

Supertitle: MULTILINGUALISM

Title

A multilingual guide to slowing aging

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Standfirst

People who speak two or more languages may experience a later onset of dementia symptoms, yet whether multilingualism promotes healthy aging in a generalizable or even actionable manner remains unclear. In an impressively large scale study, Amoruso and colleagues provide robust evidence that knowing multiple languages supports healthier aging trajectories.

Main text

What if knowing more than one language does not simply enable you to speak with more people or open new cultural horizons— what if it helps you age more healthily? The hypothesis that *the mental gymnastics inherent to juggling multiple languages is one life-style factor that fosters healthier cognitive aging* has garnered support over the past two decades [1]. In a new study, Amoruso et al. [2] innovatively test this hypothesis at an astoundingly large scale, analyzing data from more than 86,000 older adults across nearly thirty European countries. Using biobehavioral age gaps (BAGs) — the difference between a person’s predicted “biological” age, derived from individual-level data on health and lifestyle factors, and their chronological age — the authors show that multilingualism is linked to slower aging, while monolingualism is linked to accelerated aging. In short: knowing more than one language lowers the odds of having an older-than-expected health profile now and the risk of developing one later (Fig. 1, Panel A).

Why was such a study needed? For years, evidence has suggested that multilingualism may contribute to cognitive reserve [3,4,5]— the brain’s capacity to cope with age-related changes or disease [6]. While some studies show multilinguals experience a later onset of dementia symptoms [1,7,8], recent meta-analyses offer conflicting interpretations [9,10]. Discrepancies likely stem from methodological limitations: small samples, reliance on indirect proxies of aging, inadequate assessment of multilingualism itself and lack of control for socio-environmental influences. Amoruso et al. [2] address many of these issues by studying large, nationally representative cohorts of healthy older adults. Their design combines cross-sectional and longitudinal approaches while also adjusting for a broad “exposome” — country-level linguistic, physical, social, and political factors such as migration, inequality, air quality and democratic institutions.

How do BAGs work? The authors trained a computational model to estimate biobehavioral age from a wide set of known risk and protective factors. Positive features included preserved cognition, daily functional independence, education, and physical activity. Adverse features included sensory problems, cardiometabolic conditions, sleep difficulties, and unhealthy lifestyle behaviors. The gap

between predicted and actual age provided a marker of health. Unlike crude outcomes such as dementia diagnosis, BAGs allow for scalable, fine-grained estimates of aging trajectories across populations.

The findings were striking. Individuals who spoke only their mother tongue were more likely to show accelerated aging, while those who spoke additional languages were less likely. Benefits increased with the number of languages spoken, potentially suggesting a dose-dependent effect. Longitudinal data confirmed this pattern: multilinguals were less likely to develop accelerated aging over time, suggesting a protective effect of the routine, yet cognitively demanding tasks associated with multiple language selection and management.

Could these effects simply reflect country-level differences? To test this, the authors adjusted analyses for national conditions. The protective effects of multilingualism remained robust, with only minor exceptions. For instance, in some contexts the benefit of speaking many languages weakened when migration patterns were considered, and the benefit of speaking one additional language weakened when gender inequality was factored in. Structural forces underlying these exceptions might dampen, but crucially do not erase gains linked to multilingualism, underscoring the complex relationship between individual experiences and health outcomes. Moreover, modeling BAGs allowed the authors to compare linguistic status/knowledge directly with, and isolate it from, influences such as education, physical activity, and chronic disease. Having done so not only situated multilingualism alongside other documented lifestyle factors affecting aging, but showed how multilingualism contributes independently. The key takeaway is compelling: across diverse (European) settings and rigorous controls, multilingualism consistently emerges as a protective factor for healthier aging. This reframes language use as a modifiable, public-health-relevant behavior, not unlike other lifestyle factors, and positions BAGs as a practical tool for tracking how everyday experiences shape the pace of aging at scale.

Indeed, Amoruso et al. [2] marks a milestone in discussions around whether speaking multiple languages protects against age-related decline. While the idea has intuitive appeal and some clinical support, consensus has been lacking. Much of the early literature relied on small samples and/or indirect markers, raising concerns about overinterpretation. Better-powered, contemporary work has refined the picture, emphasizing the need to treat multilingualism not as a binary variable but as a continuous experience of engagement. Most recently, studies using detailed experiential measures — individual differences in proficiency, frequency of use, and active switching — show how multilingual engagement modulates cognition and neural dynamics across the lifespan [11,12]. These developments build on earlier theories linking multilingualism to cognitive reserve [1,5] and adaptive control processes that influence brain structure and function [13, 14].

Against this backdrop, the scale of Amoruso et al. [2] is both its triumph and limitation. Because the study draws on population-level data across 27 countries, it cannot capture the fine-grained nuances of individual level multilingual experience which contemporary work shows to be critical [15]. It does not, for example, distinguish between a person who once studied another language in school and someone who uses multiple languages daily. By current standards, this is too blunt. While such bluntness hinders a more granular understanding of how multilingualism is protective, it is all the more striking that the protective effect emerges so clearly. Indeed, the fact that it shines through without fine-grained measures of multilingual engagement only serves as a testament to the robustness of multilingualism's protection. This does not mean that granularity in multilingual engagement is irrelevant. On the contrary, it highlights the complementary roles of different approaches. Fine-grained studies [11,12] illuminate mechanisms by which multilingualism engages the brain and shapes decline [13,14], while large-scale

epidemiological work such as Amoruso et al. [2] demonstrates that the protective effect generalizes across populations, even when multilingualism is measured crudely (Fig. 1, Panel B).

To the extent that multilingualism is a *bona fide*, independent protective factor, the logical next question is what to do with it. One answer lies in policy. Unlike potentially expensive dietary, lifestyle or translational interventions, multilingual language use is not confined to those who can afford specific resources [3]. Multilingualism is the default state of the world, emerging from necessity, community or opportunity. It is embedded in daily life, spreading across social, cultural, and economic boundaries. That makes it uniquely positioned as a low-cost, scalable lever for public health. If multilingualism builds resilience against aging, then encouraging additional language learning in schools, protecting migrant and minoritized languages, fostering and maintaining opportunities for multilingual usage across the lifespan could be as important as campaigns promoting physical activity or smoking cessation. Dementia prevention frameworks increasingly emphasize modifiable lifestyle factors [6]. While future dedicated work is needed to precisely quantify effect size comparability between independent lifestyle factors, it is clear that multilingual language use merits being part of the conversation [3,4,5].

Still, a crucial question remains unresolved — one with significant consequences for both science and practice. Most work to date, including Amoruso et al. [2], conflates two distinct experiences that can reasonably fall under the umbrella term multilingualism: learning new languages and using/maintaining multiple languages once learned over time. Both may shape neurocognitive trajectories and provide cognitive reserve, but they are not (necessarily) the same; perhaps they involve only partially overlapping neurocognitive mechanisms [3,14]. The former—becoming multilingual—is episodic and effortful, the latter—engaging multilingualism—is continuous, involving switching, maintenance, socialization and more. Intuitively, one might expect each to confer different neurocognitive adaptations across space and time, yet no research has systematically disentangled them. Future research should, therefore, move in two directions simultaneously. On the one hand, intervention studies can test whether teaching new languages in mid- or later life improves cognitive functioning. If so, the efficacy, scalability and durability of such effects for how cognitive aging trajectories play out must also be established. On the other hand, it will be equally important to investigate how variation in pre-existing multilingualism over the lifespan and in particular at older age, modulates aging trajectories. Should we expect the same linear trajectory for all multilinguals, even for individuals matched on all relevant variables earlier in life? Multilingual engagement patterns can shift dramatically with individual circumstances, for example upon retirement, or as social networks reduce [3]. Studies that turn these insights into empirically sound protocols will require finer tools and long-term designs, but the payoff could be transformative: understanding not just whether multilingualism protects, but how distinct forms of non-static, real-world multilingual experiences and their ebbs and flows contribute differentially precisely in the timeframe where any accrued protection is needed the most (Fig. 1, Panel C).

The claim that multilingualism buffers against age-related decline is not new, but the work of Amoruso et al [2] demonstrates this association with impressive magnitude and cross-disciplinarity. The challenge for researchers now is not to pursue the path of (dis)proving if the effect exists — it clearly does — but to map its mechanisms, refine its boundaries, and translate its potential into strategies for promoting healthier aging worldwide.

Competing interests

The authors have no competing interests to report.

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References

1. Bialystok, E., Craik, F. I., & Freedman, M. *Neuropsychologia*, 45(2), 459-464 (2007).
2. Amoruso, L. et al. *Nat. Aging*. vol, XXX-XXX (2025).
3. Rothman, J. *Biling.: Lang. Cogn.* 28, 793–801 (2025).
4. Gallo, F., DeLuca, V., Prystauka, Y., Voits, T., Rothman, J. & Abutalebi, J. *Front. Hum. Neurosci.* 16, 819105 (2022).
5. Bialystok, E. *Trends Cogn. Sci.* 25, 355–364 (2021).
6. Stern, Y., et al. *Alzheimers Dement.* 16, 1305–1311 (2020).
7. Craik, F. I., Bialystok, E. & Freedman, M. *Neurology* 75, 1726–1729 (2010).
8. Alladi, S., et al. *Neurology*, 81, 1938-1944 (2013).
9. Mukadam, N., Sommerlad, A. & Livingston, G. *J. Alzheimer's Dis.* 58, 45–54 (2017).
10. Anderson, J. A., Hawrylewicz, K., & Grundy, J. G. *Psychon. Bull. Rev.* 27, 952–965 (2020).
11. Voits, T., et al. *Neurobiol. Aging* 140, 70–80 (2024).
12. Elin, K., Gallo, F., Gabrielsen, A., Voits, T., Rothman, J. & DeLuca, V. *NeuroImage* 121312 (2025).
13. Green, D. W., & Abutalebi, J. *J. Cogn. Psychol.* 25, 515–530 (2013).
14. Pliatsikas, C. (2020). *Biling.: Lang. Cogn.* 23, 459–471 (2020).
15. DeLuca, V., Rothman, J., Bialystok, E., & Pliatsikas, C. *Proc. Natl Acad. Sci. USA* 116, 7565–7574 (2019).

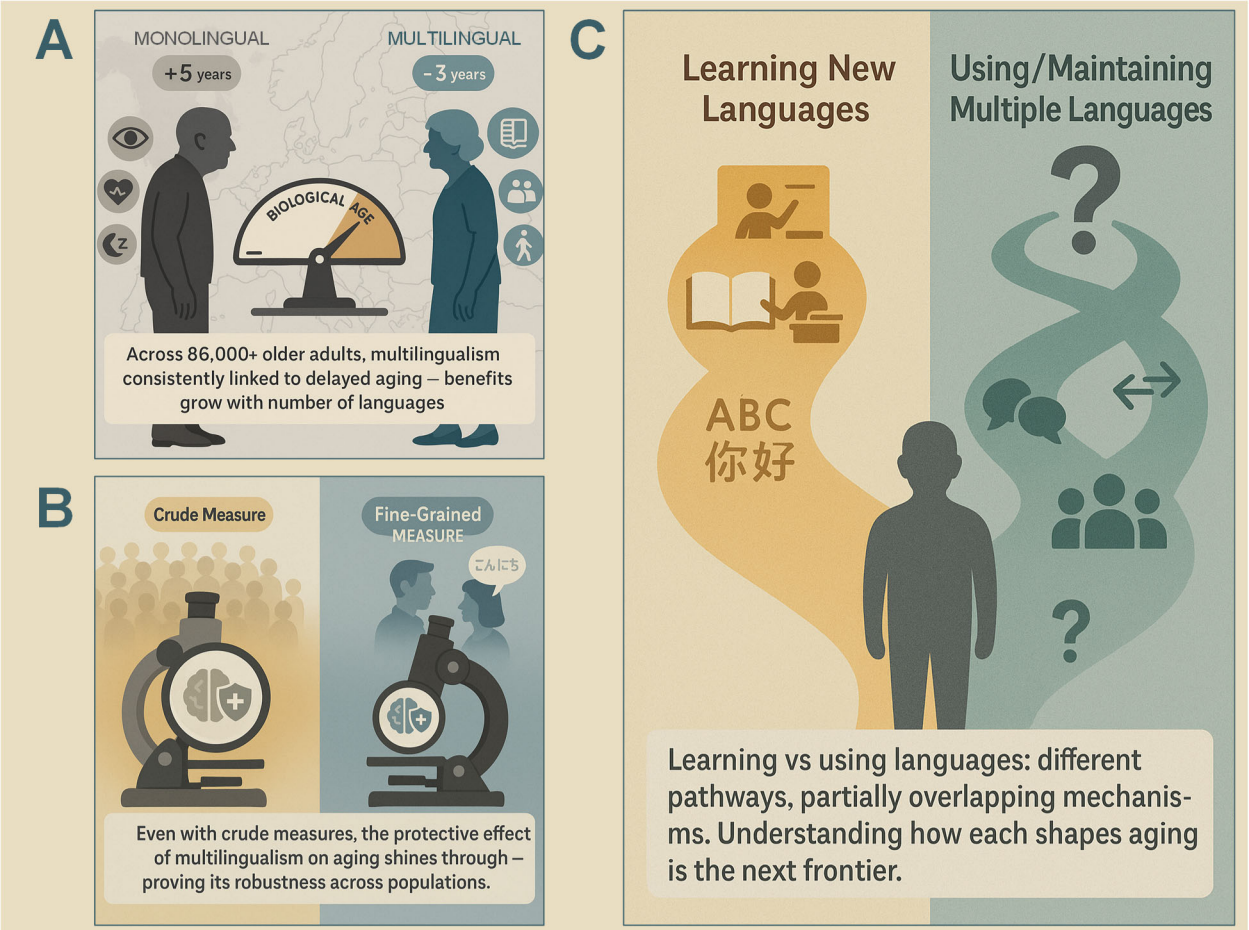


Figure 1. Multilingualism as a buffer against aging. Speaking more than one language is linked to healthier aging profiles in older adults. Panel a, multilinguals show delayed biological aging compared to monolinguals, as measured by biobehavioral age gaps. Panel b, this protective effect is visible even with crude measures of language knowledge, underscoring its robustness. Panel c, future work must separate the benefits of learning new languages from those of maintaining and using them across life, to reveal how each shapes aging differently.