VOXEU COLUMN | HEALTH ECONOMICS

Use it or lose it: How cognitive skills change with age

Eric Hanushek, Lavinia Kinne, Frauke Witthoeft, Ludger Woessmann / 12 Apr 2025

Cognitive skills are commonly assumed to begin deteriorating from the age of 30, which could pose a significant challenge for rapidly ageing populations. But this assumption relies largely on cross-sectional data that cannot distinguish between ageing patterns and cohort differences. Using German longitudinal data, this column finds that skills, on average, increase markedly into one's 40s before decreasing slightly in literacy and more severely in numeracy. In addition, skills decline at older ages only for those with below-average skill usage, outlining a clear policy pathway for avoiding skill declines.

AUTHORS

Eric Hanushek

Lavinia Kinne

Frauke Witthoeft

Ludger Woessmann

Many disciplines have addressed brain ageing and cognitive decline. Research from psychology and neuroscience shows that ageing is differently related to several components of cognitive functioning (Desjardins and Warnke 2012, Haier et al. 2023, Sánchez-Izquierdo and Fernández-Ballesteros 2021). While capacities unrelated to prior learning decline in early adulthood, cognitive capability based on prior learning often increases until age 50 and stagnates afterwards (Staudinger 2020, Oltmanns et al. 2017, Salthouse 2004). These patterns have been related to neurological alterations in different parts of the aging brain (McDonough et al. 2022, Dexter and Ossmy 2023, Ebaid and Crewther 2023), particularly the decrease of grey and white brain matter (Oltmanns et al. 2017, Hedman et al. 2012, Brito et al. 2023).

Economists are increasingly interested in skill development from a different angle (Gust et al. 2022, 2024, Kugler and Silliman 2020, Nicoletti et al. 2021). Cognitive skills such as literacy and numeracy are closely related to individual earnings (Hanushek et al. 2015 and 2017, Hampf et

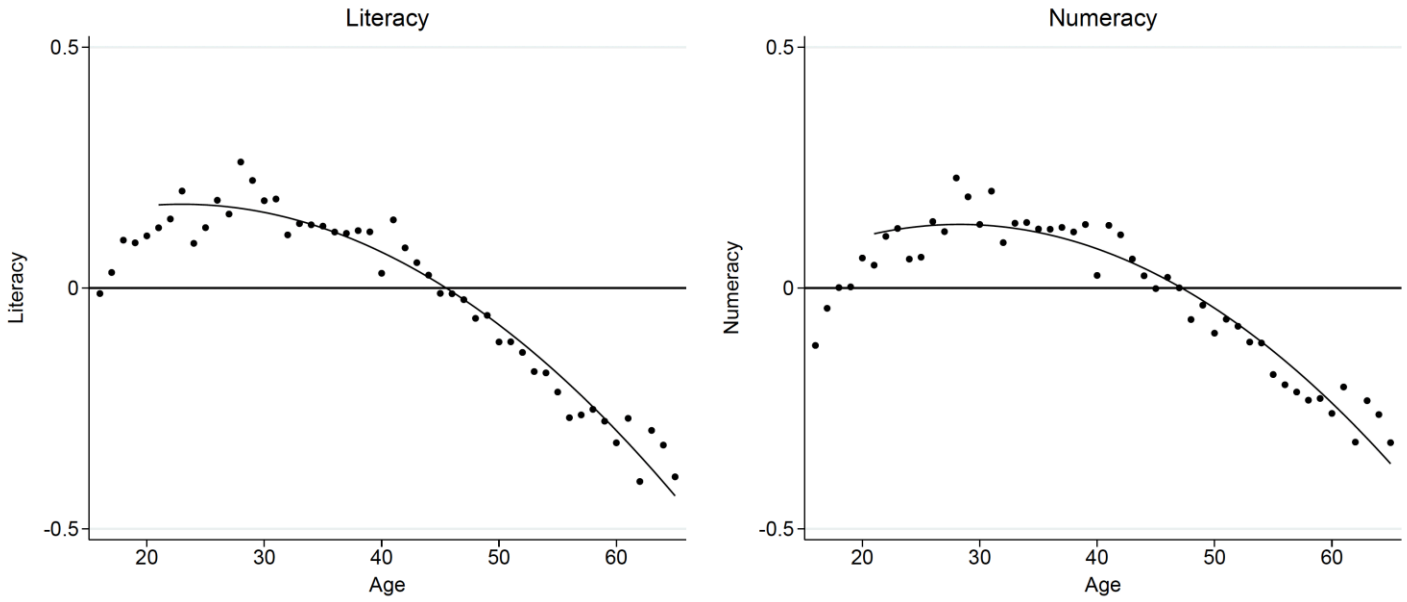
al. 2017) and national growth rates (Hanushek and Woessmann 2008 and 2015), implying that the steady and marked changes in the age composition of societies (Bloom and Zucker 2023) might directly affect the economic wellbeing of nations (Bloom 2022, Kotschy and Bloom 2023).

In new research, we use unique German longitudinal data to show robust age patterns in cognitive skills (Hanushek et al. 2025). We overcome the commonly faced limitation of not being able to distinguish between age and cohort patterns, and additionally account for measurement errors that arise from repeated testing.

Separating age from cohort effects and reducing measurement error

Cross-sectional data suggest declines of cognitive skills at age 30 or before. In 2011–2012, the Programme for the International Assessment of Adult Competencies (PIAAC), administered by the OECD, tested the numeracy and literacy skills of adults aged 16 to 65 in 39 countries (OECD 2013). Figure 1 shows that skills differ markedly by a respondent's age: both literacy and numeracy seem to be declining for respondents in their late 20s or early 30s. However, cross-sectional data necessarily contain not only aging patterns but also cohort differences in skills, such as those due to differences in skill accumulation in varying schooling structures. To properly understand the implications of aging societies and their associated economic concerns, it is crucial to isolate the pure ageing effect.

Figure 1 Cross-sectional age-skill profiles



***Notes*: PIAAC, OECD countries.**
***Source*: Hanushek et al. (2025).**

Individual longitudinal skill tests for a representative population of German adults allow us to avoid confounding age and cohort patterns, and to estimate credible age-skill profiles for the adult population. Germany, unique among all participating countries, created a panel of participants from the PIAAC sample who were re-surveyed and re-tested three and a half years after the original survey. We use the panel dimension of the German PIAAC data to estimate actual changes in adult skills over the full age spectrum. More specifically, we estimate average annual changes in skills separately for each observed age, and then concatenate these across individuals of different ages to derive full age-skill profiles.

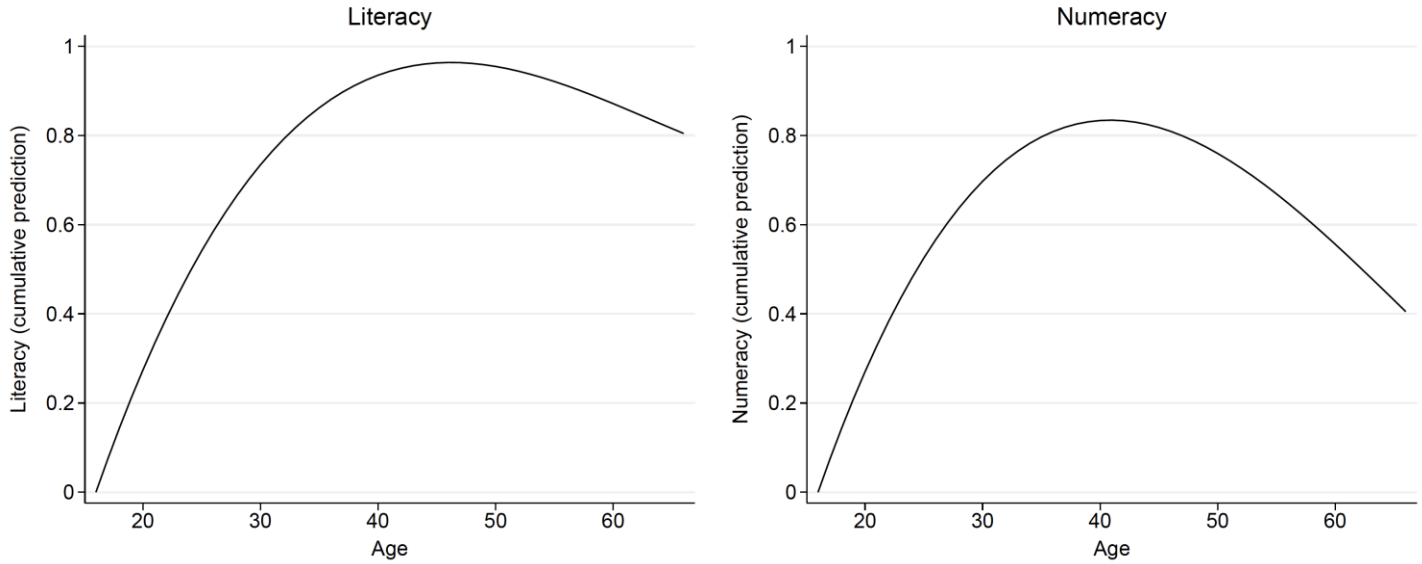
We also address the bias from measurement error that accompanies the testing of skills over time. Observations of test scores include a combination of true scores and measurement errors. Intuitively, observed low test scores are more likely to include negative errors. When we observe another assessment for an initially low-scoring individual, the measurement error is unlikely to be as negative as the first time, implying that for low-scoring individuals, the change in observed test scores seems more favourable than it actually is. For initially high-scoring individuals, the opposite will be true. This so-called reversion to the mean will distort the overall age-skill relationship when skills vary by age. Following Berry et al. (1984), we correct for this distortion to obtain error-adjusted age-skill patterns.

Actual skill decline starts much later than previously assumed

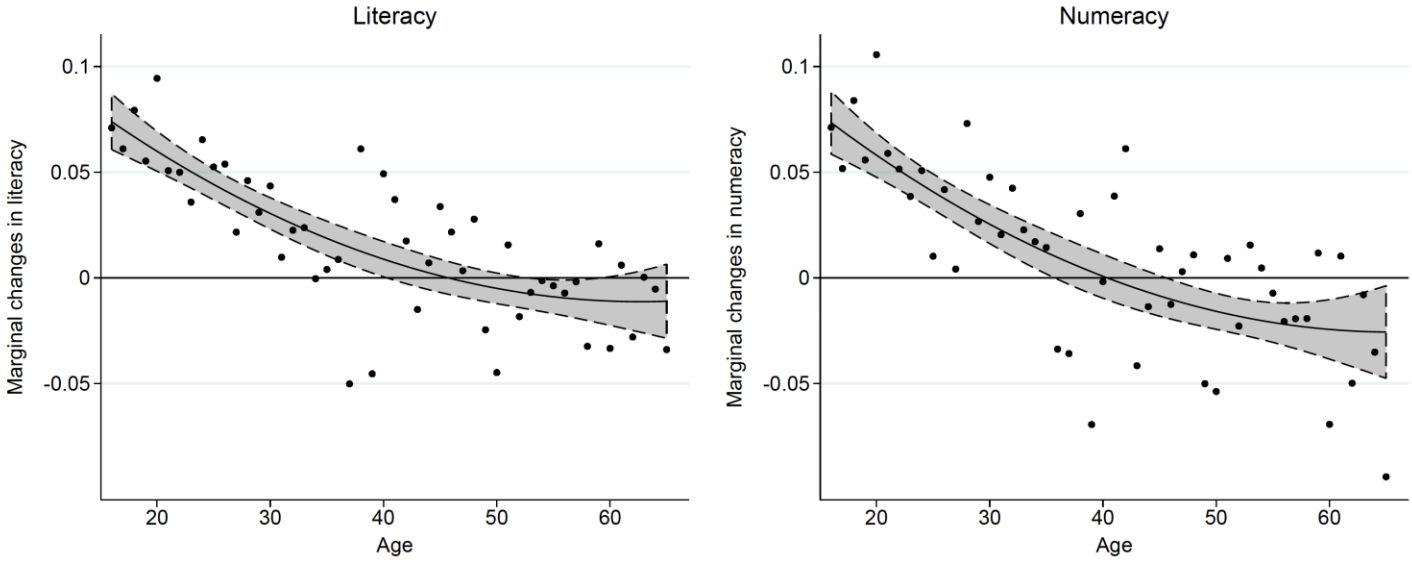
The changes in observed numeracy and literacy skills for individuals over time show a very different pattern than suggested by the cross-sectional data. Figure 2B, which plots annual marginal test score changes (corrected for reversion to the mean), shows that skills increase for individuals up to age 45 in literacy and up to age 40 in numeracy in the German population. (Shaded areas reflect confidence bans on estimated quadratic age patterns.) Skill changes turn negative beyond these ages, with notably stronger declines for numeracy than for literacy.

Figure 2 Longitudinal age-skill profiles

a) Cumulative age-skill profiles



b) Marginal skill changes by age



***Notes*: PIAAC-L, Germany.**
***Source*: Hanushek et al. (2025).**

Figure 2A displays the resulting cumulative age-skill profiles. Literacy skills increase in the 20s and 30s before stabilising in the late 30s. The peak is at age 46, and subsequent declines are modest. Numeracy skills also increase strongly at young ages but peak earlier, at age 41, and decline substantially at later ages. Nonetheless, scores at age 65 (the limit of our data) remain above levels observed in the early 20s.

Frequent skill usage is crucial for skill retention

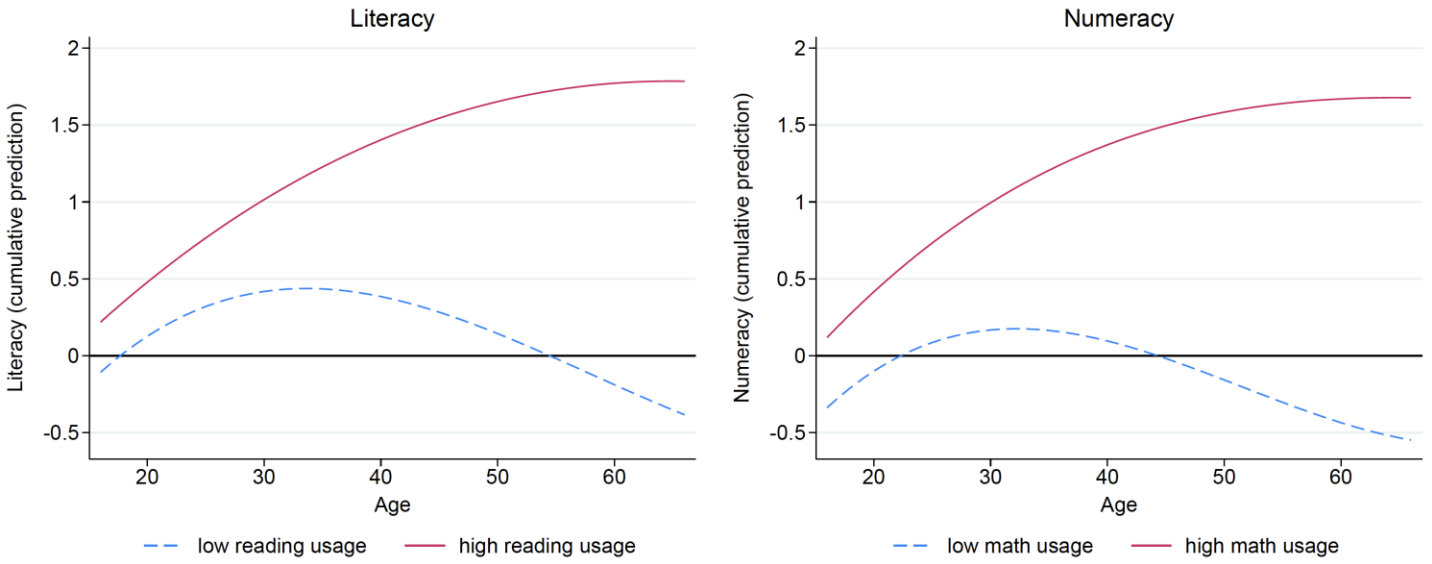
Average age-skill profiles mask important heterogeneity. Previous analyses have considered whether individual background or occupations influence the evolution of age-skill patterns. These investigations have been motivated by assumed differences in skill usage across groups, but data on actual skill usage have not been generally available. We use information on the detailed nature and frequency of participants' skill usage at work and at home from the background questionnaire of the PIAAC survey to explore the heterogeneity of demographic ageing patterns by actual skill use.

Considering age-skill profiles by the frequency of skill usage paints a more nuanced picture of skill development with ageing. We repeat our analysis for respondents above and below the median of aggregate skill usage at work and at home. To do so, we create an index based on the frequency of reported activities related to reading and math at work and in everyday life from separate items such as "calculating prices, costs, or budgets" (for maths) or "reading letters, memos, or e-mails" (for reading).

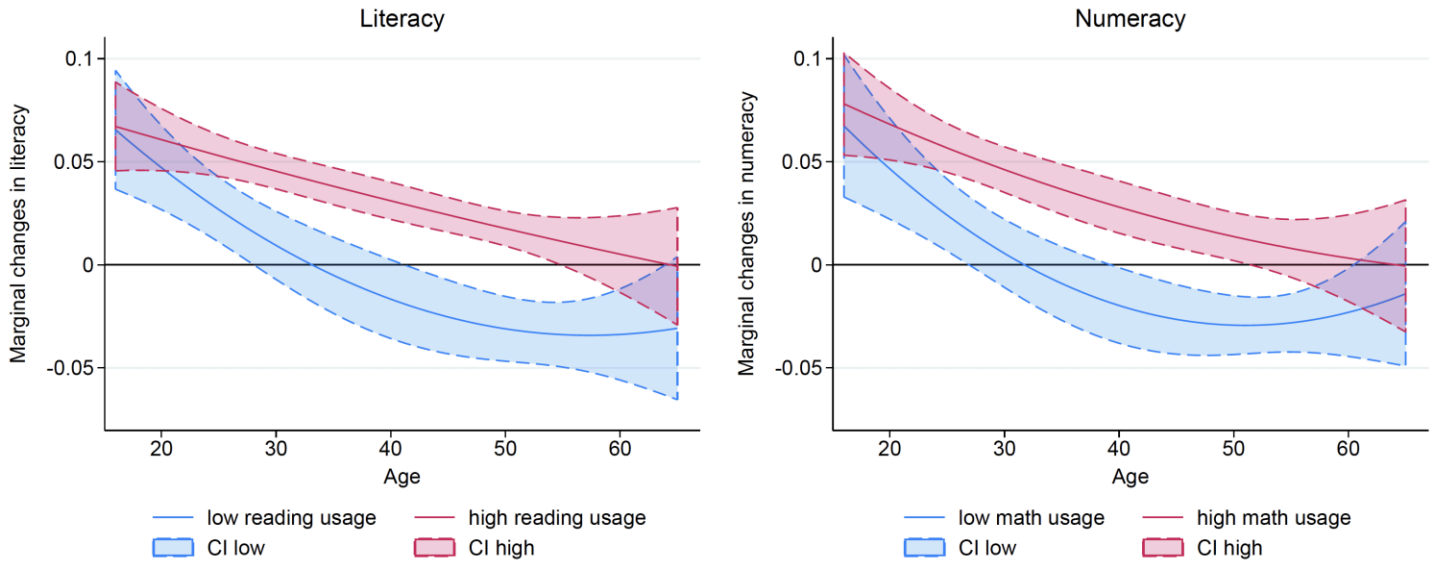
On average, those with above-median usage of numeracy and literacy never lose skills in the observed age range (Figure 3B, red lines and shades). Their skills increase steeply into their 50s and then flatten out, with no indication of average decline (Figure 3A, red lines). Instead, for those with below-median usage (blue lines and shades), skill decline begins in their mid-30s.

Figure 3 Age-skill profiles by skill usage

a) Cumulative age-skill profiles



b) Marginal skill changes by age



***Notes*: PIAAC-L, Germany.**
***Source*: Hanushek et al. (2025).**

In contrast to the aggregate pattern, usage-specific patterns are quite similar for numeracy and literacy competencies. These results suggest that skill usage plays a leading role in determining whether skills are gained, retained, or lost over time.

Concluding remarks

Cognitive skills such as literacy and numeracy are important not only for individual incomes but also for the economic growth of nations. As a result, the aging of world populations presents economic concerns if skills decline with age.

We use longitudinal variation in individual literacy and numeracy skills for a representative adult sample to create age-skill profiles that credibly separate age from cohort effects. The pure age component that we derive suggests that skills decline later than previously assumed. Additionally, skill decline is only present for those who do not use their skills much at work or at home. Overall, our results challenge the idea that natural law dictates an inevitable decline in skills with age. Behavioural choices can overcome natural biological changes. It is thus crucial for individuals and societies that populations maintain their competencies through frequent skill usage.

In principle, our results offer some consolation for countries with aging populations. At the same time, they highlight the importance of policy attention aimed not only at the accumulation of skills, as in schools, but also their retention through skill usage and lifelong learning.

References

Berry, D A, M L Eaton, B P Ekholm and T L Fox (1984), "Assessing Differential Drug Effect", *Biometrics* 40(4): 1109–115.

Bloom, D (2022), "Healthy ageing for a healthy economy", VoxEU.org, 15 November.

Bloom, D E and L M Zucker (2023), "Aging is the Real Population Bomb", *Finance and Development* 60(2): 58–61.

Brito, D V C, F Esteves, A T Rajado and N Silva et al. (2023), "Assessing Cognitive Decline in the Aging Brain: Lessons from Rodent and Human Studies", *npj Aging* 9(1): 23.

Desjardins, R and A J Warnke (2012), "Ageing and Skills: A Review and Analysis of Skill Gain and Skill Loss over the Lifespan and over Time", OECD Education Working Paper 72, Paris: Organisation for Economic Co-operation and Development.

Dexter, M and O Ossmy (2023), "The Effects of Typical Ageing on Cognitive Control: Recent Advances and Future Directions", Frontiers in Aging Neuroscience 15: 1231410.

Ebaid, D and S G Crewther (2020), "Time for a Systems Biological Approach to Cognitive Aging? A Critical Review", *Frontiers in Aging Neuroscience* 12: 114.

Gust, S, E A Hanushek and L Woessmann (2022), "A world unprepared: Missing skills for development", VoxEU.org, 5 December.

Gust, S, E A Hanushek and L Woessmann (2024), "Global Universal Basic Skills: Current Deficits and Implications for World Development", *Journal of Development Economics* 166: 103205.

Haier, R J, R Colom and E Hunt (2024), *The Science of Human Intelligence*, Second Edition, Cambridge University Press.

Hampf, F, S Wiederhold and L Woessmann (2017), "Skills, Earnings, and Employment: Exploring Causality in the Estimation of Returns to Skills", *Large-scale Assessments in Education* 5(12): 1–30.

Hanushek, E A, L Kinne, F Witthöft and L Woessmann (2025), "Age and Cognitive Skills: Use It or Lose It", *Science Advances* 11(10): eads1560.

Hanushek, E A, G Schwerdt, S Wiederhold and L Woessmann (2015), "Returns to Skills around the World: Evidence from PIAAC", *European Economic Review* 73: 103–30.

Hanushek, E A, G Schwerdt, S Wiederhold and L Woessmann (2017), "Coping with Change: International Differences in the Returns to Skills", *Economics Letters* 153: 15–19.

Hanushek, E A and L Woessmann (2008), "The Role of Cognitive Skills in Economic Development", *Journal of Economic Literature* 46(3): 607–68.

Hanushek, E A and L Woessmann (2015), *The Knowledge Capital of Nations: Education and the Economics of Growth*, MIT Press.

Hedman, A M, N E M van Haren, H G Schnack, R S Kahn and H E Hulshoff Pol (2012), "Human Brain Changes across the Life Span: A Review of 56 Longitudinal Magnetic Resonance Imaging Studies", *Human Brain Mapping* 33(8): 1987–2002.

Kotschy, R and D Bloom (2023), "Economic growth prospects in the face of population ageing", VoxEU.org, 22 October.

Kugler, A D and M Silliman (2020), "Hard and soft skills in vocational training: Experimental evidence from Colombia", VoxEU.org, 24 October.

McDonough, I M, S A Nolin and K M Visscher (2022), "25 Years of Neurocognitive Aging Theories: What Have We Learned?", *Frontiers in Aging Neuroscience* 14: 1002096.

Nicoletti, G, P Gal, T Leidecker and C Criscuolo (2021), "The human side of productivity: Uncovering the role of skills and diversity for firm productivity", VoxEU.org, 23 December.

OECD (2013), *OECD Skills Outlook 2013: First Results from the Survey of Adult Skills*, Organisation for Economic Co-operation and Development.

Oltmanns, J, B Godde, A H Winneke, G Richter, C Niemann, C Voelcker-Rehage, K Schömann and U M Staudinger (2017), "Don't Lose Your Brain at Work – the Role of Recurrent Novelty at Work in Cognitive and Brain Aging", *Frontiers in Psychology* 8: 117.

Salthouse, T A (2004), "What and When of Cognitive Aging", *Current Directions in Psychological Science* 13(4): 140–44.

Sánchez-Izquierdo, M and R Fernández-Ballesteros (2021), "Cognition in Healthy Aging", *International Journal of Environmental Research and Public Health* 18(3): 962.

Staudinger, U M (2020), "The Positive Plasticity of Adult Development: Potential for the 21st Century", American Psychologist 75(4): 540–53.

AUTHORS

Eric Hanushek
Paul and Jean Hanna Senior Fellow at the Hoover Institution, Stanford University

Lavinia Kinne
Postdoctoral Researcher, Diw Berlin

Frauke Witthoeft
Junior Economist, Ifo Institute; Doctoral student, Ludwig Maximilian University Of Munich

Ludger Woessmann
Director, ifo Center for the Economics of Education; Professor of Economics, Ludwig-Maximilians University of Munich (LMU)

THEMES

KEYWORDS