is detrimental in the context of cognitive decline (Alley et al, 2007).

According to a review by Pettigrew and Soldan, the cognitive reserve theory suggests that education contributes to a mental "reserve" that aids in maintaining an individual's cognitive

function (Pettigrew & Soldan, Year). It also relates being more educated to having stronger neural connections, further assisting the brain's ability to resist age-related changes or damages (Pettigrew & Soldan, 2019).

A study by Leibovici et al found results that support the cognitive reserve theory (Leibovici et al., 1996). The study's participants were a group of 283 subjects from Southern France with an average age of 74.7 years old. Within this group of participants, 3.5% had no education, 44.5% had primary education, 35.7% had secondary education, and 16.3% had tertiary education. The researchers used Principal Component Analysis to assess the impact of education on cognitive decline, and found that education helped slow cognitive decline, especially in cognitive domains like secondary memory and language (Leibovici et al., 1996). While the results of this study does demonstrate that education helps protect against cognitive decline, the localization of this study leads to an inability to extrapolate its findings onto other populations (Leibovici et al., 1996). A study conducted by Zhong et al on adults aged 50+ from outpatient clinics in Jilin Province, China addresses the issue of Leibovici et al.'s findings. Zhong et al.'s study evaluated subjects on the Cognitive Reserve Index (CRI) scale, which considers factors like education, occupational complexity, and engagement in mentally stimulating activities to quantify an individual's cognitive reserve (Zhong et al., 2024). Cognitive Decline was measured in the subjects by the Mini-Mental State Examination (MMSE), Montreal Cognitive Assessment (MoCA), and the Clinical Dementia Rating (CDR) scale. Researchers found that "Higher education was significantly associated with a lower risk of cognitive impairment …, regardless of occupation." (Zhong et al., 2024). This study, similar to Leibovici et al.'s study with a Southern French population, also found similar protective effects of education against cognitive decline in a Chinese population (Leibovici et al., 1996; Zhong et al.,

2024). Thus, Zhong et al.'s broader Chinese sample furthers the cognitive reserve theory and highlights the protective role of education against cognitive decline across diverse populations.

Alley et al hypothesized that if education slows the rate of cognitive decline, the cognitive reserve theory would be supported (Alley et al., 2007). The studies conducted by Leibovici et al. and Zhong et al. support this hypothesis. However, Alley et al. also hypothesized that if education were to increase the rate of cognitive decline, a compensation hypothesis would be supported, in which older adults rely on intact domains to supplement the declining function of deteriorating domains, until the supplementary domains begin to deteriorate (Alley et al., 2007).

A study conducted by Contador et al showed results favoring the compensation hypothesis (Contador et al., 2017). Their study included 306 individuals with dementia who were classified into two groups by their education level: high-educated for subjects with a primary school degree or higher, and low-educated for illiterate subjects or those only able to read and write. They tested participants using the Spanish version of the MMSE, the MMSE-37, and the Spanish version of the Pfeffer's Functional Activity Questionnaire. The researchers found that the rate of cognitive decline was higher in the high-educated group when compared to the low-educated group (Contador et al.). However, it is important to note that these individuals had dementia, and were already undergoing cognitive decline (Contador et al., 2017). In turn, this could suggest that cognitive decline rates increase in highly-educated individuals when compared to their lesser-educated counterparts only after cognitive decline has begun (Contador et al., 2017). This means that education acts as a double edged sword in the realm of cognitive decline: Leibovici et al. and Zhong et al. suggest that it plays a preventive role against cognitive

decline, while Contador et al.'s findings suggest that education also speeds up cognitive decline once it has begun (Contador et al., 2017; Leibovici et al., 1996; Zhong et al., 2024).

A study by Clouston et al. supports this finding (Clouston et al., 2020). Clouston et al. ensured their population was carefully scrutinized to certify effective results, data from 62,485 Americans' cognitive assessments over 2-3 years was studied to test for the relationship between education and the occurrence of accelerated cognitive decline (Clouston et al., 2020). These researchers created multiple models of their data. In their fourth model, they found that, among participants with Alzheimer's Disease and Related Dementias (ADRD), those with high education generally experienced delayed onset of ADRD's associated cognitive decline (Clouston et al., 2020). However, Model 5 found that once cognitive decline began, individuals with higher education experienced it at a greater rate than their lower-educated counterparts (Clouston et al., 2020). Clouston et al. 's findings mirror Alley et al. 's hypothesis, and the synthesis of Leibovici et al. 's, Zhong et al. 's, and Contador et al.'s works (Alley et al., 2007; Clouston et al., 2020; Contador et al., 2017; Leibovici et al., 1996; Zhong et al., 2024).

In conclusion, the evidence from these studies suggests that both the cognitive reserve theory and the cognitive compensation theory may coexist in explaining the impact of education on cognitive decline (Alley et al., 2007; Clouston et al., 2020; Contador et al., 2017; Leibovici et al., 1996; Pettigrew & Soldan, 2019; Zhong et al., 2024). Education appears to play a dual role: it helps delay the onset of cognitive decline, as proposed by the cognitive reserve theory, but once decline begins, it may accelerate in those with higher education, consistent with the cognitive compensation theory (Alley et al., 2007; Clouston et al., 2020; Contador et al., 2017; Leibovici et al., 1996; Pettigrew & Soldan, 2019; Zhong et al., 2024). This dual effect highlights the complex relationship between education and cognitive decline, indicating that while education can be

protective, it may also lead to faster deterioration once cognitive impairment sets in (Alley et al., 2007; Clouston et al., 2020; Contador et al., 2017; Leibovici et al., 1996; Pettigrew & Soldan, 2019; Zhong et al., 2024).

The Effect of Time and Quality of Education on Cognitive Health

While a positive relation can be established with years of education and cognitive performance, many factors contribute to this conclusion, such as the time of education attainment and its quality (Zahodne et al., 2015, Contador et al., 2017, Seblova et al., 2023, Lövdén et al., 2020). Multiple studies have concluded that earlier education helps with cognitive development during a crucial period in one's life while decreasing the chances of cognitive decline later in life, whereas later education is correlated with a higher socioeconomic status (cite some of these studies). Additionally, better teachers and resources provide students with the means to maintain high cognitive development (add citation).

A study by Laura B. Zahodne administered neurological tests to 3,435 older adults at 24 month intervals for 18 years (Zahodne et al., 2015). Individuals were separated into low (0-8 years) and high (9-20 years) levels of education. Consistent with the previous contents of this paper, more years of education were associated with higher cognitive levels and a slower rate of cognitive decline (Zahodne et al., 2015). However, within the high-education leveled group, cognitive decline correlated with having a lower income (Zahodne et al., 2015). Another connection with the effects of later education was found in a study by Scielo Brazil. It was found that higher educated individuals have faster cognitive decline if diagnosed with dementia, compared to those without dementia (Contador et al., 2017) In summary, education sped up the

brain's decline under the context of dementia. This shows room for further studies examining how, in some scenarios, higher education can be negative for the brain.

Adding on to this, according to the Alzheimer's Association, the Project Talent Aging study examined the question of whether school quality affected cognitive performance. 2,289 participants with a mean age of 74.8 took part in telephone neurocognitive testing (Seblova et al., 2023). Multiple educational factors in participants' high schools were assessed, including teacher headcount and better graduate training. Students coming from schools with these two factors consistently performed better in the cognitive tests than other students (Hill-Jarret). All things considered, students with access to better schools and childhood education consistently showed greater cognitive health in tests, and thus exhibited slower cognitive decline (Hill-Jarret). Researchers in the Association for Physiological Science conclude that, "Improving the conditions that shape development during the first decades of life carries great potential for improving cognitive ability in early adulthood and for reducing public-health burdens related to cognitive aging and dementia" (Lövdén et al., 2020). This is the call to action: reformating schools will benefit the cognitive health of future generations and improve our society!

Overall, we can conclude that the quality of schools and access to higher education are impactful factors in avoiding cognitive decline in later life (Zahodne et al., 2015, Contador et al., 2017, Seblova et al., 2023, Lövdén et al., 2020). Earlier education sets the foundation for cognitive strength, and access to a good school during this time period plays into continuation of cognitive enhancement (Zahodne et al., 2015, Contador et al., 2017, Seblova et al., 2023, Lövdén et al., 2020). After initial education, later education only parallels benefits to cognitive health in the context of higher income, showing another connection between SES and cognitive health (Zahodne et al., 2015, Contador et al., 2017, Seblova et al., 2023, Lövdén et al., 2020).

Conclusion

Education plays an important role in cognitive health, with early and high-quality education contributing to a cognitive "reserve" that delays cognitive decline's onset (Alley et al., 2007). However, once cognitive decline begins, highly educated individuals have been shown to experience a faster rate of cognitive decline, consistent with the cognitive "compensation" theory (Alley et al., 2007; Contador et al., 2017; Clouston et al., 2020). This complex relationship between education, cognitive reserve and compensation, and cognitive decline is influenced by factors like socioeconomic status and timing of education.

Despite these findings, several gaps in the literature remain. Most studies focus on specific populations, typically from higher-income,Western countries. The lack of population diversity in these studies highlights the need for more diverse studies with populations more inclusive of other cultural and socioeconomic backgrounds. Additionally, education type and quality, as well as continued education in adulthood, are underexplored and could provide more insights into cognitive decline. Understanding these factors could be the key to development of targeted interactions that maximize the benefits of education on cognitive health throughout an individual's life.

References

Alley, D., Suthers, K., & Crimmins, E. (2007). Education and Cognitive Decline in Older Americans: Results From the AHEAD Sample. *Research on Aging*, *29*(1), 73–94. https://doi.org/10.1177/0164027506294245

Clouston, S. A. P., Smith, D. M., Mukherjee, S., Zhang, Y., Hou, W., Link, B. G., & Richards, M. (2020). Education and Cognitive Decline: An Integrative Analysis of Global Longitudinal Studies of Cognitive Aging. *The Journals of Gerontology: Series B*, *75*(7), e151–e160. https://doi.org/10.1093/geronb/gbz053

Contador, I., Bermejo-Pareja, F., Pablos, D. L., Villarejo, A., & Benito-León, J. (2017). High education accelerates cognitive decline in dementia: A brief report from the population-based NEDICES cohort. *Dementia & Neuropsychologia*, *11*(3), 297–300. https://doi.org/10.1590/1980-57642016dn11-030012

Kilander, L., Nyman, H., Boberg, M., & Lithell, H. (1997). Cognitive function, vascular risk factors and education. A cross-sectional study based on a cohort of 70-year-old men. *Journal of Internal Medicine*, *242*(4), 313–321. https://doi.org/10.1046/j.1365-2796.1997.00196.x

Leibovici, D., RITCHIE, K., Ledésert, B., & Touchon, J. (1996). Does Education Level Determine the Course of Cognitive Decline? *Age and Ageing*, *25*(5), 392–397. https://doi.org/10.1093/ageing/25.5.392

Lövdén, M., Fratiglioni, L., Glymour, M. M., Lindenberger, U., & Tucker-Drob, E. M. (2020). Education and Cognitive Functioning Across the Life Span. *Psychological Science in the Public Interest*, *21*(1), 6–41. https://doi.org/10.1177/1529100620920576

Pettigrew, C., & Soldan, A. (2019). Defining Cognitive Reserve and Implications for Cognitive Aging. *Current Neurology and Neuroscience Reports*, *19*(1), 1. https://doi.org/10.1007/s11910-019-0917-z

Seblova, D., Eng, C., Avila-Rieger, J. F., Dworkin, J. D., Peters, K., Lapham, S., Zahodne, L. B., Chapman, B., Prescott, C. A., Gruenewald, T. L., Arpawong, T. Em., Gatz, M., Jones, R. J., Glymour, M. M., & Manly, J. J. (2023). High school quality is associated with cognition 58 years later. *Alzheimer's & Dementia: Diagnosis, Assessment & Disease Monitoring*, *15*(2), e12424. https://doi.org/10.1002/dad2.12424

Zahodne, L. B., Stern, Y., & Manly, J. J. (2015). Differing effects of education on cognitive decline in diverse elders with low versus high educational attainment. *Neuropsychology*, *29*(4), 649–657. https://doi.org/10.1037/neu0000141

Zhong, T., Li, S., Liu, P., Wang, Y., & Chen, L. (2024). The impact of education and occupation on cognitive impairment: A cross-sectional study in China. *Frontiers in Aging Neuroscience*, *16*. https://doi.org/10.3389/fnagi.2024.1435626