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Article

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

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Economic Policy and its Impacts

Use It or Lose It:

How Cognitive Skills Change with Age

Key Messages

- It is commonly assumed that cognitive skills start to decline by age 30 if not earlier, which could pose major challenges for rapidly aging populations
- But this assumption largely relies on cross-sectional data that cannot distinguish between aging patterns and cohort differences in skills
- Using unique German longitudinal skill data, our analysis breaks the confounding of age and cohort patterns
- We find that skills on average actually increase strongly into the forties before decreasing slightly in literacy and more strongly in numeracy
- Furthermore, skills decline at older ages only for those with below-average skill usage



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Many disciplines have been concerned with brain aging and cognitive decline. Research from psychology and neuroscience shows that aging 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 afterward (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), in particular the decrease of gray and white brain matter (Oltmanns et al. 2017; Hedman et al. 2012; Brito et al. 2023).

Economists have increasingly become interested in skill development from a different angle (Gust et al. 2024). Cognitive skills such as literacy and numeracy are closely related to individual earnings (Hanushek et al. 2015, 2017; Hampf et al. 2017) and national economic growth rates (Hanushek and Woessmann 2008, 2015), implying that the steady and marked changes in the age composition of societies (Bloom and Zucker 2023) might directly affect the economic well-being of nations.

In new research, we use unique German longitudinal data to show robust age patterns of cognitive skills (Hanushek et al. 2025).¹ We overcome the commonly faced limitation of not being able to distinguish between age and cohort patterns and additionally account for measurement error coming from repeated testing.

Separating Age From Cohort Effects and Reducing Measurement Error

Cross-sectional data suggests declines of cognitive skills at age 30 or before. In 2011 and 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 twenties or early thirties. However, cross-sectional data necessarily contains not only aging patterns but also cohort differences in skills, e.g., 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 aging effect.

Individual longitudinal skill tests for a representative population of German adults allow us to break the confounding of 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 resurveyed and retested 3.5 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.

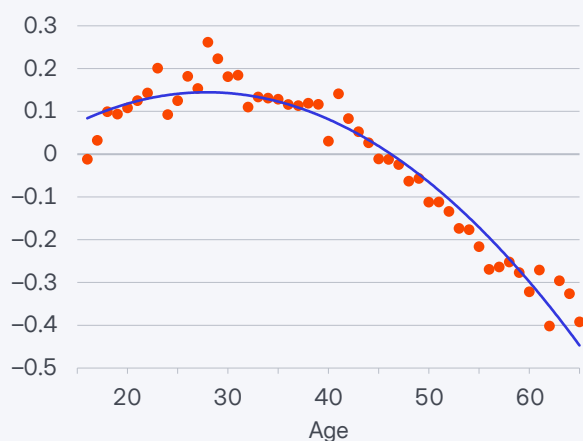
We also address the bias from measurement error that inevitably accompanies testing of skills over time. Observations of test scores include a combination of true scores and measurement errors. Intuitively, low observed test scores

¹ The underlying research paper, "Age and Cognitive Skills: Use It or Lose It", has been published in Science Advances. This summary was first published on VoxEU.org.

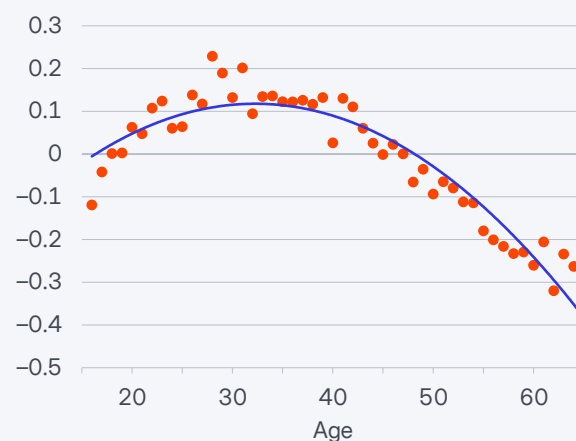
Figure 1

Cross-Sectional Age-Skill Profiles

Literacy



Numeracy



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

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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 favorable 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.

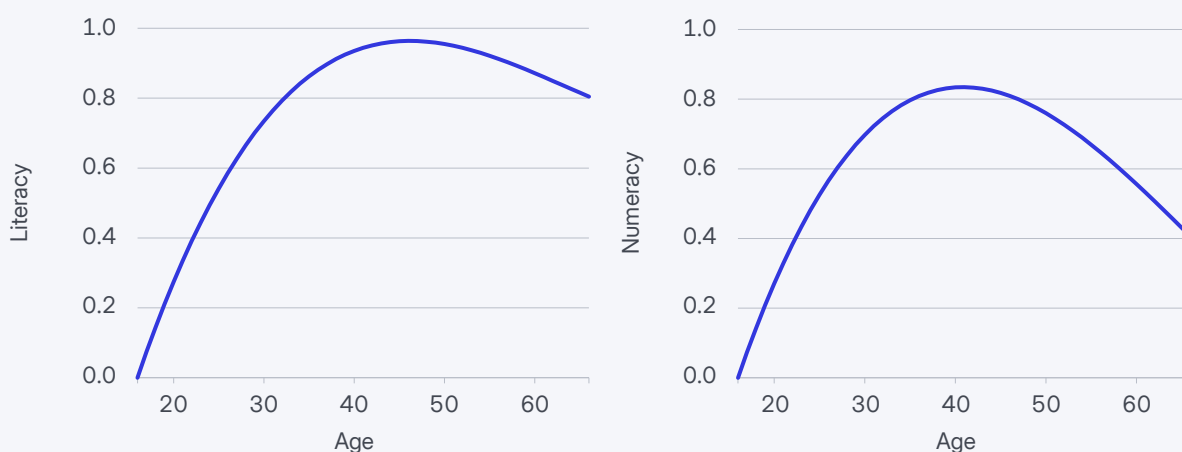
Actual Skill Decline Starts Much Later Than Previously Assumed

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

Figure 2

Longitudinal Age-Skill Profiles

A. Cumulative age-skill profiles



B. Marginal skill changes by age



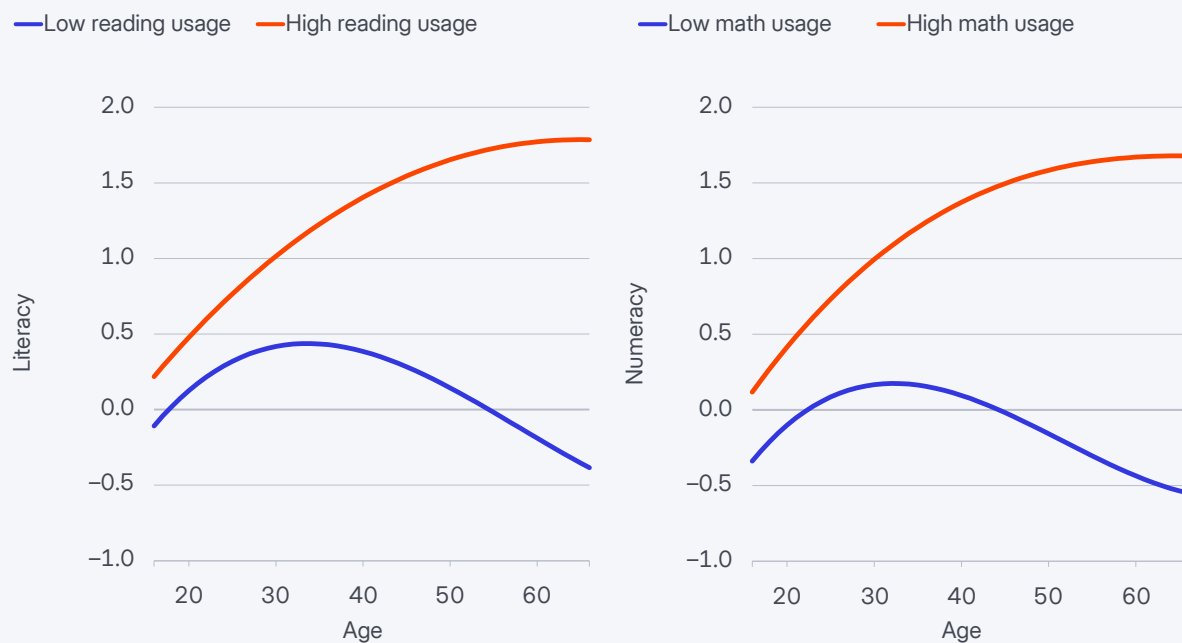
Data: PIAAC-L, Germany.
Source: Hanushek et al. (2025).

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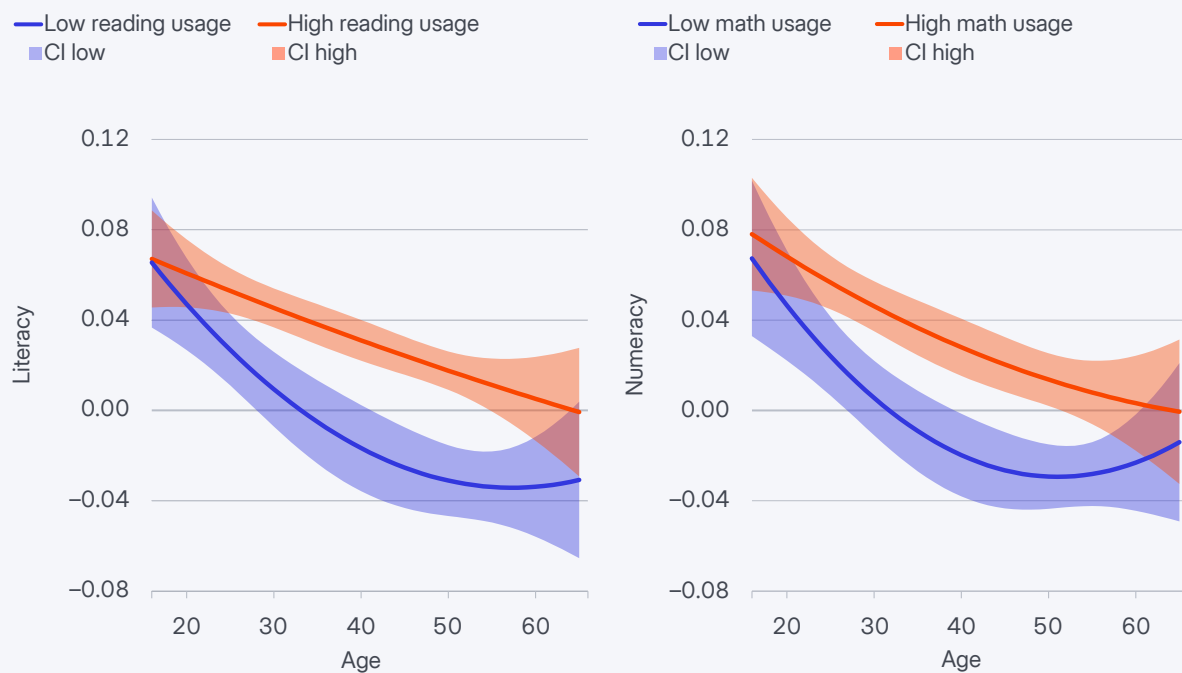
Figure 3

Age-Skill Profiles by Skill Usage

A. Cumulative age-skill profiles



B. Marginal skill changes by age



confidence bands on estimated quadratic age patterns.) Skill changes turn negative beyond these ages, with notably stronger declines for numeracy than for literacy.

Figure 2A displays the resulting cumulative age-skill profiles. Literacy skills increase strongly in the twenties and thirties before stabilizing in the late thirties. 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 the levels observed in the early twenties.

Frequent Skill Usage Is Crucial For Skill Retention

Average age-skill profiles, however, mask important heterogeneity. Previous analyses have considered whether an individual's background or occupation influences 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 generally not been 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 aging patterns by actual skill usage.

Considering age-skill profiles by the frequency of skill usage paints a more nuanced picture of skill development with aging. 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 math or "reading letters, memos, or e-mails" for reading.

Those with above-median usage of numeracy and literacy on average never lose any skills in the observed age range (Figure 3B, red lines and shaded areas). Their skills increase steeply into the fifties and then flatten out, with no indication of average decline (Figure 3A, red lines). Instead, for those with below-median usage (blue lines and shaded areas), skill decline begins in their mid-thirties.

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.

Policy Conclusion

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 an economic concern 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 implies that skills decline later than previously assumed. Additionally, skill decline is present only for those who don't use their skills much at work or at home. Overall, our results speak against a natural law that dictates an inevitable decline in skills with age. Behavioral choices can overcome any natural biological changes. It is thus crucial for individuals and societies that the population maintains their competencies through frequent skill usage.

While our results in principle offer some consolation for countries with aging populations, they also highlight the importance of policy attention to not only the accumulation of skills, e.g. in schools, but also their retention through skill usage and lifelong learning. •

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